9^{th} INTECOL

International Wetlands Conference

WETLANDS IN A COMPLEX WORLD

Conference Abstracts

June 3-8, 2012
Orlando, Florida, USA

www.conference.ifas.ufl.edu/INTECOL

Index of Topical Sections

PLENARY SPEAKERS

WHITHER WETLAND CONSERVATION? A VIEW FROM DEVELOPING COUNTRIES

Brij Gopal
National Institute of Ecology, Jaipur

Historically, wetlands laid the foundation of human civilisation and were an integral part of the socio-cultural ethos of human societies in many regions of the world. Natural wetlands were drained and reclaimed extensively first in Europe and North America. It is largely during the colonial period that wetlands were degraded or lost in Asia and Africa where the pressures for economic development in the post-colonial period accelerated the degradation. Yet, while the local communities in developing countries managed wetlands for subsistence and livelihoods, concern for wetlands was raised from the viewpoint of conservation of the avian species first in the 'developed' countries. The conservation efforts gained a momentum soon after the once 'wastelands' were discovered to be 'liquid assets' and 'waterlogged wealth'. The emergent wetland science placed these 'ecosystems' on a high pedestal bringing into focus the need for their conservation worldwide for their many ecological functions. The developing countries soon started rallying around the Ramsar Convention, sometimes vying with each other for attention. Today, only a couple of developing countries with significant wetland habitats have yet to join the Ramsar Convention.

In recent years, much has been talked and published about distribution and kinds of wetlands, their ecosystem characteristics and services, causes and threats to their loss and degradation and needs for policies, strategies and governance for their conservation and even restoration in most of the developing countries. Yet in reality, there is hardly little, often isolated, effort to develop indigenous wetland science that is needed for understanding the functioning of wetlands and their responses to anthropogenic disturbances under local conditions. Few countries have a comprehensive wetland inventory that also accounts for the biodiversity, functions and ecological character. The distinction between the natural, man-modified and man-made wetlands has been so blurred that it is impossible to set objectives and formulate strategies for conservation. Floodplain wetlands are degraded or lost at the cost of upstream reservoirs that are treated as important wetlands. So are the backwaters and mangroves getting converted into paddy fields and shrimp farms which also now deserve conservation. Only a handful of developing countries have developed specific policies aimed at protecting and conserving wetlands, and even the existing policies and laws are not fully and properly implemented. Whereas over-exploitation of wetland resources, pollution, reclamation and invasive species are widely discussed as major threats, little attention is paid to the hydrological alterations throughout the catchments, and the role of trade, industry, cash crops and globalisation is rarely considered and always underestimated. Conservation in most countries is largely symbolic as a few iconic wetlands receive some attention while conflicting approaches to land and water management ignore the vast majority of wetlands. In such a scenario, restoration of degraded wetlands is a far cry, despite some noteworthy attempts.

Contact Information: Prof. Brij Gopal, Centre for Inland Waters in South Asia, National Institute of Ecology, 41 B Shiv Shakti Nagar, Jagatpura Road, Jaipur 302017, India. Tel: +91-9414044283; email: brij44@gmail.com

INTERACTIONS BETWEEN HUMAN ACTIVITIES AND THE STRUCTURE AND FUNCTIONING OF WETLAND ECOSYSTEMS

Jan Květ[1,3], *Hana Čížková*[2,3] and *Martina Eiseltová*[4]

[1]University of South Bohemia, Faculty of Science, České Budějovice, Czech Republic
[2]University of South Bohemia, Faculty of Agriculture, České Budějovice, Czech Republic
[3]Czech Academy of Sciences, CzechGlobe, Center for Global Change Research, Brno, Czech Republic
[4]Crop Research Institute, Praha 6 – Ruzyně, Czech Republic

Structure and functioning are inseparable attributes of any ecosystem. This naturally also holds true for wetlands, both those forming land-water ecotones and those that are independent of any water body and depend on either groundwater supply or precipitation (rain- and snowfall), or both. The responses of the structure and functioning of these wetlands to various kinds of their management, conservation and restoration are in the focus of our presentation.

From various case studies, we have chosen examples of human management impacts on the spatial and trophic structure and associated processes, in such temperate freshwater wetlands as the littoral zones of both natural and constructed lakes, among them especially fish ponds. Other examples concern the wet grassland and mires (bogs and fens). Particular attention is paid to the effects of agricultural activities and fish farming on structural and functional attributes of these wetlands. When they are suitably managed, all of these wetlands can play a prevailingly positive role in sustainable management of agricultural landscapes.

The functioning of wetland ecosystems dealt with in this contribution is largely determined by such processes as the energy flow, water balance, carbon and nutrient uptake and accumulation, and the resulting growth and primary production of wetland vegetation. These processes are naturally projected into the species variety and diversity of the wetland ecosystems considered. So are also the actual or potential human impacts on important functional relationships between wetland plant and animal populations or communities. Steering of either the bottom-up or the top-down control of ecosystem structure and functioning is a powerful management tool in certain wetlands, e.g., fish ponds. Attention is also paid to both intentional and unintentional human impacts on structural and functional adaptations of wetland plants and animals to their respective habitats modified by human activities.

Finally, thoughts are given to the applicability of the concept of sustainable ecosystem services to defining desirable, tolerable or undesirable human impacts on wetlands, especially those used as examples in this contribution.

Contact Information: Jan Květ, University of South Bohemia, Faculty of Science, Dept. of Ecosystems Biology, 0Branišovská 31, CZ-37005 České Budějovice, Czech Republic, Phone : +420 384 723 123 ; Fax. +420 384 721 136; E-mail: Jan.Kvet@seznam.cz

VALUING NATURE: INCORPORATING ECOSYSTEM SERVICES INTO DECISION-MAKING

Stephen Polasky
Department of Applied Economics / Department of Ecology, Evolution and Behavior, University of Minnesota, St. Paul, MN, USA

Human society depends on vital goods and services provided by ecosystems but human actions are eroding the natural capital that underlies the provision of ecosystem services. Understanding how human actions impact the value of ecosystem services requires understanding the links between: a) human actions and impacts on ecosystem functions, b) ecosystem functions and the provision of ecosystem services, and c) the contribution of ecosystem services to human well-being. Making these links requires spatially explicit mapping of the provision of ecosystem services and the value of those services to beneficiaries. In this talk I will use recent examples of integrated analysis on land use choices in Minnesota, Hawaii and Oregon to illustrate how human actions affect the provision and value of various ecosystem services, and how such information could be used in a policy or management context.

Contact Information: Stephen Polasky, Fesler-Lampert Professor of Ecological/Environmental Economics Department of Applied Economics / Department of Ecology, Evolution and Behavior, University of Minnesota, 1994 Buford Avenue / 1987 Upper Buford Circle, St. Paul, MN 55108, Phone: 612-625-9213 / 612-624-3663, Fax: 612-625-2729, Email: polasky@umn.edu

BIODIVERSITY – ENDANGERED SPECIES

THE RIVER OF FIRE: FIRE MANAGEMENT IN THE MODERN EVERGLADES

Rick Anderson
National Park Service, Homestead, Florida, USA

Fire is often cited as an important ecological process within the Everglades National Park. However, much of the emphasis of everglades restoration external to the National Park is focused on "getting the water right" with fire relegated to an epiphenomenal role. Restoration efforts rarely propose fire management strategies. This may be in part because of a collective assumption that in a restored, and thus wet ecosystem that unwanted fire effects will cease to exist. Like water flow the landscape level fire process has been compartmentalized and constrained by water management structures, roads, exotic species, and human populations. Furthering endangered species, particularly the single species approach, created by the endangered species act creates a complicated matrix of regulations and often conflicting objectives for fire managers. Presented here are the challenges that fire managers encounter and proposed solutions such as applying Fire Return Interval Departure methods. Prioritization methods will also be discussed as applications that guide managers through decision making.

Contact Information: Rick Anderson, Fire Management Officer, National Park Service, Everglades National Park, 40001 State Road 9336; Homestead, Florida, USA 33034; PH 305.242.7853; Email: Rick_Anderson@nps.gov

USING ECOLOGICAL TRAITS TO EVALUATE THE VULNERABILITY OF THREATENED AND ENDANGERED SPECIES TO CLIMATE CHANGE

***Allison M. Benscoter*[1]**, *Laura A. Brandt*[2], *Frank J. Mazzotti*[1], *Stephanie S. Romañach*[3] and *James I. Watling*[1]

[1]University of Florida, Fort Lauderdale, FL, USA
[2]U.S. Fish and Wildlife Service, Fort Lauderdale, FL, USA
[3]U.S. Geological Survey, Southeast Ecological Science Center, Davie, FL, USA

Global climate change affects species via changes in physiology, phenology, migration patterns, distribution, and survival. Climate change presents unique challenges to threatened and endangered species because they are already at risk for extinction, and may have traits that make them particularly vulnerable to environmental change. Endangered species may be less capable of buffering the potential effects of climate change because they often exhibit small population sizes and restricted distributions. We evaluated the vulnerability of endangered subspecies to climate change by using subspecies-species comparisons. We compared ecological traits between endangered subspecies and non-endangered species by gathering Information from published literature on clutch size, litter size, home range, and territory characteristics for species located in Florida. Using a minimum of three independent observations of a given trait per taxon, we obtained data from the literature describing home range characteristics for 3 subspecies-species pairs and reproductive output for 4 subspecies-species pairs.

Preliminary results indicate that the endangered subspecies exhibited smaller litter and clutch sizes when compared to non-endangered species, as determined by Wilcoxon rank sum tests comparing ecological traits between our species pairs. Specifically, the endangered Florida panther (*Puma concolor coryi*) displayed a smaller mean litter size (2.314) than the cougar (*Puma concolor*; 2.695) ($W = 8$, $p = 0.030$), and the endangered Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) had a smaller mean clutch size (3.593) than the grasshopper sparrow (*Ammodramus savannarum*; 4.302) ($W = 0$, $p = 0.011$). We also observed a larger mean territory size in the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*; 0.024 square kilometers) when compared to other seaside sparrows (*Ammodramus maritimus*; 0.004 square kilometers) ($W = 15$, $p = 0.018$). Because higher reproductive output should lead to more rapid population growth and the ability to recover more quickly from disturbances, lower litter and clutch sizes observed in the endangered subspecies not only indicates they may be more susceptible to climate change, but may also help explain their endangered status. Additionally, the larger territory size observed in the endangered Cape Sable seaside sparrow may be indicative of higher resource requirements, which may also make this species more vulnerable to environmental change. Given the small population sizes and restricted ranges of these species, any compromise in the ability to buffer climate change effects may increase their probability of extinction.

Contact Information: Allison M. Benscoter, University of Florida, Fort Lauderdale Research and Education Center, Fort Lauderdale, FL, 33314, USA, Phone: 954-577-6448, Email: abenscoter@ufl.edu

INCORPORATING CLIMATE EXTREMES INTO CLIMATE ENVELOPE MODELS FOR FLORIDA THREATENED AND ENDANGERED SPECIES

David N. Bucklin[1], *Laura A. Brandt*[2], *Carolina Cabal*[1], *Frank J. Mazzotti*[1], *Stephanie S. Romañach*[3] and *James I. Watling*[1]

[1]University of Florida Fort Lauderdale Research and Education Center, Fort Lauderdale, FL, USA
[2]U.S. Fish and Wildlife Service, Fort Lauderdale, FL, USA
[3]U.S. Geological Survey, Southeast Ecological Science Center, Fort Lauderdale, FL, USA

Understanding how species respond to climate is the primary goal of climate envelope models (CEMs), which use relationships between presence data and climatic variables to determine a species' suitable climate "niche". Climate, and the extreme weather events that occur within its variability, can affect many aspects of a species' biology, including individual fitness, morphology, timing of activity and geographical distribution. However, CEMs typically use long-term monthly or seasonal means of temperature and precipitation (or bioclimatic variables derived from these means) as inputs, ignoring potentially deterministic extreme weather events which take place at variable temporal intervals. Despite growing understanding of climate change and its effect on extreme events, little attention has been paid to how measures of climate extremes might be implemented into CEMs, and potentially improve their predictive capacity. For threatened and endangered species, especially inherently range-limited endemics or climate "specialists," determining the response of species to climate extremes may play an important role in their management and conservation under a changing climate.

In this study, CEMs using monthly temperature and precipitation means from the thirty-year period 1981-2010 will be constructed for 15 terrestrial threatened and endangered species and sub-species with current Florida-confined ranges. A pool of extreme climate variables will be generated and added to the models derived from climatic means. Extreme climate measures derived from daily station data will describe probabilities of potentially important short-term (lasting at least one day) extreme temperature and precipitation events, such as freezes, heat waves, and abnormally wet/dry periods. Longer-term measures of extreme climate derived from monthly data will describe mean and absolute extreme monthly values of temperature and precipitation within the 30-year period, while standard deviation of climate values will be implemented as a measure of climate variability. The inclusion of a set of independent extreme climate variables at different temporal resolutions may allow us to better understand and predict biological responses of individual species to extreme weather events and species' climate niches for future climate scenarios.

Contact Information: David Bucklin, Department of Wildlife Ecology and Conservation - Fort Lauderdale Research and Education Center, University of Florida, 3205 College Avenue, Fort Lauderdale, FL 33314, USA, Phone: 954-577-6448, Email: dbucklin@ufl.edu

MODELING THE IMPACT OF CLIMATE AND ANTHROPOGENIC DISTURBANCE ON THE DISTRIBUTION OF FLORIDA'S THREATENED AND ENDANGERED VERTEBRATES

Carolina Cabal[1]*, Laura A. Brandt*[2]*, David N. Bucklin*[1]*, Frank J. Mazzotti*[1]*, Stephanie S. Romañach*[3] and *James I. Watling*[1]

[1]University of Florida/IFAS, Davie, FL, USA
[2]U.S. Fish and Wildlife, Davie, FL, USA
[3]U.S. Geological Survey, Southeast Ecological Science Center, Davie, FL, USA

Florida is one of the fastest growing states in terms of human population and development of natural lands. Within the last 100 years, the state has experienced major construction of roads, highways, and sprawling commercial and residential buildings. The protection of natural areas from development is an important issue because threatened and endangered species are commonly regarded as being particularly susceptible to changes in natural habitats because of their already low population numbers. This project aims to understand how anthropogenic factors and climate affect the geographic range of some of Florida's threatened and endangered vertebrate species. Temperature and precipitation climate variables were used to develop an initial set of models that would define the distribution of six species: the American Crocodile, the Wood Stork, the Sand Skink, the Lower Keys Marsh Rabbit, the Florida Panther and the Everglades Snail Kite. In a second set of models, a Human Influence Index (HII) variable was added to the climate models to compare the impact of anthropogenic alteration of the landscape on the species' distribution. The models were prepared using the Random Forests (RF) algorithm, and their prediction performance, which was compared to actual records of species' occurrences, was calculated through Kappa and receiver-operator curve (AUC) performance metrics. Finally, a Spatial Correlation analysis was run between the two sets of models (climate with HII and climate only) to quantify the difference between each species' distribution models. The results of the 6 preliminary species performance metrics do not show major differences in the performance of the HII vs non-HII models. Four out of the six species had lower kappas and AUCs for the models created with the HII variable, meaning that anthropogenic effects might not be as important of an indicator of species distribution. Only one species restricted to the Florida Keys, the Lower Keys Marsh Rabbit, shows a modest improvement in model performance which might indicate that anthropogenic effects play a bigger role in the species' distribution. The spatial correlations between the HII and non-HII models vary from 0.85 to 0.94, with the models of 5 species having correlations above 0.9. Thus it appears that for this preliminary set of species, incorporating data on anthropogenic disturbance may not contribute significantly to model performance or predictions. Future work will include similar analyses for additional species to test the generality of results observed to date.

Contact Information: Carolina Cabal, University of Florida/IFAS, 3205 College Ave, Davie, FL 33314 USA, Phone: 954-577-6448, Email: ccabal@ufl.edu

GENETIC EVIDENCE FOR WEST TO EAST MOVEMENT BY FLORIDA MANATEES THROUGH A SOUTH FLORIDA MIGRATION CORRIDOR

Margaret E. Hunter[1#], *Kimberly Pause Tucker*[2#] and *Robert K. Bonde*[1]
[1]Southeast Ecological Science Center, U.S. Geological Survey, Gainesville, FL, USA
[2]Department of Mathematics and Natural Sciences, College of Coastal Georgia, Brunswick, GA, USA
[#]These authors contributed equally to this work

The endangered Florida manatee (*Trichechus manatus latirostris*) is a large aquatic mammal inhabiting coastal regions of the southeastern United States. The subspecies is impacted by natural and anthropogenic threats such as cold stress, habitat degradation, and watercraft collisions. Information on the genetic spatial structure, effective population size, and migration patterns could aid management and research agencies with listing status decisions and trend analyses for the Florida manatee. The single mitochondrial haplotype previously identified cannot be used to delineate spatial structure and has raised concerns about the genetic diversity within the population. To better define the population structure, movement patterns, and genetic variability, 11 nuclear-based microsatellite markers were investigated for 331 Florida manatees. Manatees were able to be individually identified and there was evidence for population differentiation between the Florida Atlantic and Gulf coasts. A mixing zone was identified on the south Atlantic coast suggesting movement through south Florida, specifically migration corridors such as the Everglades or Lake Okeechobee. Overall, the subspecies exhibited low heterozygosity (0.41) allelic diversity (N_A = 4.18), and effective population size (N_e = 242.9). Specifically, the effective population size was lower on the Gulf coast then the Atlantic coast, suggesting a migration direction from west coast to east coast which corresponds with the Gulf current. This study supports the treatment of the population as two genetic management units and the protection of migration corridors in south Florida. The low genetic diversity in Florida manatees could increase the subspecies' susceptibility to stochastic events and inbreeding depression.

Contact Information: Margaret E. Hunter, Sirenia Project, Southeast Ecological Science Center, U.S. Geological Survey, 7920 NW 71st Street, Gainesville, FL 32653 USA, Phone: 352-264-3484, Fax: 352-378-4956, Email: mhunter@usgs.gov

EDNA MONITORING: PRESENCE-ABSENCE SAMPLING TECHNIQUE FOR A RARE AMPHIBIAN SPECIES

Thomas Newcomb[1]*, Frank Cipriano*[2] and *Eric Routman*[2]

[1]Environ, Philadelphia, PA, USA

[2]San Francisco State University, San Francisco, CA, USA

The wide spread and sudden loss of amphibian species around the world signals a growing threat to global biodiversity. Efforts to meet the threat are hampered by a lack of basic Information on the distribution of rare and endangered species; forcing conservation policy and land management decisions to be based on species occurrence data that are incomplete or biased. The high level of effort required to obtain accurate species occurrence Information is costly and limits the scope of conservation efforts. Obtaining occurrence data is particularly difficult when survey methods have low detection rates. Survey techniques for the accurate and efficient collection of occurrence data are needed to inform conservation efforts.

The application of molecular techniques may provide a means of accurately determining the presence or absence of difficult to sample species. DNA discarded by an organism through its waste or another means can persist in the environment (eDNA) where it can be detected. Using polymerase chain reaction (PCR), small amounts of eDNA can be amplified from a variety of different types of samples to identify the presence of species. An additional benefit of monitoring species using eDNA techniques is direct Contact with the study organism is avoided eliminating potential harm to species from handling or the need for extensive permitting.

The feasibility of eDNA monitoring technique was demonstrated for the endangered California red-legged frog (*Rana draytonii*). The presence-absence of California red-legged frogs at a given pond was determined by extracting and amplifying DNA from water samples. Water samples from ten ponds where the presence (7 of 10) or absence (3 of 10) of *R. draytonii* was known, based on visual encounter surveys, were tested. Species-specific primers and a PCR reaction optimized for low concentrations of target DNA were used to amplify a 260 base pair fragment of the mitochondrial cytochrome-b gene. PCR analysis and DNA sequencing demonstrated 100 percent concordance with the visual encounter survey data. The study successfully demonstrates the feasibility of obtaining occurrence data for California red-legged frogs by collecting water samples from aquatic habitats.

Contact Information: Thomas Newcomb, Environ Global, 1760 Market Street, Suite 1000, Philadelphia, PA 19103, USA, Phone: 510-859-5903, Fax: 215-496-0164, Email: tnewcomb@environcorp.com

FORECASTING CLIMATE CHANGE EFFECTS ON THREATENED AND ENDANGERED SPECIES IN THE GREATER EVERGLADES ECOSYSTEM

James Watling[1], Laura Brandt[2], Alison Benscoter[1], David Bucklin[1], Carolina Cabal[1], Frank Mazzotti[1] and ***Stephanie Romañach[3]***

[1]University of Florida, Fort Lauderdale, FL, USA
[2]U.S. Fish and Wildlife Service, Fort Lauderdale, FL, USA
[3]U.S. Geological Survey, Southeast Ecological Science Center, Davie, FL, USA

Climate change is expected to result in shifts in the spatial distribution of habitats and the species that occupy them, and responding to these shifts will be an important focus of applied conservation in the twenty-first century. We are creating climate envelope models for 26 species of threatened and endangered terrestrial vertebrates that occur in Peninsular Florida. Analysis of preliminary models for the 26 species suggests a decrease in the overlap of climate envelopes for multiple species by the middle of the twenty-first century; whereas a given location may be characterized by climate that is appropriate for up to 12 out of 26 species today, by midcentury climate is expected to be matching for no more than seven species at any given location. We also report the potential for loss of species representation in the protected area network. The number of National Wildlife Refuges that contain matching climate for the greatest number of species is projected to decrease by midcentury compared with the present day. In addition to reporting species- and refuge-specific patterns, we also examine how changing land use and sea level rise may affect the amount of habitat available within species' future climate envelopes.

Contact Information: James I. Watling, University of Florida, Ft Lauderdale Research and Education Center, Ft Lauderdale, FL 33314, Phone: 954-577-6316, email: watlingj@ufl.edu

HABITAT ASSESSMENT FOR SMALLTOOTH SAWFISH, *PRISTIS PECTINATA*, ALONG THE SOUTHWESTERN COAST OF FLORIDA

G. Tiling-Range[1] and *T.J. Smith III*[2]
[1]Jacobs Technology, Inc., co Southeast Ecological Science Center St. Petersburg, FL, USA
[2]U.S. Geological Survey, Southeast Ecological Science Center, St. Petersburg, FL, USA

Historically, smalltooth sawfish, *Pristis pectinata*, were reported to number in the hundreds, and possibly thousands, on both coasts of Florida. Unfortunately, populations of this species have steadily declined since the nineteenth century possibly due to bycatch and sport fishing for collection of the sawfish rostrums. Consequently, *Pristis pectinata* was placed on the Federal Endangered Species list, and NOAA National Marine Fisheries Service has initiated recovery efforts. One important question for recovery is how juveniles utilize various habitats. To address this question, we selected three study areas along the southwest coast of Florida: Ten Thousand Islands, Caloosahatchee River-Matlacha Pass, and the mouth of the Shark to the mouth of Lostmans Rivers. In each study site, we classified the shoreline habitat type using a four-leveled classification criterion for each sawfish occurrence and for 300 randomly located points. Sawfish occurrence data was provided by NOAA.

We used a hierarchical classification scheme with four levels to classify shorelines. Level 1 was whether the shoreline was natural or altered. Level 2 was whether vegetation was present or absent. Level 3 classed the shoreline by a description of what was present: mangrove, marsh, beach, reef, spoil, exotic or mixed vegetation, or concrete. Finally, level 4 was water depth as shallow, < 3m, or deep, > 3m.

We compared 2004 DOQQs with historic aerial photos to assess the amount and type of habitat change that has occurred. From these data, we calculated the frequency distribution of shoreline types utilized by *Pristis pectinata.* Preliminary results show that in one study site juvenile sawfish prefer natural shallow mangrove shoreline. Moreover, in one of our study sites not much shoreline habitat has changed whereas some shorelines have changed in other study sites.

Contact Information: G.Tiling-Range, Jacobs Technology/U.S. Geological Survey, St. Petersburg, FL 33701 USA, Phone 727-803-8747, Fax: 727-803-2030, Email: gtrange@usgs.gov

BIODIVERSITY - HABITATS

THE ROLE OF WETLAND PATTERN AND CLIMATIC CHANGE IN DETERMINING WETLAND BIRD DIVERSITY, TAIWAN

Liang-Hsien Chen[1], *Mark D. Barnes*[2] and *Monica Kuo*[3]

[1]Associate Professor, Chinese Culture University Department of Life Science, Taiwan
[2]Associate Professor, Chinese Culture University Department of Natural Resources, Taiwan
[3]Associate Professor, Dean, College of Environmental at Design Chairman, Dept. of Landscape Architecture Chinese Culture University Resources, Taiwan

The main goals of this study were: (1) to test how diversity of wetland birds varies among different wetland habitats, including rice paddies and estuaries, and (2) to determining how diversity of wetland birds varies under climate change. Rice farming creates diverse cultural landscapes, including extensive paddy field and irrigation canals intermixed with wetlands. Many wetland birds are dependent on traditional paddy fields and irrigation systems as forage habitat for survival during annual migrations. We surveyed 52 inland wetlands and wetlands in Lanyang Estuary, Ilan County, northeastern Taiwan. Ilan is unique in having high average of annual rainfall (2839.9 mm) and paddy coverage. In winter, the northeastern monsoon season, it attracts many resident wetland birds.

This study was carried out from January 1998 to August 1999 and from June 2002 to December 2011, long enough for the researchers to investigate the impact of climate fluctuation. Climate change provided that the environment setting for these wetland birds studies.

A total of 118 species of birds in 36 families were recorded from the study sites. The bird populations of community in the 52 inland wetlands and Lanyang Estuary exhibited periodic fluctuation. *Calidris aipina* and *Pluvialis fulva* of were the most abundant shorebirds in Lanyang Estuary (2002-2003). The dominant species in the 52 inland wetlands were shorebirds, with the waterfowl *Anas crecca* and *Anas poecilorhyncha* having lower numbers during summer each year. We compared two sites based on habitat conditions and feeding guilds in our survey, including waterfowl, shorebirds, egrets, and resident birds, to check community composition fluctuation over time. Wetland bird stopover sites tend to be on mudflats and paddy fields, where they can feed and replenish nutrients periodically during migrations. The 52 inland wetlands had sufficient water and food resources, as is weel known from the wetland ecology after remediation of the Dongshan River. Patterns of microhabitat use were related in part by species morphology; while feeding, birds glean fish and invertebrates from the surface of mud, probe deeply into moist soil water, irrigation canal sand, and paddy fields. At the Lanyang Estuary wetland refuge, we observed bird community and wetland type responding to change over study periods at long time scales. Dry and wet years have been shown to impact habitat conditions and food resources of wetland bird populations, including shorebirds, waterfowl, and resident birds. Consequently, wetland birds and their habitats are closely linked to human livelihood and culture. Traditional paddy fields provide important habitats for many wetland bird species and increase nutrient retention and forage. Today there is great demand, not only in Ilan but throughout Taiwan, for remedial approaches, such as reconnecting rice paddles and restoring wetlands, which allow rice farmers to practice traditional agriculture without degrading the ecological value of natural habitats.

Contact Information: Liang-Hsien Chen, Chinese Culture University department of Life Science, Taipei, Taiwan, Phone: 02-2861-0511#26222, Fax: 02-2862-3724, Email: hsien@faculty.pccu.edu.tw

ANT DIVERSITY IN THE COASTAL WETLANDS OF LOUISIANA

***Xuan Chen**, Benjamin J. Adams* and *Linda M. Hooper-Bui*
Louisiana State University, Baton Rouge, LA, USA

Louisiana is home to one of the largest wetland-rich habitats in the world. However, these areas are among the fastest vanishing ecosystems today. Detailed Information about key invertebrate groups such as ants is currently lacking in these regions. Ants are keystone species, ecosystem engineers, and bioindicators in many ecosystems. The objective of this work was to study ant diversity in three main habitats: saline marsh, fresh floating marsh, and swamp.
Quadrat sampling, sweeping, and hand collecting were used to sample ants in marshes. Canopy, trunk, and ground traps, baiting, Berlese funnel, quadrat sampling, and hand collecting were used to survey ants in swamps.

In total, 30 species in 14 genera were captured. In marshes, we found nigh species with *Crematogaster pilosa* being the dominant. Our sites in swamps had 24 species, the richest genus was *Camponotus* and the dominant species was *Crematogaster vermiculata*. Differences in ant richness and composition between tree species were low, but more significant between swamp type and between microhabitats. Overall, vegetation structure was the main factor influencing ant assemblages. Few invasive ants and high number of habitat specialized species emphasize the importance to protect biodiversity in wetlands for long-term conservation programs.

Contact Information: Xuan Chen, Department of Entomology, Louisiana State University, 404 Life Sciences Building, Baton Rouge, LA 70803. Phone: 225-578-7149, Fax: 225-578-7504, Email: chenxuan1128@gmail.com

IMPORTANCE OF BIODIVERSITY AND BIOLOGICAL INTERACTIONS ON MANGROVE ARCHITECTURE IN MIXED SALTMARSH/MANGROVE SYSTEMS

Donna J. Devlin and *C. Edward Proffitt*

Florida Atlantic University, Department of Biological Sciences at Harbor Branch, Ft Pierce, FL, USA

In subtropical New World estuaries, below ground production of mangroves is critical to the maintenance of soil elevations as sea level rises. In latitudes where herbaceous salt marsh species and mangroves co-occur, the type of interaction (competition, facilitation, or none) that can occur between herbaceous species and early life stages of *Rhizophora mangle* is influenced by biological and physical factors and can have a profound effect on the above and below ground architecture and overall performance of seedlings and saplings. Further, the effects of competition or facilitation can be either direct or indirect.

We compare below and above ground production and architecture of *Rhizophora* seedlings and saplings along a tidal flood gradient on barrier and spoil islands under varying neighboring herbaceous plant conditions. We also assess the effects of maternal tree fertilization (nitrogen and phosphorous) history on above and below ground architecture of these life stages. We found that above ground production was not always a good predictor of below ground production. Compartmentalization among leaves, stems and coarse and fine roots varied along the tidal gradient, with presence/absence of neighboring plant species identity and diversity. Our results show that herbaceous plants can either facilitate or impede the formation of side branches and/or roots in *Rhizophora*. As an example when physical conditions are stressful *Spartina alterniflora* facilitates *Rhizophora* growth. In contrast, when physical conditions are amenable to *Rhizophora* growth, *S.alterniflora* appears to compete with *Rhizophora* for above and below ground space or other resources, resulting in changes in mangrove production and architecture.

Contact Information: Donna Devlin, Department of Biological Sciences, Florida Atlantic University, 5775 Old Dixie Highway, Ft. Pierce, FL 34946, Phone 772-242-2206, Email: ddevlin@fau.edu

REED FLADS: UNIQUE BUT LITTLE-KNOWN WETLAND ENVIRONMENTS IN THE NORTHERN BALTIC SEA

Riggert Munsterhjelm and ***Henrietta Pitkänen***
University of Helsinki, Helsinki, Finland

Reed flads are shallow (<1.2 m) open water areas left inside *Phragmites australis* –stands. These lagoon-Like openings are extraordinary wetland environments contributing to the diversity of aquatic habitats in coastal areas of the brackish Baltic Sea. The main factors in reed flad formation are ice-erosion and freezing during winter that prevent *P*. *australis* rhizome colonization on soft substrates. The existence and ecological relevance of reed flads has been brought out in the estuary area of Pohjanpitäjänlahti bay–Tammisaari archipelago, on the southern coast of Finland (Luther 1951a, Munsterhjelm 1997, 2005). However, the more detailed knowledge concerning the diversity of the aquatic vegetation and the morphological features of these habitats has remained very scarce. Describing the characteristics of reed flad vegetation is associated with Munsterhjelm´s (1997) classification of the successional stages of shallow bays (flads). Flads are gradually diverged from the open sea by the post-glacial land uplift. Reed flads resemble them in many aspects. *P*. *australis* has conquered the Finnish seashores during the last half of the 20th century. This has increased the significance of remaining reed-free shallow water space for aquatic plant species limited to <2 m depths. It can be anticipated that through sheltered, nutrient rich and less turbid reed flads *P*. *australis* can also have a positive impact on other aquatic vegetation.

Vascular (submersed and helophytic) plants and charophytes of varying-sized reed flads were surveyed along the Pohjanpitäjänlahti bay–Tammisaari archipelago gradient in 2009/2011. In addition, morphological and environmental features (e.g. depth, salinity, turbidity, water and sediment nutrients) of the reed flads were investigated. On the basis of the field results, reed flads proved to be ecologically important and versatile habitats. The distinctive nature of reed flad vegetation is due to the shelter given by a reed stand between the flad and the open sea. In addition, depth, the magnitude of ice-erosion and bottom type were found to be important factors shaping the aquatic vegetation of individual reed flads into mosaics formed by stands of different plant species. Reed openings often provide excellent habitats for a variety of fish and invertebrates and can serve as nutrient traps. Especially significant is the finding that reed flads host several shallow water and helophyte species that can otherwise be outcompeted from the shores by reeds. These species have decreased in frequency in the study area (Pitkänen et al. in preparation).

Next, the reed flad vegetation patterns will be analyzed further with multivariate methods (Canoco 4.5) in relation to the environmental variables. More extensive knowledge about the reed flad vegetation and ecological values widens the overall image of the Baltic Sea aquatic vegetation and lays a better foundation for protecting coastal habitats threatened by e.g. eutrophication and mechanical disturbances.

Contact Information: Henrietta Pitkänen, Department of Environmental Sciences, University of Helsinki, P.O. Box 65 (Viikinkaari 1), FI-00014 Helsinki, Finland, Phone: +358-40-5011832, Email: henrietta.pitkanen@helsinki.fi

OYSTER POPULATION AND REEF COMMUNITY RESTORATION IN THE ST. LUCIE RIVER ESTUARY

Edward Proffitt and *Elizabeth Salewski*
Florida Atlantic University, Ft. Pierce, FL

The rates and trajectories of development of oyster reef biodiversity is a crucial aspect of the Comprehensive Everglades Restoration Plan for the "northern estuaries, which includes the St. Lucie River. We studied reef development on fossil shell material placed subtidally in the St. Lucie estuary which receives discharges from Lake Okeechobee and runoff from other urban and agricultural sources. Discharges can result in wide salinity fluctuations and affect the estuary through the input of nutrients and other pollutants. We sampled oyster reef sites throughout the estuary for invertebrates, conducted a field experiment that crossed topographic relief with reef complexity, and employed Sediment Elevation Tables (SET) and marker horizons to estimate the balance between elevation gains due to colonization by reef-forming species, with elevation losses resulting from reef sinkage into the soft sediment, compaction due to shell re-working, and sedimentation. Oyster and other invertebrates were analyzed in alternative structural equation models posed *a priori* to determine the important factors affecting reef development.

Oysters, primarily *Crassostrea virginica*, colonized and grew on created reefs at different rates depending on location in the St. Lucie River estuary. Sites varied in mean salinity from 10 to 30 psu depending on location within the estuary. Structural equation modeling indicated that mean salinity had no effect on oyster abundance but that increasing variability in salinity had a moderate negative impact. During most of the study (2009-2011) drought conditions prevailed which produced low runoff. In wet years, mean salinity will probably have a drastic negative effect on oysters. Variability in chlorophyll a, used as a proxy for oyster food source, also had a negative impact on oysters. SET analysis indicated that despite rapid initial elevation loss (>10 cm in 8 months), reef development by oyster and mussel colonization and growth was eventually able to keep up with subsidence and sedimentation.

The reef invertebrate community developed rapidly and total abundance at some sites reached >14,000 animals/m2. The sessile reef formers were dominated by oysters and several species of mussels, with barnacles and ascidians also abundant at times. Motile species were dominated by polychaetes and amphipods, although larger decapod crabs and shrimp were abundant as well.

An structural equation model of water quality over a longer period (2000-2011) indicated that salinity and nitrogen were primary drivers of chlorophyll a, and that these were linked to canal flow, distance from inlet, and ultimately to rainfall patterns.

<u>Contact Information</u>: Edward Proffitt, Florida Atlantic University, 5775 Old Dixie Hwy, Ft. Pierce, FL 32968; United States; PH: 772-242-2207; EMAIL: cproffit@fau.edu

ENVIRONMENTAL CHARACTERISTICS OF *CICUTA VIROSA* HABITATS

Cha Jeong Shin, *Jong Min Nam* and *Jae Geun Kim*
Seoul National University, Seoul, Republic of Korea

The population of *Cicuta virosa*, a water hemlock known as a perennial herb native to northern and central Europe, northern Asia and northwestern North America has decreased in Korea, where is a southern marginal area, and became an endangered species. To conserve and restore habitats of this plant, we tried to identify environmental characteristics of this plant: water depth, pH, temperature, conductivity, dissolved oxygen and concentration of NO^3-N, NH^4-N, PO^4-P, K^+,Ca^{2+}, Na^+,Mg^{2+} in water and soil texture, water contents, loss of ignition, pH, conductivity, concentration of NO^3-N, NH^4-N, PO^4-P, K^+,Ca^{2+}, Na^+,Mg^{2+} in soil. Total ranges of environmental characteristics were wide and overlapped with the optimal range of environmental characteristics of accompanying species. Water depth and competitive interaction with accompanying species through seasonal change of water depth were important factors for the population size of *C. virosa*. There are three types of environments based on water depth and companion species. First type is 0~5cm water depth abandoned rice field emerged with *Persicaria thunbergii*, and ion concentrations and conductivity in water are at relatively medium and stable. Second one is 10-15cm water depth streamlet with *Phragmites japonica,* and ion concentrations and conductivity in water are at relatively low and stable. The last type is 0-5cm water depth floating mat in 60cm water depth reservoir with *Zizania latifolia* and ion concentrations and conductivity in water are at relatively high and seasonally changing very high. The floating mat as *C. virosa*'s habitat was made of undecomposed plant matters. Floating mat makes *Cicuta virosa* to have stable habitats in highly unstable reservoir where water level is highly changing seasonally and to avoid strong competition with other plants. These results suggest that we can create *Cicuta virosa* habitats in warm and low area in Korea.

Contact Information: Cha Jeong Shin, Department of Biology Education, Seoul National University, Seoul 151-748, Republic of Korea, Phone: +82-2-880-9077, Email: s960283@snu.ac.kr

CLAM BAY NATURAL RESOURCE PROTECTION AREA (NRPA) BENTHIC HABITAT ASSESSMENT

Kathy Worley and *Jeffrey R. Schmid*
Conservancy of Southwest Florida, Naples, Florida, USA

Clam Bay Natural Resource Protection Area, located on the coast of southwest Florida, consists of ~243 ha. of bay and mangrove preserve. The objectives were to perform comprehensive mapping of benthic habitat distributions in Clam Bay; analyze benthic habitat compositions relative to the geographic location; and to perform a visual survey of any benthic species utilizing mangrove prop roots. Systematic benthic sampling was used to characterize sediments and biological assemblages and their distribution within the Clam Bay system.

Substrate is an important abiotic factor influencing the spatial and temporal distribution of estuarine benthic communities. Mud was the dominant substrate in the northern and southern portions of Clam Bay. This is consistent with other mangrove dominated estuaries as mangroves tend to facilitate the deposition of fine sediments leading to high rates of accumulation of organic muddy material in the back bays of an estuary. A geographic gradient of sediment types existed within Clam Bay. Areas farther from Clam Pass consisted primarily of mud substrates; while those areas closer to the pass were primarily composed of sand and shell substrate. Muddy sand and sandy mud dominated the Upper Tributary and Inner Clam Bay.

Seagrasses were found primarily on muddy sand and sand substrates, only in Lower Clam Bay. *Halodule beaudettei* was the most prevalent species. Previous seagrass studies suggest that the spatial distribution of seagrasses in Clam Bay has persisted over the last 30 years, albeit seagrass species and extent of coverage have changed throughout the years. Seagrass coverage in all likelihood declined in Clam Bay between 1990 and 1996. Causes for this decline are speculative and could include physical environmental changes such as increased turbidity, salinity extremes and/or biological factors such as eutrophication during 1995-1996, when the Pass was closed. Alternatively, the decline could be the result of a gradual increase in muddy, fine-grained sediments that do not favor seagrass establishment. *Halodule beaudettei* has been the most prevalent, both spatially and temporally, and this species tolerance to environmental variability may explain its persistence in Lower Clam Bay.

Polychaetes dominated Inner and Lower Clam Bays and were primarily associated with muddy and sandy substrates. Bivalves, primarily shells of *Tagelus plebeius* and *Crassostrea virginica*, were more commonly collected than gastropods such as *Bittiolu varium*. These gastropods seemed to have a preference for sandy substrate, which could explain their presence primarily in the upper reaches of Lower Clam Bay. Echinoderms including *Moira atropos* and *Ophiophragmus filograneus* were primarily found in Lower Clam Bay in muddy substrates.

Estuaries are threatened by anthropogenic disturbance and pollution. Clam Bay has proved to be somewhat resilient over the years, although indications of stress such as seagrass decline and mangrove die-backs are evident. The question that arises is whether or not impacts of anthropogenic disturbance (in combination with natural stressors) could impact the estuary to the point where the original community structure is unable to rebound. To this end, estuarine management becomes increasingly important and must balance multiple ecological and anthropogenic objectives.

Contact Information: K. Worley, Conservancy of Southwest Florida 1450 Merrihue Drive, Naples, FL. 34102 USA,
Phone: 239-403-4223; Fax: 239-262-5872, Email: kathyw@conservancy.org

BIODIVERSITY - VEGETATION

BIRD PERCHES AS A TOOL TO RESTORE VEGETATION IN NEOTROPICAL GRASSLAND DOMINATED BY EXOTIC GRASS

João Carlos B. da Silva[1], *João B. Campos*[2] and *José F. Cândido-Jr.*[3]
[1]Universidade Estadual de Maringá, Maringá, PR, Brasil
[2]Secretaria de Estado de Meio Ambiente e Recursos Hídricos – SEMA, Curitiba, PR
[3]Universidade Estadual do Oeste do Paraná, Cascavel, PR, Brasil

The upper Paraná River basin, located in South Brazil, presents high biological diversity in a heterogeneously habitat matrix. The lotic remnant of this basin was transformed in a Federal Protected Area, along with a National Park (Ilha Grande) and a State Park (Ivinhema), all created purposing to protect this unique environment. However, humans have altered several of its habitats, mostly due to the removal of the native vegetation to conduct ranching (pasture) activities; now these areas are abandonment grassland.

Seed dispersal has been considered as one of the most important factors on restoration. However, not less important, the local characteristics have been shown as the most expressive factor on restoration. For example, biological and chemical composition of soil are strong barriers in restoration processes. Therefore, the seedbed (removal of grass) may have an important role in this process. Since the study area is dominated by exotic grass *Urochloa humidicola* (Rendle) Morrone & Zuloaga, the following two hypotheses were tested; (i) the presence of exotic grass prevents germination and establishment of young plants (ii); and artificial perches increase germination and establishment as a consequence of increased seed rain. To test these hypotheses, we evaluate the restoration process in old fields, using artificial perches and grass removal, with monthly sampling during one year of seed rain (sampled with seed traps), germination and plant establishment. Samplings were conducted as an experimental approach, in which we used five treatments (comparing removal of grass, bird perches and both together; seed rain), every one we took four replicates in circular (1.5 m radius, 5 m apart) plots. Data were analyzed with Repeated measures ANOVA.

In the artificial perches, we observed 36 bird species, mostly insectivorous birds that occasionally may eat some fruits. In the installed seed traps, we collected 155 fecal samples, of which, 10,059 seeds were removed from 10 species and six morphospecies, with a clear dominance of *Cecropia pachystachya* Trecúl. Most of the seeds were zoochorous plants and were in earlier successional stages. The species that germinated and became established during the study period were mainly herbaceous and shrubs, with little contribution of trees and lianas.

The natural regeneration in the monitored plots, we registered 24 species representing 11 families, with dominance of four species. Richness and abundance were significantly different depending on the treatment and on time. Our results showed that the exotic grass in the treatments had a significant effect in seed establishment. All treatments without exotic grass had greater abundance and richness of germinated plants. However, even when the treatments had no exotic grass, the presence or absence of bird perches did not show significant differences in the treatments. The grass cover from *Urochloa humidicola* clearly limited seedling germination and establishment of young plants in the area, and also blocked the beginning of succession and restoration. However, the use of artificial perches did not contribute to augment germination and establishment as a consequence of the increased seed rain in grassland without seedbed.

Contact Information: João Carlos Barbosa da Silva, Universidade Estadual de Maringá, Departamento de Biologia, Programa em Ecologia de Ambientes Aquáticos Continentais, Bloco G90, SALA 06, Avenida Colombo, 5790, Jardim Universitário, 97.020-900 Maringá- PR, Brasil. Phone 55-44-3011-4633 Email: jc.ornito@gmail.com

FIRST REPORT OF *RHIZOPHORA RACEMOSA* (RHIZOPHORACEAE) IN THE WIDER CARIBBEAN REGION

Maria B. Barreto and *Eduardo Barreto-Pittol*
Universidad Central de Venezuela, Caracas, Venezuela

The genus *Rhizophora* is the most common of the three genera found in worldwide mangrove forests. In the Atlantic-Caribbean-Eastern-Pacific (ACEP) region, three species of the genus have been recognized: *R. mangle* L., *R. harrisonii* Leechm. and *R. racemosa* G.Mey.

The presence of *R. racemosa* in the Cariaco River and the Gulf of Santa Fe represents a new finding for the Venezuelan Caribbean coast and broadens the distribution of the species in the ACEP region. The restricted distribution of *R. racemosa* along the more humid areas of the Pacific coast and along South America's eastern coast from Brazil to Venezuela can be explained by the reduction of its range during the Miocene-Pliocene, and more recently during the last glacial period.

Two possible pathways for the recent dispersal and colonization of *R. racemosa* throughout Venezuela's eastern Caribbean coast could explain the actual distribution. First, through an ancient channel connecting the gulfs of Paria and Cariaco, and second, by migration and dispersal along the northern coast of the Paria and Araya Peninsulas from South American Atlantic coast.

Contact Information: Maria B. Barreto, Laboratorio de Ecologia de la Vegetacion, Instituto de Zoologia y Ecologia Tropical, Facultad de Ciencias, UCV, Caracas 1041A, Venezuela; Phone: (58) 212-605-1408, Fax: (58) 212-605-1204, Email: maria.barreto@ciens.ucv.ve

THE IMPACT OF SURROUNDING LAND USES ON PLANT SPECIES RICHNESS IN FLORIDA WETLANDS

Valerie A. Burkett
University of Florida, Gainesville, FL, USA

As urban areas expand, their influence on natural areas increases. Roads lead to habitat fragmentation, but also act as seed dispersal mechanisms. Manicured lawns and agricultural areas are a source of nutrients as well as pesticides. Increases in impervious surfaces add to heat retention, less infiltration and increased runoff to surrounding waterbodies. These factors as well as others can impact the biodiversity (richness) of nearby wetlands. Determining whether urbanization has a positive or negative impact on plant species richness of Florida wetlands could have important implications for policy and management.

Plant species richness was surveyed during the National Wetland Condition Assessment (NWCA). The NWCA is a nationwide evaluation of U.S. wetlands, including the conterminous states and Alaska. As part of the NWCA, 67 wetlands in Florida were randomly chosen from across the state and evaluated in assessment areas (AA) of 0.5 ha. Plant species were surveyed in five 10 m X 10 m plots for each AA. The richness of each plot was averaged together to determine a site mean.

The species richness of each wetland was compared to the Landscape Development Intensity (LDI) index of the surrounding land uses in order to determine the relationship between plant biodiversity (richness) and urbanization. The LDI index calculates the energy intensity of a land use type, with more developed areas having higher values than rural ones. This provides a method for calculating the human disturbance of a landscape. This comparison of species richness to LDI was made for several wetland types, including palustrine forested, emergent, and scrub/shrub as well as estuarine intertidal emergent and shrub/forested wetlands.

Contact Information: Valerie A. Burkett, Howard T. Odum Center for Wetlands, University of Florida, 102 Phelps Lab, Museum Road, Gainesville, FL 32611, Phone: 352-392-2424, Fax: 352-392-3624, Email: vburkett07@gmail.com

PREDATION AND PRODUCTIVITY GRADIENTS AFFECT ARTHROPODS, HERBIVORY AND PLANT ARCHITECTURE IN MANGROVE FORESTS

Alexander J. Forde[1], *Ilka C. Feller*[2], *Daniel S. Gruner*[1] and *John D. Parker*[2]
[1]Entomology Department, University of Maryland, College Park, MD, USA
[2]Smithsonian Environmental Research Center, Edgewater, MD, USA

Top-down effects of predators and bottom-up effects of inorganic nutrients are known to be important determinants of community structure and ecosystem function in many aquatic and terrestrial habitats. However, general, cross-system conclusions regarding the independence and relative importance of predator and nutrient effects are lacking. Mangrove forests often exhibit coupled productivity and biochemical gradients and host populations of insectivorous vertebrate predators (known to cause trophic cascades in other habitats). Therefore, these systems provide an excellent opportunity to experimentally investigate the relative importance and interactivity of predator and nutrient effects. While nutrient availability is known to affect productivity and plant-herbivore interactions in mangrove forests, the ecological significance of predators in these threatened systems is less clearly understood.

We investigated the relative and interactive effects of predators and abiotic factors on plants and arthropods by excluding vertebrate top predators (birds and bats) from *Rhizophora mangle* (red mangrove) canopies across natural productivity gradients caused by nutrient-limitation. We constructed $1m^3$ PVC frames around entire small, slow-growing trees (situated in highly nutrient-limited, relatively unproductive areas) and around individual branches of comparable size from large, fast-growing trees (situated in nutrient-rich, productive areas) on two islands off the coast of Belize. Half of these frames (n=20) were covered with propylene netting to exclude vertebrate top predators while the rest served as controls. Data on arthropod presence, herbivory and branch growth were collected periodically over 16 months.

Arthropod density increased and herbivore damage inflicted on leaves and buds was greater in the absence of predators as well as in more productive areas. Top-down and bottom-up influences had impacts of similar magnitude on most responses and interactive effects were not strongly supported. While the exclusion of predators did not affect branch elongation or leaf production, it did significantly alter the architecture of branches. Branch architecture was less complex (fewer segments per total length) in the absence of predators, and also less complex in more productive areas. Predators likely affected the architecture of mangrove trees by reducing herbivory on apical buds, from which new branch segments are produced.

<u>Contact Information</u>: Alexander J. Forde, University of Maryland, Department of Entomology, 4112 Plant Sciences Building, College Park, MD 20742, Phone: 651-208-3043, Email: fordealex@gmail.com

MANAGED DISTURBANCE ENHANCES BIODIVERSITY OF RESTORED WETLANDS IN THE AGRICULTURAL MIDWEST

Anya M. Hopple and *Christopher B. Craft*
School of Public and Environmental Affairs, Indiana University, Bloomington, Indiana, USA

We compared plant diversity in four restored and four natural wetlands in the glaciated interior plains to evaluate how quickly plant biodiversity develops following cessation of agriculture and reintroduction of wetland hydrology. After approximately ten years, restored wetlands had alpha and beta richness comparable to natural wetlands; 6.2 $\pm$ 0.5 species per plot and 33.8 $\pm$ 2.3 species per site for restored wetlands versus 5.5 $\pm$ 1.3 species per plot and 27 $\pm$ 6.4 species per site for natural wetlands. The natural wetlands, however, contained higher quality plant communities based on greater abundance of hydrophytic plant species (OBL, FACW, and FAC) and species with higher Coefficients of Conservatism (C of C). There was no difference in the Floristic Quality Assessment Index (FQAI) values for natural and restored wetlands.

A record of the seed mixture applied to one restored wetland was available. Seventy-six percent of the species documented during sampling had naturally colonized the site, while the remaining 24 percent colonized from the seed mixture. Species that naturally dispersed to the site included more opportunistic (20%) and tolerant (44%) species than those introduced through the seed mixture, which contained no opportunistic and fewer tolerant (2%) species. Species that naturally established on the site also contained a greater abundance of drier (FAC and FACU) species than species that colonized from the seed mixture.

The comparable alpha and beta diversity of restored wetlands is attributed to the use of management tools (such as seeding, prescribed burning, and herbicidal treatments) during restoration that enhance species richness and diversity and shorten the time required for the plant community to converge with levels in natural wetlands. Further investigation of active management techniques is needed to better understand how they can contribute to the restoration of a diverse assemblage of wetland vegetation.

Contact Information: Anya M. Hopple, School of Public and Environmental Affairs, Indiana University, Bloomington, IN 47401 USA, Phone: 812-856-7491, Fax: 202-354-4810, E-mail: ahopple@indiana.edu

FLORISTIC VARIATION ACROSS 600 KM OF INUNDATION FORESTS ALONG THE RIO NEGRO

***Juan Carlos Montero*[1]**, *Florian Wittmann*[2], *Albert Reif*[1] and *Maria Teresa Piedade*[3]
[1]Institute of Silviculture and Vegetation Science, University of Freiburg, Germany
[2]Max Planck Institute for Chemistry and Biogeochemistry, INPA/Max Planck Project, Manaus, Brazil
[3]National Institute for Research in the Amazon (INPA), Manaus, Brazil

The Negro River (NR) is the largest black-water river in the world and one of the main tributaries of the Amazon. The waters of the NR are very acidic and carry low quantities of suspended matter, but contain high concentrations of humic acids being responsible for the particular dark brownish color. Igapó, the black-water inundation forests occur all over the main river channel and most of its tributaries. Due to precipitation seasonality and low inclination of most parts of its catchment and the river course, the NR is mostly governed by a predictable, monomodal flood-pulse. Flood amplitudes range from 3.6 m at the upper reach to 9.3 m near its lower reach, and subject the floodplain vegetation to periodical inundations lasting from 50 to 230 days year^{-1}. The variable flooding regime may determine tree species composition and diversity patterns along the river channel and are considered important factors influencing the spatial distribution of tree communities. However, despite the large extent of the NR and its ecological importance, only few quantitative floristic inventories have been carried out in igapó forests. In particular, little is known about the floristic variation along the course of the river.

We present a quantitative inventory of 10 hectares (160 x 625m^2) on late-succesional inundation forest distributed in three river sections and a tributary river across a 600 km long corridor of the NR within Brazilian territory. We provide a descriptive account of the floristic variation addressing large-scale patterns of tree composition and diversity. Additionally, by compiling studies on igapó and várzea forest along the Amazon and Orinoco basins we compare species richness and alpha diversity. Finally, at continental scale we examine diversity gradients along geographical locations and geological zones. Specifically, we address the following questions: (1) Is species diversity and composition constant along the course of the river or are there abrupt changes from one site to another exhibiting spatial gradients? (b) How are species richness and alpha diversity of igapó compared to várzea and (c) Can we expect alpha-diversity gradients of igapó forests across geographical locations and geological zones?

Our results suggest that although mean alpha diversity may not consistently differ between river sections, species turnover (beta diversity) is consistently high and significant. The latter is particularly influenced by the species pool of the tributary river which displays abrupt floristic discontinuities. Continental-scale comparisons of species richness and alpha diversity revealed that the igapó forest of the NR is one of the poorest forest types in the Neotropics and compared with várzea the poorest inundation forest in the Amazon. Our results also show a slight trend of increasing diversity in an east to west gradient. When overlapping plots on geological zones we found a gradual decrease of alpha diversity while increasing the age the geological formations. The floristic data presented is the first on blackwater inundation forest based on an extensive quantitative dataset. The results, therefore, contribute essential Information for the classification and management of Amazonian floodplains.

Contact Information: Juan Carlos Montero, Institute of Silviculture and Vegetation Sciences, University of Freiburg, Tennenbacher Str. 4 79085 Freiburg, Germany; Phone: 049 (0)761-203-3683; Email: carlos.montero@waldbau.uni-freiburg.de

DECLINING SPECIES RICHNESS AND RESTORATION POTENTIAL OF AQUATIC PLANTS IN JAPANESE LAKES

Jun Nishihiro and *Munemitsu Akasaka*
Graduate School of Agricultural and Life Sciences, University of Tokyo, Tokyo, Japan

Aquatic macrophytes play a vital role in the maintenance of biodiversity and functioning of lake ecosystems. The amount and diversity of aquatic vegetation of many lakes throughout the world, however, have been reduced by various anthropogenic impacts, including land reclamation, water pollution, eutrophication, and water-level alterations. Also, in Japan, 52, 45, and 55% of the native submerged, floating-leaved, and free-floating plants are now listed in the national Red List, respectively. Thus, the scientific monitoring of remnant vegetation and assessment of restoration potential of lake macrophytes are important themes for conservation and management of lake ecosystems. In our study, temporal changes in taxon richness of macrophytes (submerged, floating-leaved, and free-floating plants) were analyzed from ten Japanese lakes in which flora records are available covering the last 60 years. In addition, the recovery potential of locally extinct taxa was analyzed using data from soil seed banks in lake bottom sediments, which are recognized as a promising source for restoration.

Among the ten lakes analyzed, a marked decline in taxon richness was observed, and 50% or more of the past flora had disappeared between the 1970s and 1990s in six of these lakes. In Lake Kasumigaura, for example, the second largest lake in Japan (170.57 km^2 water surface), 31 macrophyte taxa were recorded in the 1970s but in the 1990s, only 13 were recorded. In Lake Hinuma (9.35 km^2), only one of 14 species recorded in 1971 was recorded in 1999. A species decline was also recognized in lakes located in Ramsar wetlands; e.g., although 26 macrophyte taxa were recorded in 1990–1991, only four taxa were found in 2001 in Lake Toro (6.37 km^2) in the Kushiro Mire.

Recent soil seed bank data were available for two lakes, Lake Kasumigaura and Lake Inba-numa (11.6 km^2). Analyses of the relationship between the presence or absence of viable seeds in the seed banks since 2000 and time of disappearance from aboveground vegetation for each species revealed that more than 50% of taxa which had disappeared in the 1990s were remained in the seed banks. For taxa that had disappeared in the 1970s or before 1969, however, 29–38% or 0%, respectively, were present in the seed bank records. These results suggest that the potential for recovery of locally extinct aquatic macrophytes from soil seed banks rapidly decreases with time. Furthermore, recovering taxa that had disappeared more than 30 years ago might be difficult. Considering that taxon richness had rapidly decreased since the 1970s, efforts for restoration of aquatic vegetation from soil seed banks and "conservation of soil seed banks", which can be achieved through plant regeneration from seeds and production of new seeds, are now very urgent tasks for restoring the majority of Japanese lakes.

The present study was supported by the Environmental Research and Technology Development Fund (S9) of the Ministry of the Environment, Japan.

Contact Information: J. Nishihiro, Graduate School of Agricultural and Life Sciences, University of Tokyo, 1-1-1 Yayoi Bunkyo Tokyo, 113-8657, Japan, Phone: +81(0)3-5841-8915, Fax: +81(0)3-5841-8916, Email: ajn@mail.ecc.u-tokyo.ac.jp

PLANT ECOPHYSIOLOGY IN TROPICAL FRESHWATER WETLANDS ON THREE CONTINENTS

Pia Parolin[1] and *Cátia Nunes da Cunha*[2]
[1]University of Hamburg, Germany
[2]INAU Cuiabá, Brazil

Plant ecophysiology in tropical wetlands is still poorly understood. Despite the ecological and economical importance of plants growing in tropical wetlands, the ecology and functional diversity has been studied only in few selected species. Single species show very high tolerance to flooding and/or drought, and various responses to the big hydric differences they are subjected to in the annual cycle. However, it is not known whether these mechanisms are common to most species within a tropical wetland, or even between wetlands across continents. In order to highlight the status quo and the major needs for future research, available data of plant growth, phenology, photosynthetic performance, seedling recruitment etc. is brought together in a comparative review of major freshwater wetlands on three continents, (i) Amazonian floodplains and the Pantanal in South America, (ii) the Okavango delta region in Africa, and (iii) the Mekong floodplains of Asia. They all have a predictable “flood pulse” as major driving force influencing all living organisms in the flood plain, however also as source of stress for which specialized adaptations for survival are required. The little available data show that e.g. morphological adaptations and phenological responses to the flood are somehow similar in the three ecosystems. Many species respond with partial or complete leaf shedding. Floodplain trees are found to have active sap flow for most of the year and their growth is not inhibited by the flooding. This growth depends on adequate carbohydrate supplies and physiological adaptations. Seedlings are highly tolerant of waterlogging or even submergence. For floodplain conservation, more Information is needed on regeneration requirements, wood productivity and non-timber products, preferably generated using reproducible comparative methods. In the light of climatic change, with increasing drought or extreme flood events, decreased groundwater availability and changes of flooding periodicities, this knowledge is needed ever more urgently to facilitate fast and appropriate management responses to large-scale environmental change.

Contact Information: Pia Parolin, University of Hamburg, Dept. Biology, Biodiversity of Plants, Ohnhorststr. 18, 22609 Hamburg, Email: pparolin@botanik.uni-hamburg.de

VEGETATION PATTERNS IN PRIOR CONVERTED, RESTORED, AND REFERENCE WETLANDS IN THE U.S. MID-ATLANTIC COASTAL PLAIN

Metthea M. Yepsen[1], *Andrew H. Baldwin*[1], *Eliza McFarland*[2], *Marina LaForgia*[2] and *Dennis F. Whigham*[2]
[1]University of Maryland, College Park, MD, USA
[2]Smithsonian Environmental Research Center, Edgewater, MD, USA

Vegetation response to changes in management, physical disturbance, and environmental conditions is a useful parameter for comparing wetlands that have experienced different degrees of alteration. Furthermore, vegetation composition, structure, and productivity are integral to many other wetland functions. As part of a multi-investigator project to assess the effectiveness of USDA-NRCS conservation measures in agricultural lands, we assessed vegetation in farmed wetlands (termed "prior-converted croplands" by NRCS) and restored wetlands compared to reference wetlands. A major goal was to assess the role of dispersal versus planting in the establishment of vegetation in restored wetlands. Fifty-seven depressional wetlands across the coastal plain of Maryland, Delaware, Virginia, and North Carolina were studied. Each site was visited during the 2011 growing season and quadrats were used to sample vegetation composition and biomass. An Anthropogenic Activity Index (AAI) worksheet was completed to assess the level of disturbance at each site. Preliminary results and field observations indicate that there is little overlap in the species composition across the three wetland categories. Vegetation composition and biomass were highly variable among sites. Farmed wetlands had few native species. Restored wetlands had the highest diversity of herbaceous species, indicating a major contribution from dispersed seeds despite the hydrologically and geographically isolated position of these wetlands. Aboveground biomass of herbaceous species differed between farmed (723 gm^{-2}), restored (430 gm^{-2}) and natural (118 gm^{-2}) wetlands. Woody vegetation was only present in the reference sites and the oldest restored sites, now ranging from 16-25 years since restoration. Results from this research will be used to assess wetland conservation and management practices in agricultural lands in the U.S. mid-Atlantic region and support national models designed to influence management of wetlands in agricultural landscapes.

<u>Contact Information</u>: Metthea M Yepsen, Department of Environmental Science and Technology, Animal Sciences Bldg., University of Maryland, College Park, MD 20742 USA, Phone: 610-401-6166, Email: myepsen@umd.edu

ROOT RELEASE OF ORGANIC CARBON AND NUTRIENT UPTAKE BY THREE EMERGENT WETLAND PLANTS

Xu Zhai and *Hans Brix*
Aarhus University, Department of Bioscience, Aarhus, Denmark

The most important N removal pathway in constructed wetlands is the sequential biochemical processes of nitrification followed by denitrification. Endogenously derived dissolved organic carbon (DOC) in root exudates from plants may provide the denitrifying bacteria with energy for the denitrification process and hence stimulate the conversion of nitrate (NO_3) into N_2 gas. In this study we quantified the amount of DOC released from roots of three wetland species, *Phragmites australis*, *Iris pseudacorus* and *Juncus effusus*, which are commonly used in constructed wetlands. Furthermore, we studied the effect of temperature and light-regime on the DOC release in root exudates. Finally, we discussed the relationship between nutrient uptake and DOC release by wetland plants.

Six hydroponically grown plants of each species were placed with their roots suspended in 1.4 liter black glass vessels containing DOC-free nutrient solution. The plants were placed in two growth chambers with different temperature (T1=10℃, T2=20℃). The light-regime in the growth chambers was a 14:10 h light: dark cycle for 5 days, followed by continuous light (24 h light) for 5 days, and complete darkness (0 h light) for 5 days. Six glass vessels without plants served as controls. The DOC release rates of each individual plant during each treatment were quantified from the increase in DOC concentration in the nutrient solution. DOC was analyzed by a Shimadzu TOC-V analyzer. Plants uptake rate of NH_4-N, NO_3-N, PO_4-N and K were estimated by the rate of depletion in growth solution during the incubation.

The average DOC release rates were highest for *I. pseudacorus* (12.2±4.1 μg g^{-1} root dry weight h^{-1}) and higher at 20°C (10.2±4.9 μg g^{-1} root dry weight h^{-1}) than at 10°C (6.7±4.9 μg g^{-1} root dry weight h^{-1}). Light stimulated the DOC release as plants in the two treatments with light had two times higher DOC release rates (10.4±4.7 μg g^{-1} root dry weight h^{-1}) than plants in the dark (5.7±4.7 μg g^{-1} root dry weight h^{-1}). The DOC release rates were positively related to relative growth rate and nutrient uptake rate, particularly for *J. effusus* DOC release rate was significant (*$p<0.05$*) positively related to relative growth rate (RGR) and the nutrient uptake rate including NH_4-N, NO_3-N, PO_4-P and K. Extrapolating the laboratory measurements to field conditions suggests that plant root exudates may potentially deliver organic carbon to support denitrification rates in constructed wetlands of 2 to 88 kg N per ha per year.

Contact Information: Xu Zhai, Department of Bioscience, Aarhus University, Ole Worms Allé 1, Building 1135, 8000 Aarhus C, Denmark, Phone: +45 87156583, Fax: +45 87154302, Email: zhai.xu@biology.au.dk

BIODIVERSITY – WILDLIFE

A COMPARATIVE EXAMINATION OF WITHIN WETLAND AND WETLAND CONTEXT CHARACTERISTICS ON STOPOVER HABITAT USE BY MIGRATORY SHOREBIRDS: IS THE NEIGHBORHOOD IMPORTANT?

Gene Albanese and *Craig A. Davis*
Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK, USA

Wetland stopover use by migratory shorebirds is concurrently influenced by habitat characteristics present within a stopover and characteristics related to the broader context surrounding the stopover. In order to conserve the stopover habitats essential for shorebirds to complete migration through the interior of North America, it is necessary to have an understanding how these factors influence stopover use. We conducted surveys of wetland stopover habitats within ten broad-scale landscapes in north-central Oklahoma from 2007 thru 2009 to determine how intra habitat and habitat context characteristics influence the abundance of migrating shorebirds within wetland stopovers. We used zero-inflated modeling and an Information theoretic framework to separately examine and then compare the relative importance of intra habitat variables and habitat context variables in explaining the differential use of wetland stopovers. Among intra habitat variables, we found that shorebirds stopover in greater abundance in large wetland habitats that were sparsely vegetated with shallow slopes. Among habitat context variables, shorebird abundance increased with shorebird habitat density at a 1.5 km scale and grazing intensity. Land cover context was also important in explaining shorebird abundance. When compared to the models with intra habitat variables, models containing habitat context variables better explained migratory shorebird abundance. We conclude that characteristics related to the broader context surrounding a wetland stopover strongly influence stopover use by migratory shorebirds. Conservation and management of migratory shorebirds should aim to provide large, sparsely vegetated and shallow sided wetland stopover habitats in an open land context within areas of high-density shorebird habitat.

Contact Information: Gene Albanese, Division of Biology, 211 Leasure Hall, Kansas Cooperative Fish & Wildlife Research Unit, Kansas State University, Manhattan, KS 66502 -0102, Phone: 405-334-8295, E-mail: albanese@KSU.edu

BROAD-SCALE RELATIONSHIP BETWEEN SHOREBIRDS AND LANDSCAPES IN THE SOUTHERN GREAT PLAINS

Gene Albanese and *Craig A. Davis*
Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK, USA

It is well established that patch-level habitat characteristics affect the use of stopover sites by migrating shorebirds, however, it is also essential to assess the broad-scale factors that influence the use of stopover habitat. We conducted surveys of ten 10-km radius landscapes in north-central Oklahoma from 2007 thru 2009 to determine how the composition of wetland habitats and peripheral land cover types influence shorebird diversity and abundance during migration. We categorized wetland habitats by inundation period and wetland type. We used generalized linear modeling and an Information theoretic framework to identify the models and wetland habitats that best explained the observed abundance and diversity patterns of five different shorebird groups, which we based on breeding status and migration distance. We found that migratory shorebird abundance and diversity increased with the wetland habitat within the landscape regardless of the amount of other semi natural and developed land cover. Furthermore, the response of shorebirds to the landscape composition of different wetland types varied with migration distance and breeding status. Generally, the landscape area of riverine and ephemeral floodwater habitats were important predictors of migratory shorebird abundance and species richness. Abundant ephemeral floodwater habitats were particularly important to intermediate and long distant migrant shorebird abundance and diversity. We conclude that landscape-level studies can provide important additional insights on the en route habitat use of migratory shorebirds. We recommend that conservation priority be given to landscapes that include abundant riverine habitats with a large compliment of potential ephemeral floodwater habitats.

Contact Information: Gene Albanese, Division of Biology, 211 Leasure Hall, Kansas Cooperative Fish & Wildlife Research Unit, Kansas State University, Manhattan, KS 66502 -0102, Phone: 405-334-8295, E-mail: albanese@KSU.edu

AVIAN AND ANURAN COMMUNITIES IN MITIGATED AND REFERENCE WETLANDS OF WEST VIRGINIA

Ann M. Anderson and *James T. Anderson*
West Virginia University, Morgantown, WV, USA

Wetlands provide valuable habitat for numerous wildlife, invertebrate, and plant species. Moreover, wetlands provide numerous other ecological services such as flood mitigation, storm abatement, nutrient cycling, aquifer recharge, improving water quality, and providing timber and other merchantable products. However, the loss and degradation of wetlands across the United States has caused population declines of some fish, shellfish, furbearing mammals, waterfowl, and amphibians that rely exclusively on these areas for survival. Moreover, the ability of watersheds to provide ecosystem services such as clean water, nutrient processing, and flood storage is being hampered by the loss of wetlands in these watersheds. The Clean Water Act of 1972 was the first major legislation that protected our nation's wetland resource base, but it was not until the "no net loss" policy of the late 1980s that the government actively sought to mitigate for these losses that have impacted wetland-dependent wildlife across the country. Under the new policy, thousands of hectares of wetlands have been constructed to compensate for wetland destruction. Monitoring of these mitigated wetlands is required to ensure that the proper wetland structure, processes, and functions occur in the created or restored wetlands. The Corridor H Highway project, which broke ground in 2000, involves the construction of 238 km of highway linking the interior of West Virginia with northern Virginia. During construction, 49 ha of wetlands were impacted and required mitigation. To mitigate for those losses, 3 large wetland complexes were constructed. The overall goal of this project was to compare the function and structure of mitigation wetlands associated with Corridor H with natural reference wetlands to better understand the structure and function of mitigated wetlands. Herein, we specifically focused on evaluating avian and anuran species composition and anuran reproduction in mitigated and reference wetlands. Avian species richness, diversity, and abundances based on point counts did not differ between mitigated and reference wetlands, but indices were higher in 2009 and 2010 than in 2001. Avian communities were represented by 104 species, primarily early successional passerine species including Red-winged Blackbirds (*Agelaius phoeniceus*), Song Sparrows (*Melospiza melodia*), Common Yellowthroats (*Geothlypis trichas*), Gray Catbirds (*Dumetella carolinensis*), Yellow Warblers (*Dendroica petechia*), Eastern Towhees (*Pipilo erythrophthalmus*), and Indigo Buntings (*Passerina cyanea*). Overall anuran (frogs and toads) call surveys indicated that total abundance, richness and diversity and pickerel frog (*Lithobates palustris*) abundance and calling index were higher in mitigated than in reference wetlands. However, relative abundances for the other 6 species did not vary between mitigated and natural wetlands ($P > 0.05$); although eastern American toads (*Anaxyrus americanus*) were greater than 3 times more abundant in reference than in mitigated wetlands. Dipnet surveys for larval amphibians supported results from the call surveys. Anuran abundance varied over years and among individual wetlands with no strong consistent increasing or decreasing trends overall. Overall, the mitigated wetlands in our study appeared to function similarly to natural reference wetlands in regards to providing habitat for amphibian and avian species. More importantly our results suggest that habitat succession appears to be structuring wildlife communities in mitigated wetlands over time.

Contact Information: James T. (Jim) Anderson, Environmental Research Center, West Virginia University, PO Box 6125, Morgantown, WV 26506-6125 USA, Phone: 304-293-3825, Fax 304-293-2441, Email:jim.anderson@mail.wvu.edu

WADING BIRD FORAGING TRADE-OFFS IN RESPONSE TO THE PRODUCTION AND CONCENTRATION OF PREY

***James M. Beerens*[1]**, *Erik G. Noonburg*[1], *Dale E. Gawlik*[1] and *Douglas D. Donalson*[2]

[1]Florida Atlantic University, Boca Raton, FL, USA

[2]US Army Corps of Engineers, Jacksonville, FL, USA

Wading birds are important indicator species for wetland ecosystems, integrating productivity across trophic levels and over a large landscape scale. However, understanding and predicting wading bird responses to environmental restoration are hindered by their complex behavior. Wading bird habitat selection is influenced by foraging strategy and multiple environmental variables that can change in strength depending on the production and concentration of prey. In the Everglades, populations of species that are visual foragers and tolerate relatively deep water (i.e., Great Egret; exploiter) have disproportionally increased when compared with populations of tactile foragers that require a higher prey density (i.e., White Ibis & Wood Stork; searchers). If differing trade-offs among species between components of prey availability can be identified, we can better understand population trends and predict how communities will respond to restoration.

Locations of foraging Great Egrets, White Ibises, and Wood Storks were obtained from Systematic Reconnaissance Flight daily distribution data from 2000-2009. Temporal models grouped foraging observations over the Greater Everglades landscape to predict daily flock abundance. Spatial models grouped observations over time to determine factors contributing to how often a 400-m cell was used. Multiple explanatory hydrological variables over a range of temporal scales were used as a proxy for prey dynamics. Days since drydown (DSD) quantified long-term prey production dynamics, recession rate quantified 2-week prey concentration dynamics, and daily water depth quantified short-term prey availability. Linear interaction terms evaluated whether the effect of one predictor variable modified the response of another.

For all species, daily flock abundance increases as portions of the landscape with higher DSD become available and are used; an important link to a previous study relating increased small fish density to increasing DSD. This effect is more prominent when Great Egrets and especially White Ibises are using shallower depths. Rapid recession rates (i.e., concentration) play a particularly important role for Great Egrets and to a lesser extent White Ibises by maintaining a foraging response when prey production is limiting. In contrast, concentration promotes Wood Stork foraging under high prey production, but not when prey production is low. Concentration is more important for Great Egrets feeding in shallower depths and White Ibises feeding in deeper depths, likely better accommodating their opposing foraging strategies. When Wood Storks are using deeper depths, prey production has no impact on the foraging response; however, storks forage more frequently when high prey production is available in shallow depths.

These patterns indicate important differences among species in their response to the trade-offs of prey production, concentration, and availability. If the Everglades ecosystem is limiting wading bird populations through the mechanism of prey production and/or concentration it will likely be reflected in these species.

Contact Information: James M. Beerens, Florida Atlantic University, 777 Glades Rd, Boca Raton, FL 33431 USA, Phone: 561-809-9793, Email: J.M.Beerens@gmail.com

TRENDS IN ALLIGATOR BODY CONDITION IN RELATION TO HYDROLOGY IN ARTHUR R. MARSHALL LOXAHATCHEE NATIONAL WILDLIFE REFUGE, FLORIDA USA

Laura A. Brandt[1] and *Frank J. Mazzotti*[2]
[1]U.S. Fish and Wildlife Service, Davie, FL, USA
[2]Department of Wildlife Ecology and Conservation, University of Florida, Davie, FL, USA

Alligators (*Alligator mississippiensis*) are one of the system-wide indicators of ecologic change in the Greater Everglades because of their linkage to hydrologic conditions at various spatial and temporal scales. Alligator body condition is used as a non-destructive measure of an animal's condition based on the relationship between body mass and length (snout-vent length). It can reflect both seasonal and long-term suitability of a wetland and we hypothesize that it is affected by seasonal water depths, longer term hydroperiod, and yearly fluctuations in water level (amplitude). From Fall 1999-Fall 2010 we captured measured, marked, and released alligators ≥ 1.25 m in the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) as part of a larger monitoring project. Over that ten year period we captured 294 alligators, 152 in Fall (September, October, November) and 142 in Spring (March, April, May) and followed trends in seasonal and yearly body condition. There were no differences in Fall (2.07±0.20) and Spring (2.09±0.28) condition; however there were differences between males (2.03±0.21) and females (2.11±0.19). When the entire period of record (1999-2010) was used there was a negative trend in average yearly body condition; however when other increments were used trends were either negative or not present. To better understand where there might be break points in the trends we plotted cumulative Z-scores of average seasonal body condition. We identified a break after Fall 2002 and found that average yearly body condition was 4% higher and less variable from Fall 1999 through Fall 2002 than from Spring 2003 through Fall 2010 ((2.17±0.06 compared to 2.04±0.12). We also compared the average length of time since the marsh dried out between those two time periods and average amplitude (maximum water depth – minimum water depth) in the previous 360 days and found that on average it had been significantly longer since the marsh dried in the first time period (1725 days) compared to the second time period (525 days) and average amplitude was higher (2.31feet compared to 1.60 feet). These results provide support for our hypothesis that alligator body condition is affected by different components of wetland hydrology at different temporal scales.

Contact Information: Laura A. Brandt, U.S. Fish and Wildlife Service, Davie, FL 33314, Phone: 954-577-6343, Fax: 954-475-4125, Email: laura_brandt@fws.gov

ONTOGENETIC, INTERSPECIFIC, AND SEASONAL VARIATION IN PREY USE OF THREE CENTRARCHIDS IN A SUBTROPICAL WETLAND

Jacob W. Bransky and *Nathan J. Dorn*
Department of Biological Sciences, Florida Atlantic University, Davie, FL, USA

Determining which predatory species place consumptive pressures on particular prey species can be important in understanding trophic interactions in real food webs. Generalist predators often occupy similar habitats and consume similar prey making determination of their ecological role difficult. In fishes, physiologically variable factors such as gape size and feeding strategy, or seasonally variable factors such as prey availability or prey size structure may further influence the consumptive impacts. Understanding the importance of these factors can help elucidate important predator/prey interactions in wetland food webs.

We quantified and compared the diets of three generalist Everglades benthivores, the bluespotted sunfish (*Enneacanthus gloriosus* 30-47 mm standard length, SL), the dollar sunfish (*Lepomis marginatus* 30-60 mm SL), and the warmouth (*Lepomis gulosus* 30-152 mm SL) in a shallow freshwater subtropical marsh in two seasons (winter/dry season and summer/wet season) to look for evidence of ontogenetic, interspecific and seasonal variation in diet composition. Of the three species, warmouth reach the largest sizes and have the largest gapes for a given SL. The fish were collected from marshes with trap nets when the water was 40-60 cm deep. Gut contents were analyzed in the lab and multivariate analyses were conducted to compare size classes, seasons, and species (i.e., size-matched by length or gape).

We found evidence of diet ontogeny in warmouth, but not in bluespotted or dollar sunfish. All size classes of bluespotted and dollar sunfish had diets dominated by dipterans, odonates, and other insects. Warmouth prey shifted from odonates, amphipods, and dipterans to fish, shrimp, and crayfish with increasing size in the dry season. Wet season diet shifts were less straightforward and included size-dependent variation in use of vertebrates, shrimp, and large predatory insects. We found evidence of seasonal diet shifts in dollar sunfish and some size classes of warmouth that may have resulted from differences in prey availability following a severe drought and lack of surface water in the marsh between sampling seasons. When the species were matched for standard length we found gape-driven compositional differences between the three species in both seasons with warmouth using larger and/or more mobile prey and the smaller-gaped species using smaller, less mobile prey (e.g., dipterans). When size-matched by gape diet differed between the three species in the wet season, but not the dry season. Declines in availability of certain prey types may provide an explanation for differences in prey use (i.e., multiple species may use an abundant prey item, however more specialized predators may outcompete others when that prey item becomes scarce).

Contact Information: Jacob Bransky, Department of Biological Sciences, Florida Atlantic University, 3200 College Ave., Davie, FL 33314 USA, Phone: 954-236-1539; Fax: 954-236-1099, Email: jbransky@fau.edu

IMPORTANCE OF MANGROVES DURING THE RAINY SEASON FOR THE HERPETOFAUNA

Coral J. Pacheco-Figueroa[1], *Juan D. Valdez-Leal*[1], *Lilia M. Gama*[1], *Eduardo Moguel*[1], *Esmeralda Marcelo*[2] *Erick Estañol*[2] and *Joel Saenz*[3]

[1]DACBiol-UJAT, Villahermosa, Tabasco, México
[2]COVINSE. DACBiol-UJAT, Villahermosa, Tabasco, México
[3]ICOMVIS-UNA, Heredia, Costa Rica

The large extension of wetlands of the Southern coast Gulf of Mexico has certainly promoted the abundance and diversity of species associated with this type of habitats. Fifty three percent of the wetlands of this region are located within the state of Tabasco and almost three percent of them are mangroves that refuge for species like as amphibians and reptiles. However, there are almost no studies regarding these groups on these habitats. The objective was to study the richness, diversity and abundance of amphibians and reptiles in six mangrove fragments among different type of vegetation during the rainy season on the coastal plains of Tabasco from 2009 to 2011. Four transects of 500 m length and 500 m width were established as monitoring stations. Monitoring was performed during three days, twice a day, 9 to12 in the morning and 6 to 9 at night. Diversity was estimated using Shannon-Wiener index, the neighborhood index to quantify the average abundance was estimated taking into account the value of each contiguous fragment and the correlation of the richness and diversity of each station the respective value of neighborhood. Thirty-three species of herpetofauna were recorded for this area (11 amphibians and 22 reptiles), of which 10 species are listed in the species at risk list (NOM-059-SEMARNAT-2010) under different categories. Stations A and B had the highest richness and B also the highest diversity. These stations (A and B) are located among other types of wetlands and lagunes, so that mangroves appear to be use as refuge areas for herpetofauna on the rainy season.

Contact Information: Coral J. Pacheco-Figueroa, DACBiol-UJAT CICEA, Carretera Villahermosa-Cárdenas km. 0.5 Entronque Bosques de Saloya.Villahermosa, Tabasco. México. CP.86035 Phone: (045) 993-153-5500. Email: pachecoral@gmail.com

AMPHIBIANS IN AGRICULTURAL FIELDS AND NATURAL AREAS IN SOUTH FLORIDA

Elise V. Pearlstine[1], *Ikuko Fujisaki*[2], *Juan Sebastian Ortiz*[1] and *Maria Alejandra Millan*[1]
[1]University of Florida, IFAS, Everglades Research and Education Center, Belle Glade, FL, USA
[2]University of Florida, IFAS, Ft. Lauderdale Research and Education Center, Davie, FL, USA

As amphibians decline globally and as wetlands are converted to other uses, alternative habitats may become important to many populations. In some cases, these are created wetlands used as filter marshes, such as the Stormwater Treatment Areas (STA), or they may be flooded fields in agricultural areas. In the Everglades Agricultural Area (EAA) a portion of the landscape is flooded each year in rice and fallow fields. Other crops such as sugarcane and vegetables are not flooded but have ditches and canals in close proximity to the fields, providing some aquatic habitat. We conducted two years of surveys in leafy green (lettuce and herbs), vegetable, rice, sugarcane and fallow fields in the EAA. We also surveyed STAs and natural Everglades habitat at the same time as reference, naturally vegetated sites. Surveys were conducted quarterly and consisted of call counts after dark. We documented environmental variables such as height of water in canal, moon phase, sky visibility, rainfall, wind, edge vegetation and canal vegetation, and crop/landcover type. Fields in the EAA were often rotated between crop types and often flooded fields were followed by upland vegetation like sugarcane or vegetables. Vegetation in the natural areas was a mix of open water, submerged aquatic vegetation and emergent vegetation. We detected 12 species of anuran in all land use types, 10 species in all agricultural types and 12 species in both natural land use types. Rice and sugarcane had the highest species count at 10 species and leafy greens, vegetables and fallow fields had 7 species in each. Everglades National Park (surveyed at Shark Valley) had 11 species and STAs had 10 species. Probability of occurrence for species varied between land use types. Cane toads (*Rhinella marina*) were found in in all land use types and Cuban Treefrogs (*Osteopilus septentrionalis*) were found only in rice and sugarcane and in natural habitats.

Contact Information: Elise V. Pearlstine, University of Florida, IFAS, Everglades Research and Education Center, 3200 E. Palm Beach Rd., Belle Glade, FL 33430, USA, Phone: 954-608-3611, FAX: 561-993-1582, Email: epearls@ufl.edu

DIVERSITY AND ABUNDANCE OF BENTHIC MACROINVERTEBRATES IN TECOCOMULCO LAKE, A WETLAND IN HIDALGO, MEXICO

***A. E. Rico Sánchez*[1]**, *A. J. Rodríguez Romero*[1], *E. López López*[1] and *J. E. Sedeño Díaz*[2]
[1]Laboratorio de Ictiología y Limnología, Escuela Nacional de Ciencias Biológicas del IPN, Distrito Federal MX, México
[2]Programa Ambiental del IPN, Edificio Adolfo Ruiz Cortines, Unidad Prifesional Adolfo López Mateos. Distrito Federal, MX, México

The Laguna de Tecocomulco, Hidalgo is a wetland with a particular geologic history, is a relic of the Anahuac lakes in Mexico Basin. This wetland is included in the International Ramsar Convention list due to the importance of this habitat for distribution of endemic species that live there, and to the great number of migratory species of birds that arrive from United States and Canada. The aim of this study was to assess the diversity and abundance of macroinvertebrates in the Tecocomulco Lake. The lake was monitored in three periods: April (dry season), August (rainy season) and November (northerly windy period) in 2011.Three study sites were analyzed (two located in the limnetic zone and the other in the litoral zone) for water quality (trough a water quality index based on twelve parameters), and the diversity of macroinvertebrates assemblages using the Simpson diversity index and Pielou Evenness Index.

Differences in space and time were detected in water quality and the composition of macroinvertebrates assemblages. Whereas the water quality decreased in the study sites from the dry to the rainy seasons, the diversity and abundance of assemblages of macroinvertebrates increased from the dry to the rainy seasons. Water Quality Index scores in Limnetic study sites were higher than litoral study site; however, the diversity and abundance of macroinvertebrates assemblages was lower than those found in the litoral study site. The litoral study site is under the influence of anthropogenic activities such as livestock and agriculture, therefore, the lowest water quality index score was obtained in all study period. The litoral study site was the most diverse. Insecta was the more representative Class in diversity and abundance in all study sites; Odonata was the dominant group, while Hirudinea was a sporadic group. The highest value of Simpson and Pielou Evenness indices were in the litoral study site in rainy season. The allochtonus material arriving to litoral zone contribute to obtain a heterogeneous habitat in this zone.

Despite the limnetic zone show the higher water quality index scores, the highest value of Simpson Diversity and Pielou indices were obtained in litoral study site during the rainy season due to the habitat heterogenity.

Contact Information: A. E. Rico Sánchez, Laboratorio de Ictiología y Limnología, Escuela Nacional de Ciencias Biológicas del IPN. Prol. de Carpio y Plan de Ayala S/N, col. Santo Tomás, México 11340, D.F. MEXICO; Tel 57296300, Ext. 62420;
E-mail: grifo_3_@hotmail.com

BIRDS FROM THE WETLAND COASTAL PLAINS OF TABASCO, MEXICO

Juan de Dios Valdez-Leal[1], *Coral J. Pacheco-Figueroa*[1], *Lilia M. Gama*[1], *Elias J. Gordillo-Chavez*[2], *Eduardo Moguel-Ordoñez*[1], *Eduardo Méndez-López*[2] and *Stefan Arriaga W.*[1]

[1]DACBiol-UJAT, Villahermosa, Tabasco, México
[2]COVINSE. DACBiol-UJAT, Villahermosa, Tabasco, México
[3]ICOMVIS-UNA, Heredia, Costa Rica

The large extensions of lowlands of Tabasco are composed by different types of wetlands like mangroves that have an important role on maintaining local wildlife, particularly birds. These areas offer shelter, food and nesting for a variety of species. The objective of the research was to study the structure and composition of the bird species in different habitats on this area. Four sampling locations were established on mangroves and four on vegetation with predominance of bulkheads (Thalia geniculata). Samples were done four times on the rainy season of 2008 and 2009, and on the dry season of 2009 and 2010. Three days samplings were done per station on eight points on cicles with fixed radios. Observations were made on mornings and afternoons. A total of 41,326 individuals of 176 bird species corresponded to 19 orders from 57 families. One hundred and twenty seven individuals were considered resident, 37 migrant and 12 on transit. There were 159 species on the dry season (22,662 individuals) and 146 on the rainy season (18.694 individuals). The dry season of 2010 had the highest number of species (84) on the site 1 followed by Site 7 with 80 species. A general value for the Shannon-Weiner diversity index for birds on these lowland areas was 4.0. Two mangroves had high values (3.78 and 3.73). Only four species appear in all the seasons sampled and in all the samples. Thirty species were recorded only once (17% of all species). Twenty one species are reported on the risk category list (NOM-059-SEMARNAT-2010). The most abundant species were Phalacrocorax brasilianus (9.94%), Eudicimus albus (6.53%) Agelaius phoeniceus (5.97%) and Ardea alba (5.60%), representing 28.05% of all the individuals recorded. Tyrannidae, Icteridae and Parulidae were the best represented families with 13 species, followed by Ardeidae with 12. These results show the ecological role importance of this taxa in lowland environments, as well as the importance of preserving the natural characteristics of Tabasco wetlands.

Contact Information: Valdez-Leal Juan de Dios, DACBiol-UJAT CICEA, Carretera Villahermosa-Cárdenas km. 0.5 Entronque Bosques de Saloya. Villahermosa, Tabasco. México. CP.86035 Phone: (045) 993-121-0101. Email: jdvaldezleal@yahoo.com.mx

BIOGEOCHEMISTRY AND MICROBIAL ECOLOGY - BIOGEOCHEMICAL PROCESSES

THE ROLE OF MICROBIAL DIVERSITY AND TRAITS IN METHANE CYCLING IN WETLANDS

Paul L.E. Bodelier
Netherlands Institute of Ecology (NIOO-KNAW), Wageningen, the Netherlands

The anomalies in atmospheric methane concentrations in late twentieth century, including the renewed increase since 2007 have been proposed to be caused by changes in (microbial) methane cycling in wetland ecosystems, including peatlands. Although microbial processes are fundamental to methane emission from wetlands, the diversity of microbial communities and traits of the microbes involved are not taking into consideration in assessing potential sources of variation in the global methane budget. Production of methane by methanogenic archaea in wetlands is a major source while consumption by methane oxidizing bacteria in these ecosystems is a major sink. There are many environmental factors that control these processes, which have also been extensively investigated. The advent of a multitude of culture independent techniques has resulted in a glimpse of the possible role of microbial community composition and or response in methane cycling reactions. Especially, the combined use of molecular biological techniques with the application of stable isotopes has led to valuable insight into the link between microbial characteristics and biogeochemical processes. Stable isotope probing studies targeting RNA, DNA, lipids and proteins demonstrate that in ecosystems important for global methane cycling only a limited number of species is responsible for production and consumption of methane. Next to this, discoveries and isolation of new species and pathways offer new insight in the role of microbial diversity in methane cycling in wetlands. This paper highlights important advancements in the area of methane cycling in wetlands with emphasis on methane oxidation and the link between diversity and activity.

Contact Information: Paul L.E. Bodelier, Netherlands Institute of Ecology (NIOO-KNAW), department of Microbial Ecology, Droevendaalsesteeg 10, 6708PB Wageningen, the Netherlands. Phone: 31 317473485. Fax: 31 317473675. Email: p.bodelier@nioo.knaw.nl

CONTROLS OVER ANAEROBIC CARBON CYCLING AND METHANE PRODUCTION IN PEATLANDS

Scott D. Bridgham[1], *Rongzhong Ye*[1], *Jason K. Keller*[2], *Steven McAllister*[1], *Qusheng Jin*[1] and *Brendan Bohannan*[1]

[1]University of Oregon, Eugene, OR, USA
[2]Chapman University, Orange, CA, USA

Rates of CH_4 production and the efficiency of CH_4 production (i.e., the ratio of CH_4 production to CO_2 production) vary dramatically among peatlands. Porewater acetate also often accumulates in many peatlands despite the fact that it is a methanogenic substrate. A number of causes for these phenomena have been proposed, including differences in the availability of labile carbon, concentrations of terminal electron acceptors (TEAs), pH, trace metal deficiencies, temperature, and methanogen community composition. We examined the relative importance of these controls over anaerobic carbon cycling in six peatlands that occur along an ombrotrophic-minerotrophic hydrogeomorphic gradient in northern Michigan, USA.

In an experiment examining the importance of various inorganic TEAs in anaerobic carbon mineralization, we found that denitrification and iron reduction were of minor importance, sulfate reduction was widely variable, and CH_4 production contributed < 12% of overall mineralization. The majority of carbon mineralization could not be explained by known pathways, which others have attributed to either humic substances acting as TEAs or the buildup of fermentation products.

We took peat from the six peatlands and incubated it at pHs 3.5, 4.5, 5.5, and 6.5 for 43 days. Higher pH greatly enhanced the efficiency of CH_4 production in all sites, suggesting that methanogens are more sensitive to low pH than other anaerobic microbes. However, CH_4 always accounted for < 25% of total gaseous production, and fermentation was the dominant pathway of anaerobic mineralization. Significant acetate pooling occurred at higher pH. Acetoclastic methanogenesis was the dominant pathway of CH_4 production in all sites, and accordingly in the more minerotrophic peats, acetate was mostly converted to CH_4 by the end of the experiment. However, acetate concentrations remained high in the ombrotrophic peats, suggesting severe inhibition of acetoclastic methanogenesis in these sites that cannot be explained solely by their low native pHs. A separate experiment demonstrated that low trace metal concentrations do not inhibit methanogenesis in these peatlands. We speculate that high concentrations of aromatic compounds may inhibit methanogenesis in ombrotrophic peatlands. Experiments with anthraquinone-2,6-disulfonate (AQDS), a humic substance-analog, verify the inhibitory effect of aromatic compounds on CH_4 production.

To our knowledge, we are the first group to measure rates of acetogenic reduction of CO_2 (using ^{14}C tracers) in peatlands. We demonstrate that this can be an important pathway of acetate production and can be a strong competitive pathway for H_2 with hydrogenotrophic methanogenesis.

Our research suggests that low pH and low carbon quality are important but insufficient explanations for the low CH_4 production in ombrotrophic peatlands. We demonstrate other important controls, including acetogenic reduction of CO_2 and the direct and indirect (via TEAs) inhibitory effects of humic substances.

Contact Information: Scott D. Bridgham, Institute of Ecology and Evolution, University of Oregon, Eugene, OR 97403 USA, Phone: 541-346-1466, Fax: 541-346-2364, Email: bridgham@uoregon.edu

AN ISOTOPE MASS BALANCE APPROACH TO DISTINGUISHING SOURCES OF CO_2 PRODUCTION IN NORTHERN MINNESOTA PEATLANDS

J. Elizabeth Corbett[1], *Jeffrey P. Chanton*[1], *Malak M. Tfaily*[1], *William T. Cooper*[2], *David J. Burdige*[3] and *Paul H. Glaser*[4]

[1]Earth, Ocean, and Atmospheric Science, Florida State University, Tallahassee, FL, USA
[2]Chemistry and Biochemistry, Florida State University, Tallahassee, FL, USA
[3]Ocean, Earth and Atmospheric Sciences, Old Dominion University, Norfolk, VA, USA
[4]Earth Sciences, University of Minnesota, Pillsbury Hall, Minneapolis, MN, USA

Methanogenesis is generally considered to be the dominant respiration pathway in saturated peatland soils producing roughly equimolar amounts of CO_2 and CH_4. Bulk $\delta^{13}C$ isotopic analyses of CO_2 and CH_4 have shown that methanogenesis is occuring. However, in both field and incubation concentration studies, we see a disproportionate amount of CO_2 with respect to CH_4. These observations can be explained in two ways: either there is another pathway contributing to CO_2 concentrations that is does not isotopically fractionate the carbon substrates or CH_4 is lost since it is less soluble in the peat pore water than CO_2. We propose that both processes are occurring. By combining concentration and isotopic data of CO_2 and CH_4, we developed an isotope mass-balance approach. This approach can distinguish whether CO_2 produced at a specific depth is from a fractionating or non-fractionating pathway. In our system, additional electron acceptors such as sulfate, nitrate, or iron are significantly limited leaving only methanogenesis, fermentation, and surface oxic respiration as potential pathways. Closed-system preliminary incubation studies show that our isotopic mass balance approach can accurately predict the expected concentration of CH_4 to within $\pm$ 3.5%. When we apply these equations to field measurements, we can calculate the percent of CO_2 from fractionating pathways (methanogenesis) and non-fractionating pathways (fermentation and oxic respiration). Produced and fugitive CH_4 can then be determined with the percent CO_2 from methanogenesis. In our peatland system, we found that both bogs and fens utilized the fractionating, methanogenic pathway more than the non-fractionating pathways. In depths below 50cm, the percent of carbon remineralization resulting from non-fractionating pathways was higher in fens (10%) than in bogs (0%). This agrees with previous studies that show fens to have more labile DOC than bogs and allow more oxygen penetration into saturated soils via plant roots. Percent methane loss was higher in fens (90%) than bogs (80%) possibly due to the presence of *Carex* roots.

Contact Information: J. Elizabeth Corbett, Florida State University, Department of Earth, Ocean, and Atmospheric Science, Tallahassee, FL 32306, USA, Phone: 3173733006; Email: corbett@ocean.fsu.edu

CARBON AND PHOSPHORUS DYNAMICS OF DISSOLVED ORGANIC SUBSTANCES IN LOW-NUTRIENT SURFACE WATERS FROM SOUTH FLORIDA CONSTRUCTED TREATMENT WETLANDS AND NATURAL MARSHES

K. A. Grace, *S. D. Jackson, N. Larson* and *T. A. DeBusk*
DB Environmental, Inc. Rockledge, FL, USA

Dissolved organic phosphorus (DOP) compounds comprise a substantial portion of the phosphorus (P) in surface waters entering the Everglades marsh. Large, recalcitrant organic substances hinder more complete DOP removal by constructed wetlands (Stormwater Treatment Areas [STAs]) deployed for P removal, yet it is unknown whether these organic compounds originate from the inflow waters (agricultural runoff and eutrophic lake waters) or are generated internally within the STAs. If the latter, it may be possible to control sources of the recalcitrant dissolved organic matter (DOM) through vegetation and soil management activities.

Phosphorus and carbon concentrations in DOM, as well as spectral slope ($S_{275\text{-}295}$, see Helms et al., 2008) were measured in wetland surface waters, leaf leachates and intact soil cores. Out of 7 independent treatment flow paths surveyed, dissolved organic carbon (DOC) ranged from 11 to 97 mg/L in surface waters. Surface water DOP concentrations decreased from STA inflow to outflow under flowing conditions, while DOC increased or decreased depending on flow condition and inflow concentrations. Highest DOC and DOP concentrations in surface waters were not associated with STA inflow waters, but were found internally within the treatment areas, suggesting internal production of dissolved organic substances. Soil cores containing newly-accrued STA sediments and P-enriched soils from Northern Everglades marsh sites released DOC and DOP to overlying waters, while marsh soils from an area far from surface inflows showed no release of either constituent.

Concentrations of DOC in a periphyton-based “PSTA” treatment cell constructed on a limerock substrate were, at times, as high as in wetland cells dominated by emergent vegetation. However, high $S_{275\text{-}295}$ from the PSTA cell indicated major differences in DOM quality between this wetland (with smaller, labile compounds in the DOM pool) and contrasting vegetation and soil types. Laboratory incubations confirmed that dissolved compounds leached from senescent emergent leaves (*Typha* and *Cladium*) into marsh water decreased $S_{275\text{-}295}$ values and increased DOP and DOC more so than SAV tissue leachates or water-only controls. Highest $S_{275\text{-}295}$ were consistently associated with the outflow region of STAs. The STA 3/4 Central flow path exhibited the most dramatic increase in $S_{275\text{-}295}$ from inflow (~ 0.0163 nm^{-1}) to outflow (0.0206 nm^{-1}). The PSTA project operated adjacent to that flow path had the highest value (0.0220 nm^{-1}) of any station sampled. Lowest $S_{275\text{-}295}$ values (0.0132 nm^{-1}) were observed in STA 5 inflow waters when heavy rainfall (>14 inches during July 2011) followed an extended dry period. These findings contribute to a better understanding of the production and transformation processes affecting dissolved organic substances within STAs.

Contact Information: Kevin Grace, DB Environmental, 102 NE 10th Ave Box#9, Suite #13, Gainesville, FL 32601 USA, Phone: 352-262-8987, FAX: 352-491-2933, E-mail: Kevin@DBEnv.com

ANAEROBIC OXIDATION OF METHANE IN NORTHERN PEATLANDS

Varun Gupta[1], *Kurt A. Smemo*[2, 3], *Joseph B. Yavitt*[4], *Brian Branfireun*[5], *David Fowle*[6] and *Nathan Basiliko*[1]

[1]University of Toronto Mississauga, Mississauga, ON, Canada
[2]The Holden Arboretum, Kirtland, OH, USA
[3]Kent State University, Kent, OH, USA
[4]Cornell University, Ithaca, NY, USA
[5]University of Western Ontario, London, ON, Canada
[6]University of Kansas, Lawrence, KS, USA

Despite the fact that many of the mechanisms underlying anaerobic oxidation of methane (AOM) in marine and freshwater aquatic ecosystems are uncertain, the process has been known to occur for more than 3 decades and is important for reducing net methane (CH_4) fluxes to the atmosphere. In northern peatland ecosystems, which are significant sources of atmospheric CH_4, evidence for AOM has only recently been presented and the process has not been characterized across a full range of peatland types.

The primary objective of this research was to characterize AOM rates in peatlands of various type (bogs and fens with varying physicochemical properties and plant communities) and climatic and latitudinal gradients. We used in vitro incubations of peat from fifteen North American peatlands and $^{13}CH_4$ stable-isotope probing to estimate AOM rates via ^{13}C recovery in CO_2 and solid organic peat phases. We found that AOM was ubiquitous across sites and more rapid in nutrient rich fen ecosystems than bogs. Assimilation in peat (and presumably microbial biomass) was detected after 20 and/or 40 days in 9 of the 15 sites. Across sites, AOM rates were 2.9 nmol C-CH_4 $kg^{-1}s^{-1}$, which represented between 2.5% to 115.6% of the CH_4 produced by the same peat over 40 days. An electron acceptor addition experiment, however, demonstrated no stimulation of AOM in response to additions of sulfate, nitrate and ferric oxide. Instead, incubations without additions demonstrated the highest AOM rates, suggesting that an organic electron acceptor(s) might be important in peatlands.

Based on this study that provides the first direct evidence of AOM and associated anabolic carbon assimilation across a globally representative set of northern peatlands, we conclude that AOM is a significant process in northern peatlands and might substantially reduce greenhouse forcing. Future empirical and modeling studies of CH_4 dynamics in peatlands should focus on characterizing controls on rate of this underappreciated process.

Contact Information: Varun Gupta, Department of Geography, University of Toronto Mississauga, Mississauga, ON L5L1C6 Canada, Phone: 647-831-5769, Email: vg.gupta@utoronto.ca

TROPHIC STATUS AND METHANOGENESIS IN PEATLANDS

Mark. E. Hines[1], *Jeff P. Chanton*[2] and *Edward A.D. Mitchell*[3]
[1]University of Massachusetts Lowell, Lowell, MA, USA
[2]Florida State University, Tallahassee, FL, USA
[3]Université de Neuchâtel, Neuchâtel, Switzerland

Typical methanogenic pathways include near-terminal C intermediates that turn over rapidly with small pool sizes. However, laboratory and field experiments demonstrated that these intermediates often accumulate in many northern peatlands due to the lack of consumption by methanogens. When this inhibition occurs, acetate becomes a primary organic end product of decomposition, which can exceed CO_2 production. Other organic acids such as propionate and butyrate can also accumulate. These organics are readily converted to CO_2 when alternate electron acceptors are present, so C destined for CH_4 in typical freshwater habitats, is converted to CO_2, a weaker greenhouse gas, as acetate diffuses to the surface or to areas adjacent to plant roots. The extent to which methanogenesis is inhibited and organic compounds accumulate is connected to trophic status, with nutrient-poor, low pH regions with less vascular plants tending to favor organic acid accumulation and low rates of methanogenesis. Hence, increases in the cover of vascular plants in peatlands that are occurring as a result of climate warming should increase the rate of methanogenesis as inhibition is relieved and acetate conversion to CH_4 increases. In addition, collapse pools in areas of discontinuous permafrost that harbor rapidly growing sphagna exhibited rapid increases in concentrations of low-molecular weight organic acids. The ability of oligotrophic, acidic peats to accumulate acetate, propionate and/or butyrate varied, suggesting that that near-terminal steps of degradation are poised delicately on a “biochemical seesaw” that can be tipped either way by slight changes in the concentrations of end products and intermediates that control free-energy yield.

Seasonal temperature regimes also appear to affect the relative importance of CH_4 or acetate as terminal decomposition products, so at higher latitudes, a greater extent of wetlands will accumulate acetate rather than produce CH_4. Similarly, high elevation peats accumulate acetate more readily than lower elevation peats of similar trophic status and season.

The connection to trophic status and vegetation distribution allows for the mapping of the changing path to CH_4 and may provide a predictive tool. A change in the pathway to $CH_{4,}$ as vegetation cover responds to warming, should increase the production rate of CH_4 much more drastically than increases due to warming alone, and needs to be included in C models used to predict climate in a warming world.

<u>Contact Information</u>: Mark Hines, University of Massachusetts Lowell, One University Ave, Lowell, MA 01854; United States; PH 978-934-2867; Email: mark_hines@uml.edu

SEASONAL DYNAMICS OF SOIL NITROGEN PROCESSING IN CONTRASTING SEASONALLY-FLOODED, CALCAREOUS, SUBTROPICAL WETLANDS

Xiaolin Liao, Kanika S. Inglett and ***Patrick W. Inglett***
University of Florida, Gainesville, FL, USA

In the calcareous oligotrophic wetland ecosystems, nitrogen (N) has received less attention compared to phosphorus (P) though it often plays significant role. Seasonal pattern of soil N cycle is a driver that integrates simultaneous variance in the factors of temperature, moisture contents and plant growth. In this study, we chose two young, more N-limited restored wetlands (cleared in 2000 and 2003) and a native P-limited, marl prairie reference wetland in Everglades National Park, Florida, USA. We measured extractable inorganic nitrogen pools, microbial biomass carbon and nitrogen (MBC, MBN), potentially mineralizable nitrogen (PMN), potential rates of denitrification (DEA), microbial biomass and two N-related enzymes (Leucine-aminopeptidase, LAP; N-acetyl-β-D-glucosaminidase, NAG) seven times during 2010 to 2011. We found that in the wet season (June to September), available nitrate/nitrite (NO_x^-) decrease while available ammonium (NH_4^+) increased. The major form of available nitrogen was NH_4^+ indicated by high NH_4: NO_x ratio; however in the extreme dry period (January, 2011), NH_4:NO_x ratio fell below 1. These results would suggest that the NO_x^- tends to lose by leaching or consumed by denitrification especially in the rainy seasons. Higher PMN was more likely in the dry season or the spring other than the rainy season. The two N-related enzymes, i.e., LAP and NAG, showed different seasonal patterns, suggesting different enzymes were regulated by different factors (e.g., moisture content and substrate availability). Moreover, the increasing LAP:NAG ratio and decreasing MBC:MBN ratio from spring to summer indicates that in the wet season, conditions may increasingly favor growth of bacteria over fungi. DEA also followed the temporal trend of moisture content and showed higher rates in the wet season, with the highest rates occurring after the onset of flooding at the beginning of the rainy season when soil NO_x^- levels are very high. The temporal patterns of the two restored wetlands were more similar with each other than that of reference site.

Contact Information: Patrick W. Inglett, Soil and Water Science Department, University of Florida, Gainesville, FL 32611 USA, Phone: 352-392-1804, Fax 352-392-3399; Email: pinglett@ufl.edu

TEMPERATURE EFFECTS ON ANAEROBIC C PROCESSING IN TWO SUBTROPICAL PEAT SOILS OF DIFFERING VEGETATION

***Patrick W. Inglett**, Kanika S. Inglett* and *Cassandra A. Medvedeff*
Department of Soil and Water Science, University of Florida, Gainesville, FL., U.S.A

Gaseous and aqueous carbon (C) export from soils is known to be affected by temperature and organic matter quality; however, few studies have focused on the potential interaction of temperature with organic matter type in warm subtropical and tropical wetlands. This study investigated the production dissolved organic carbon (DOC), carbon dioxide (CO_2) and methane (CH_4), as well as activities of extracellular enzymes (β-glucosidase, phosphatase, aminopeptidase) at four temperatures ranging from 4°C to 35°C in subtropical peat soils of two vegetation types (*Cladium*, *Panicum*). Results showed that both vegetation type and temperature influenced the total carbon released from soils as well the dominant C forms, where higher temperature increased the proportion of gaseous forms versus DOC and CH_4 versus CO_2. Peat type affected the temperature response, where *Cladium* soils released more total C, DOC and 2-16 times more CH_4 than *Panicum*-based peat. Calculated Q_{10} values were highest for CH_4 (~13) followed by CO_2 (~2.0) and DOC (~1.7). Activities of β-glucosidase and aminopeptidase declined at higher temperature while the phosphatase activity appeared to be unaffected indicating that decomposition at higher temperatures may coincide with shifts in nutrient availability. These findings suggest an interactive role of soil organic matter type and temperature leading to altered C processing (favoring methanogenic pathway) in subtropical peat soils in response to higher temperatures.

Contact Information: Patrick W. Inglett, Department of Soil and Water Science, University of Florida, Gainesville, FL., U.S.A, Phone: 352-392-1804, Fax: 352-392-3399; Email: Pinglett@ufl.edu

RELATIONSHIP BETWEEN SOIL CORE DIAMETER AND NUTRIENT FLUX

L. Keenan[1]*, A.L. Wright*[2]*, E. Dunne*[1] and *K.R. Reddy*[2]

[1]St. Johns River Water Management District, Palatka, FL, USA

[2]University of Florida, Gainesville, FL, USA

The diameter of soil cores may influence measurement of nutrient flux rates. Soil cores of various diameters were collected from the St. Johns River floodplain and subjected to flooding to a floodwater depth of 20 cm. Release rates of dissolved organic matter and nutrients were calculated as the slope of the regression of floodwater nutrient concentrations versus time ranging from 0 to 12 days. There was no significant difference in release rates of NH4 due to core diameter, with an average NH4 flux of 9.7 mg N/m2/d. Similarly, SRP flux was unaffected by core diameter and averaged 1.7 mg P/m2/d. There was no discernable trend in DOC flux with changes in core diameter. Dissolved organic C flux from 5 cm cores was significantly lower than cores with diameters ranging from 10-20 cm, but not 25 cm. Total N was also not significantly affected by core diameter, and the TN release rate was about 3.6 times that of NH4. Likewise, total P was not significantly influenced by core diameter, with the average release rate being 9.0 mg P/m2/yr, approximately 5 times higher than the flux rate of SRP. There was no discernable relationship between either EC and pH as a function of core diameter. Generally, soils from different core diameters were similar in terms of nutrient and organic matter content. Nutrient flux, with potential exception of DOC, were generally unaffected by soil core diameter.

Contact Information: Lawrence Keenan, St. Johns River Water Management District, P.O. Box 1429, Palatka, FL 32178-1429, Phone: 386-329-4425, Email: lkeenan@sjrwmd.com

THE ROLE OF HUMIC SUBSTANCES AS TERMINAL ELECTRON ACCEPTORS IN PEATLAND DECOMPOSITION

Jason K. Keller*, Kimberly K. Takagi* and *Crisand Anderson*
Chapman University, Orange, CA, USA

Understanding anaerobic decomposition in peatland ecosystems is crucial for understanding the role that they will play in the global carbon cycle in the face of ongoing global change. However, we currently lack a complete mechanistic understanding of peatland decomposition as indicated by the consistent findings that (i) much of the mineralized carbon in these soils cannot be explained by measured microbial processes and (ii) many peatland soils release small amounts of methane for reasons which are not well understood. A growing body of evidence suggests that humic substances can serve as organic terminal electron acceptors in microbial respiration, and that this process might account for the unexplained decomposition observed in wetland soils while competitively suppressing methane production. This study explored the role of humic substances as terminal electron acceptors in peatland decomposition. We measured the electron shuttling capacity of humics through time in both chemically- and biologically-reduced incubations. Carbon dioxide and methane production were also measured in these incubations. Our results suggest that humic reduction plays an important role in ombrotrophic (bog-like) peat soils where methane production appears to be competitively suppressed by this novel microbial process. In contrast, humic reduction does not appear to dominate decomposition in more minerotrophic (fen-like) peat soils. Ongoing experiments demonstrate that this effect is independent of confounding pH effects which have been influential in previous research on this topic. Our findings also support previous studies suggesting that humic reduction involves solid-phase (i.e., soil) materials rather than dissolved humics. Taken together, these results suggest that the electron accepting capacity of soil humic substances may be key a mediator of carbon storage and methane production in peatland ecosystems.

Contact Information: Jason K. Keller, School of Earth and Environmental Sciences, Chapman University, Orange, CA 29782 USA, Phone: 714-289-2072, Fax: 714-532-6048, Email: jkeller@chapman.edu

SEDIMENT POREWATER CHEMISTRY AND PHOSPHORUS RELEASE FOR PARALLEL EMERGENT MACROPHYTE AND SUBMERGED MACROPHYTE TREATMENT WETLANDS

Michelle D. Kharbanda[1], *Dawn E. Sierer*[1], *Forrest E. Dierberg*[1], *Karen Hileman*[1], *Sara Carrano*[1] and *Delia Ivanoff*[2]

[1]DB Environmental, Inc., Rockledge, FL, USA;

[2]South Florida Water Management District, West Palm Beach, FL, USA

Sediments are the primary storage compartment for phosphorus (P) removed from surface waters by treatment wetlands. As new sediments accumulate, the conditions which affect sediment P stability and retention can differ from the antecedent wetland soils. To maximize water treatment efficacy and sustainability using wetlands, it is essential to understand the factors that regulate the accrual rate and chemical characteristics of newly-formed sediment material. Our study compares chemical and physical properties of accreted sediments in adjacent cells of a large treatment wetland (Stormwater Treatment Area 2 [STA-2]) in the Florida Everglades.

Two parallel flow paths (Cells 2 and 3 in STA-2), flooded in June 1999, began flow-through operations in July 2001. The wetlands are both 919 ha in size, and receive approximately the same inflow water quality. Cell 2 was constructed on an existing wetland and is dominated by emergent aquatic vegetation (EAV), whereas Cell 3 was constructed on former farmland and is dominated by submerged aquatic vegetation (SAV). During July 2001 – October 2008 the flow-weighted mean inflow TP concentrations for Cells 2 and 3 were 89 and 74 µg/L, respectively. During this same period, mean hydraulic loading rates were 4.46 and 4.33 cm/day and mean TP loading rates were 1.84 and 1.40 g $P/m^2 \cdot yr$, respectively. Under these operating conditions mean outflow TP concentrations were 28 and 18 µg/L for Cells 2 and 3, respectively.

Porewater in a SAV-dominated region near the inflow of Cell 3 contained higher SRP, ammonia, and sulfide concentrations, and lower redox potentials, as compared to the Cell 2 inflow region. These differences were less pronounced at the midpoint and outflow stations; however, porewater SRP concentrations in SAV sediments were lower than in EAV sediments in both regions. Surficial (upper 4 cm) sediments from the inflow region of both cells released P into overlying waters during dark laboratory incubations, while outflow sediments showed no P release. Therefore, distance from the inflow structures was more important than vegetation community in determining sediment P release rates.

Low bulk density (as low as 0.02 ± 0.008 g/cm) of sediments within some areas in Cell 2 with emergent vegetation may increase the potential for resuspension of these flocculent materials, whereas dense Ca-rich sediments were cohesive. These attributes indicate that sediments formed in both emergent and submerged macrophyte communities can store and retain P. However, differences in bulk density and porewater P of outflow sediments may partially explain the slightly greater P reductions observed by the SAV-based wetland, as compared to the EAV wetland.

Contact Information: Michelle D. Kharbanda, DB Environmental, Inc., 365 Gus Hipp Blvd., Rockledge, FL 32955 USA, Phone: 321-639-4896, Fax: 321-631-3169, Email: michelle@dbenv.com

PLANT COMMUNITY COMPOSITION AND BIOGEOCHEMISTRY OF CLEAR AND TURBID SHALLOW LAKES

***La Toya T. Kissoon*[1]**, *Donna L. Jacob*[1], *Mark A. Hanson*[2], *Brian R. Herwig*[2], *Shane E. Bowe*[3] and *Marinus L. Otte*[1]

[1]Wet Ecosystem Research Group, Department of Biological Sciences, North Dakota State University, Fargo, ND, USA
[2]Minnesota DNR, Wetland Wildlife Population and Research Group, Bemidji, MN, USA
[3]Red Lake DNR, Water Resources Program, Red Lake, MN, USA

Shallow lakes can shift between a clear vegetation dominated regime and a turbid phytoplankton dominated regime. The mechanisms responsible for these changes are poorly understood but total phosphorus concentrations, changes in fish biomass, submerged vegetation communities and water levels have been found to play a role. This study was conducted to determine the relationships between lake turbidity, plant community composition and sediment and water chemistry. Field studies involved 45 shallow lakes over a range of turbidity and plant cover in northern, central and southern Minnesota. Submerged aquatic plant species were identified and their cover estimated. Sediment and water samples were collected and analyzed for multiple element concentrations (e.g. Al, As, Ca, Cu, Cr, Fe, K, Mg, Mn, Na, Ni, P, Pb, S, Si, Sr, Ti, V, Zn). Loss on ignition and particle size was determined for sediments, and pH and turbidity for water. Element concentrations in the water and sediment varied significantly by geographic region. Plant community composition, turbidity, pH, LOI and particle size also varied significantly. Shallow lakes that were classified as turbid by cluster analysis had higher concentrations of Ca, Mg, Si and Sr and lower concentrations of Mn, Na and S compared to lakes classified as clear. Decision Tree Analysis showed that 1) plants were present in shallow lakes when the turbidity was less than or equal to 6 NTU, 2) turbid lakes had greater than 13 mg l^{-1} Si or less than 13 mg l^{-1} Si and less than 0.04 mg l^{-1} Mn and 3) clear lakes had less than 13 mg^{-1} Si and greater than 0.04 mg l^{-1} Mn.

Contact Information: La Toya Kissoon, North Dakota State University, NDSU Dept 2715, P.O. Box 6050, Fargo, ND 58108-6050, United States; PH 701-231-7087; Email: latoya.kissoon@ndsu.edu

AN ECOSYSTEM MODEL FOR DETRITUS DECOMPOSITION IN A EUTROPHIC WETLAND, CHINA

Xia Li[1, 2], *Baoshan Cui*[1], *Hanqin Tian*[2, 3], *Qichun Yang*[2, 3], *Yan Lan*[1], *Tingting Wang*[1] and *Zhen Han*[1]

[1]School of Environment, Beijing Normal University, State Key Joint Laboratory of Environmental Simulation and Pollution Control, Beijing, China,

[2]Ecosystem Dynamics and Global Ecology (EDGE) Laboratory, School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL, USA

[3]International Center for Climate and Global Change Research, Auburn University, Auburn, AL, USA

Detritus decomposition is a fundamental process in nutrient-enriched wetlands because it can influence nutrient availability and organic matter accumulation, which can regulate primary production, causing the terrestrialization of the wetlands. To explore how plant detritus decomposition would affect nutrient cycling in a eutrophic wetland, a process based ecosystem model has built to simulate dominant macrophyte decompositions in Baiyangdian Wetland. The model is composed of four components, including hydrology, plant physiology, water chemistry, and sediment biochemistry. The sediment biochemistry considers nutrient and carbon releases as well as detritus accumulation from macrophytes decomposition. Effects of both abiotic factors and biotic factors controlling detritus decomposition were simulated and tested. Calibration and validation of the model were performed using observed data and field experiment data in the wetland. Multi-variate sensitivity analysis was used to identify the dominant factors controlling decompositions. Results of this study demonstrate that the model is able to reconstruct decomposition process in the wetland. The simulation data are in agreement with observed data, including plant biomass, P concentration in water, and dead mass. The detritus accumulation is sensitive to water level, water phosphorus (P) and nitrogen (N) contents. The model was further applied to predict the long-term effects of high-level nutrient contents in the water body. Enriched water nutrients and decreased water levels have created favorable conditions for aquatic macrophytes and enhanced plant growth in the wetland, which affects detritus decomposition and increases detritus accumulation at the bottom. This study may provide some insights for management practices aiming to protect the functioning and structure of the wetland ecosystem.

Keywords: Detritus decomposition; Organic matter accumulation; Nutrient cycling; Ecosystem model; Eutrophic wetland.

Contact Information: X. Li, School of Environment, Beijing Normal University, Beijing, 100875, China, Phone: 334-707-9152, Email: xzl0023@auburn.edu

LINKING METHANE PRODUCTION RATE TO METHANOGEN COMMUNITY STRUCTURE IN PEATLAND SOILS

Brendan Bohannan, ***Steven A. McAllister****, Scott D. Bridgham* and *Qusheng Jin*
University of Oregon, Eugene, OR, USA

The relationship between community structure and ecosystem function has been of interest to ecologists for decades, and is a fundamental question in ecology. More recently there has been emphasis on this relationship in terms of global climate change, as community structure interacts with other biotic and abiotic factors to determine an ecosystem's response to perturbations, and often provides key feedbacks to those perturbations. These questions are especially relevant with regard to microbial communities, as they contain most of life's genetic diversity and mediate the vast majority of global biogeochemical cycles.

Methane is a significant greenhouse gas, trapping up to 25 times as much infrared radiation as carbon dioxide per unit weight. All of the methane produced by the world's biosphere is produced by methanogens, a polyphyletic group of microorganisms in the domain Archaea, in anaerobic environments. In this study we explored the relationship between methane production and methanogen community structure in peatlands, along a landscape gradient in northern Michigan spanning six sites from an ombrotrophic bog to a minerotrophic fen. This gradient of pH and hydrology is very distinctive in peatlands, and a site's position on this gradient has been shown to influence methanogenesis pathways and efficiency of methane production. Methanogenesis rate potentials in peat samples taken throughout 2009 and 2010 were measured in sealed bottles, and the relative contributions of both methanogenesis pathways were determined via addition of ^{14}C tracer to the incubations. When quantifying community structure, we used mcrA, a functional gene that is ubiquitous in methanogens, as a marker for molecular analysis. DNA sequences of *mcrA* were aligned in MOTHUR and binned into OTUs for putative assignment of taxonomic (and functional) identity.

The community structure of each site was significantly different from each of the others, and both Bray-Curtis and Jaccard Dissimilarity trees of genus-level OTUs reveal strong clustering of communities by gradient position. A large number of sequences in the most ombrotrophic site in spring 2010 were identified as putative acetoclasts, a surprising finding that matches the unexpectedly high rate of acetoclastic methanogenesis in that site at that time. Total methanogenesis was much higher in minerotrophic sites, and the hydrogenotrophic pathway of methanogenesis increased in dominance in all sites as time progressed; methanogen richness and diversity also increases dramatically from ombrotrophic to minerotrophic sites and the methanogen community in each site was dominated by putatively hydrogenotrophic methanogens.

Altogether, this suggests a link between functional community structure and methanogenesis pathways in peats. We also discuss the relative utility of Sanger and 454 pyrosequencing technologies for functional gene analysis, and future directions for the use of mRNA sequencing to clarify temporal relationships between community structure and methane production.

Contact Information: Steven A. McAllister, Institute of Ecology and Evolution, University of Oregon, Eugene, OR 97403 USA, Phone: 541-543-3776, Fax: 541-346-2364, Email: smcalli1@uoregon.edu

NITROGEN CYCLING IN HEADWATER WETLANDS ACROSS CONDITION GRADIENTS IN PENNSYLVANIA AND OHIO

Jessica B. Moon[1], *Denice H. Wardrop*[1], *M. Siobhan Fennessy*[2], *Hannah M. Ingram*[1] and *Nicole Kirchner*[2]
[1]Penn State University, University Park, PA, USA
[2]Kenyon College, Gambier, OH, USA

Although small in area, riparian wetlands provide a disproportionate share of valuable ecosystem functions to the larger landscape. Through microbial biochemical cycling of large portions of the global carbon and nitrogen pools, they act as sinks for and transformers of inorganic nutrients and as sources of organic material to aquatic systems during flooding events. Given our reliance on these important ecosystem services, and in light of the pressures on these systems from surrounding land use, assessments must be performed in order to elucidate the current condition of riparian wetlands as they relate to these microbial functions. In a larger study we aimed to investigate the relationships between wetland condition, as described by condition assessments developed in Pennsylvania (Level 2 Rapid Assessment Protocol) and Ohio (ORAM), and key ecosystem services such as flood storage, carbon sequestration, and nitrogen cycling. Here we present results on the nitrogen cycling component. Sixteen riparian wetlands were selected for nitrogen mineralization and denitrification measurements. Nitrogen mineralization was calculated for a one month period in the fall of 2011 using a modified resin core method. During this period surface cores were also collected for potential denitrification measurements using the acetylene-block technique. After this incubation period, *in situ* denitrification potential measurements were collected on groundwater from a subset of the sites (n = 7) using the push-pull method. Although strong relationships have been identified between chemical and physical soil measurements (e.g., SOM, pH, and bulk density) and condition gradients across these and other states, in this study ambient groundwater measurements including dissolved organic carbon, ammonium, and nitrate concentrations were highly variable within sites and across the condition gradients. Such variability could translate into more complex relationships between condition assessment measurements and denitrification potential, depending on the method being employed.

Contact Information: Jessica B. Moon, Riparia, 302 Walker Building, University Park, PA 16802 USA, Phone: 610-392-8799, Fax: 814-863-7943, Email: jbm162@psu.edu

REVIEW OF NOVEL ANALYTICAL APPROACHES TO DETERMINE SOIL ORGANIC MATTER STABILITY IN WETLANDS

Anna E. Normand and *K. Ramesh Reddy*
University of Florida, Gainesville, FL USA

One of the most complex challenges in environmental science is determining the molecular composition of organic matter in soils and sediments of the biosphere. Organic matter plays a key role in the function of wetland soils: it regulates the binding and release of nutrients and anthropogenic chemicals, affects biological activity rates, and influences the structure of soil. Organic matter in wetlands has received increasing attention due to its role in the global carbon (C) cycle by sequestering C and its regulation of nutrient fluxes affecting ecosystem eutrophication. Therefore, it is advantageous to further our understanding of this critical wetland soil component. As insight to organic matter evolves, questions pertinent to global environmental processes should be addressed, such as: What are the biotic or abiotic mechanisms that will foster the accretion and stability of organic matter? How stable is "recalcitrant" organic matter and what environmental changes may prompt its degradation? How can we link the transformation of organic matter composition to regional, and even global, environmental processes and nutrient cycles?

The onset of global climate change justifies the significance of these questions. Examples of current and future issues of concern include, thawing of wetland tundra soil that will expose critical stores of organic C to microbial decomposition, and increased frequency of fires will drastically transmute wetland soil to recalcitrant char and release nutrients. Ecosystem shifts resulting from sea level rise will also alter organic matter composition and function. As the Earth undergoes ecological and climatological shifts in the next century, advances in the understanding of organic matter will provide insight into its uncertain fate.

To progress our knowledge of wetland soil organic composition and processes, we must employ the most advanced techniques available that are compatible with experimental design and within research means. This review briefly addresses classical studies that are limited by operationally defined pools, and then proposes advanced techniques that provide the most promising uses for addressing pertinent questions related to organic matter in soil. Advanced spectroscopic techniques presented include Nuclear Magnetic Resonance (NMR), X-ray Absorption Near Edge Spectroscopy (XANES), and Fourier-Transform Ion Cyclotron Resonance Mass Spectrometry (FT-ICR MS). The basic theory, specific advantages and disadvantages, and application of each technique to study organic matter in wetlands are explained.   Finally, the integration of multiple techniques and organic soil components (C, nitrogen - N, and phosphorus - P) is stressed because findings from advanced spectroscopic experiments are strengthened upon combination of methods. By developing an understanding of novel instrumental tools and their application to wetlands, we will move forward in addressing important analytical questions relating to wetland soil organic matter.

Contact Information: Anna E. Normand, Department of Soil and Water Science, University of Florida, 106 Newell Hall, P.O. Box 110510, Gainesville, FL 32611 USA, Phone: 352-392-1803 Fax: 352-392-3399 Email: evangeline@ufl.edu

SEASONAL PATTERNS IN GREENHOUSE GAS EMISSIONS FROM US GULF COAST BALDCYPRESS SWAMPS

Brian J. Roberts[1], ***Samantha B. Primer*[1],** *Tiffany R. Warner*[1], *Carrie M. Semmler*[1], *Brendan Young*[1] and *Beth Middleton*[2]

[1]Louisiana Universities Marine Consortium, Chauvin, LA, USA

[2]U.S. Geological Survey National Wetlands Research Center, Lafayette, LA, USA

Freshwater diversions are often used to decrease salinity and/or increase sediment delivery to promote land building, but can also other impacts on coastal environments. One of the proactive actions taken in Louisiana to prevent the oiling of coastal environments following the 2010 Deepwater Horizon oil spill incident was to open most of the Mississippi River freshwater diversions to full or close to full capacity in an attempt to push oil away from coastal wetlands in Louisiana south of New Orleans. In total, these diversions rerouted ~35000 cfs (~1000 m3 s-1) of Mississippi River water out through Louisiana's sensitive coastal wetlands. One of these diversions, Davis Pond (10,650 cfs or 302 m3 s-1), increased the freshwater flow through our long-term study sites of baldcypress swamp function in Jean Lafitte National Historic Park. In addition to changing the hydrology, freshwater diversions can also increase the delivery of nutrients and other solutes to downstream ecosystems. All of these changes can potentially influence wetland greenhouse gas emissions.

We are studying the impacts of this hydrological remediation on ecosystem processes related to elevation maintenance including production, decomposition, tree growth, and regeneration and soil respiration and greenhouse gas fluxes. Throughout 2011, we studied ecosystem processes seasonally in three coastal baldcypress swamps across the US Gulf Coast including a hydrologic remediation site (Jean Lafitte National Historical Park in LA) and two control sites (Big Thicket National Preserve in TX and St. Marks National Wildlife Refuge in FL). Here, we will present results on seasonal patterns of net carbon dioxide, methane, and nitrous oxide emission rates from baldcypress swamp sites in Texas, Louisiana, and Florida based on 6-8 sampling dates for 5-6 plots at 3 sites in each park. Soil respiration and greenhouse gas fluxes were measured using the static chamber method and the floating chamber where water depth exceeded 10cm. Additionally, we assessed potential denitrification rates for control and amended (C, P, and one of three N addition levels) soils from the 3 study sites in each park using the acetylene inhibition method. These results represent some of the first measurements of rates and controls on baldcypress swamp greenhouse gas emissions and denitrification.

Contact Information: Brian J. Roberts, Louisiana Universities Marine Consortium, 8124 Highway 56, Chauvin, LA 70344 USA, Phone: 985-851-2821, Fax: 985-851-2874, Email: broberts@lumcon.edu

SPATIAL VARIABILITY OF DISSOLVED ORGANIC CARBON AND SULFATE IN GROUNDWATER IN CENTRAL PENNSYLVANIA HEADWATER WETLANDS

***Aliana Reichert-Eberhardt*[1]**, *Denice Wardrop*[1,2] and *Elizabeth Boyer*[3]

[1]Intercollegiate Graduate Degree Program in Ecology, The Pennsylvania State University, University Park, PA, USA
[2]Geography Department, The Pennsylvania State University, University Park, PA, USA
[3]School of Forest Resources, The Pennsylvania State University, University Park, PA, USA

Dissolved organic carbon (DOC) and sulfate are known to be important factors in many microbially-mediated biogeochemical processes, such as mercury methylation, that occur in wetlands. The spatial variability of DOC and sulfate within a wetland could determine the distribution of microhabitats for specific microbial communities that fuel mercury methylation. However, it is unknown how anthropogenic disturbance to wetlands can affect spatial variability of DOC or sulfate. Previous research in central Pennsylvania headwater wetland soils has shown that wetlands impacted by anthropogenic activity had decreased heterogeneity in soil microbial parameters, but did not address groundwater. In this study, 20 monitoring wells were installed in a random pattern in a 400m^2 plot in three low-disturbance headwater wetlands and three high-disturbance headwater wetlands in central Pennsylvania. Water samples from these wells will be analyzed for DOC, dissolved inorganic carbon, nitrate, ammonia, total mercury (tHg), total methylmercury (tMeHg), sulfate concentrations, pH, conductivity, and temperature. It is hypothesized that there will be greater spatial variability of DOC and sulfate in the low disturbance wetland than the high disturbance wetland, and that this spatial variability will be reflected in tHg and MeHg concentrations. This poster will present the initial data concerning DOC and sulfate spatial variability as well as initial tHg and tMeHg results. Preliminary results indicate that variability of DOC and tMeHg is high at both disturbed and undisturbed sites and that sulfate concentrations are significantly higher at disturbed sites.

Contact Information: Aliana Reichert-Eberhardt, Intercollegiate Graduate Degree Program in Ecology, The Pennsylvania State University, 217 Walker Building, University Park, PA 16802 USA, Phone: (814) 863-2962. Email: ajr314@psu.edu

UNDERSTANDING ANAEROBIC C DYNAMICS AND METHANE PRODUCTION IN PEATLANDS THROUGH MOLECULAR CHARACTERIZATION OF POREWATER DOM REACTIVITY: OXYGEN SHEDDING BY DOM DURING FERMENTATION

Malak M.Tfaily[1], *J. Elizabeth Corbett*[1], *Jeffrey P. Chanton*[1], *Paul H. Glaser*[2], *William T. Cooper*[2], *David J. Burdige*[3] and *Paul H. Glaser*[4]

[1]Earth, Ocean, and Atmospheric Science, Florida State University, Tallahassee, FL, USA
[2]Chemistry and Biochemistry, Florida State University, Tallahassee, FL, USA
[3]Ocean, Earth and Atmospheric Sciences, Old Dominion University, Norfolk, VA, USA
[4]Earth Sciences, University of Minnesota, Pillsbury Hall, Minneapolis, MN, USA

We used UV-Vis absorption spectroscopy, Excitation/Emission Matrix (EEM) fluorescence spectroscopy and ultrahigh resolution Fourier Transform Ion Cyclotron Resonance Mass Spectrometry (FT-ICR-MS) to identify the source of the excess anaerobic CO_2 production in peatlands relative to methane production, and investigate the differences in the reactive and refractory DOM pools supporting methanogensis in two distinctly different peatland formations within the Glacial Lake Agassiz Peatlands (GLAP) of northern Minnesota: bogs and fens. Our data demonstrates that organic matter held under sub-aqueous sub-oxic conditions sheds organically bound oxygen presumably to produce CO_2 associated with fermentation. Moreover, this effect was more pronounced in sedge-dominated fen peatlands than *Sphagnum*-dominated peatlands, consistent with the hypothesis that fen DOM is more reactive than bog DOM.

Only 76 % of the molecular formulas generated in the surface fen samples were maintained in the deep fen porewater samples, with 24 % non-matching molecular formulas. In particular, compounds with high O/C ratio were consumed with depth at the fen sites with considerable formation of compounds with low O/C and high H/C ratios, indicative of organic matter fermentation. In contrast, 83 % of the molecular formulas observed in the surface bog samples were also present in the deep bog porewater samples. Compounds with high O/C ratios also appear to be consumed with depth with some formation of compounds with low O/C. The finding of 83% identical formulas between surface and deep samples indicate that the majority of bog DOM is refractory compared to the more reactive character of fen DOM.

Contact Information: Malak. M.Tfaily, Florida State University, Department of Earth, Ocean, and Atmospheric Science, Tallahassee, FL 32306, USA, Phone: 8502749385; Email: mmt07d@fsu.edu

THE BURNING OF NORTHERN PEATLANDS: ARE WE APPROACHING A TIPPING POINT?

Merritt R. Turetsky
Department of Integrative Biology, University of Guelph, Guelph, ON, CAN

Climate change has increased both annual area burned and the severity of biomass combustion in some boreal regions. For example, there has been a four-fold increase in late season fires in Alaska over the 10 years relative to the previous 5 decades. Such changes in the fire regime are expected to stimulate ecosystem carbon losses through fuel combustion, reduced primary production, and increased decomposition. Because most northern fire research has focused on forests, our understanding of the importance of fire to peatland ecology and carbon cycling is very limited.

Peatlands have a number of stabilizing mechanisms that increase their resilience to perturbations. For example, thick moss and peat layers buffer surface soils and permafrost from fluctuating hydrology and air temperatures and also inhibit flaming combustion during fires. Because of their resistance to burning, there are strong positive correlations between pre- and post- fire peat thickness that persist through multiple fire cycles. However, recent research has highlighted the potential for regime shifts in northern peatlands associated with interactions between climate and disturbances. Thawing permafrost in peat plateaus leads to a state change with the creation of thermokarst bogs or fens, causing large changes in vegetation as well as carbon and energy fluxes. Drainage of forested peatlands can increase woody biomass, which lowers the resistance of peatlands to burning, accelerates burning of deep peat layers, and may lead to new trajectories of vegetation succession. Our understanding of these changes and their consequences for the carbon source/sink capacity of ecosystems is still limited, but point to the potential for new climate-fire relationships for the boreal biome.

Contact Information: Merritt R. Turetsky, Department of Integrative Biology, University of Guelph, Guelph, Ontario N1G 1G2, Canada, Phone: 519-824-4120 ext 56166, Email: mrt@uoguelph.ca

INFLUENCE OF EXTRACELLULAR ENZYME ACTIVITIES ON MACROELEMENTAL CYCLING IN SUBTROPICAL TREATMENT WETLANDS

Christine M. VanZomeren*, Rupesh K. Bhomia, Kanika S. Inglett* and *K. Ramesh Reddy*
Univeristy of Florida, Gainesville, FL, USA

Soil enzyme activities are used as proxies to microbial mineralization of organically bound macro-elements including carbon (C), nitrogen (N), and phosphorus (P). Enzymes play key roles in hydrolyzing complex polymers into simple labile compounds. This study compares the activities of select extracellular enzymes including: alkaline phosphatase (monoesterase), phosphodiesterase, β-glucosidase, and leucine aminopeptidase, in floc, recently accreted and underlying native soil of Stormwater Treatment Area-2 (STA-2) of the Everglades. The STA-2 has been in use for 10 years supporting a combination of emergent and submerged aquatic vegetation. We hypothesized that enzyme activities will decrease with soil depth and influenced by type of vegetation (emergent and submerged aquatic vegetation). Triplicate soil cores were obtained from the center of each cell and sectioned into floc, newly accreted and native soil sections. Newly accreted soil is material accreted after the creation of STA-2 and native soil is peat (formerly used for agriculture). Extracellular enzyme activities with depth were quantified using the microplate fluorimetric enzyme assay using 4-methylumbellerone (MUF) and its conjugates for alkaline phosphatase, phosphate diesterase, and β-glucosidase. Leucine aminopeptidase was quantified using 7-amino-4-methyl coumarin and its conjugate. Physiochemical characteristics of each sample was analyzed for soil moisture content, bulk density, total C, N, and P, $\delta^{15}N$ and $\delta^{13}C$, extractable NH_4^+, potentially mineralizable N (PMN), microbial biomass C, N, and P, and respiration of CO_2 and CH_4. Preliminary results showed that in general, floc has the highest enzyme activity while enzyme activity decreases with soil depth until native soil is reached. Native soil does not follow the pattern of enzyme activity of newly accreted soil. Ongoing research includes determining potential relationships between extracellular enzyme activities and biogeochemical properties related to cycling of C and N.

Contact Information: Christine M. VanZomeren, Soil and Water Science Department, University of Florida, Gainesville, FL 32611 USA, Phone: 352-392-1803, Fax: 352-392-3399, Email: cvanzomeren@ufl.edu

DETERMINING THE ROLE OF DIFFERENT WETLAND PLANT COMMUNITIES ON THE EXPORT OF DISSOLVED ORGANIC CARBON IN THE FLORIDA EVERGLADES – A MESOCOSM EXPERIMENT

Jorge A. Villa and *William J. Mitsch*
The Ohio State University, Columbus, OH, USA

Dissolved organic carbon (DOC) plays an important role in wetlands ecosystems; for example, it can be an energy source supporting microbial activity and can also control the availability of other nutrients. We investigated the role of different wetland plant communities in the export of DOC from wetlands mesocosms, using carbon stable isotope signatures to assess the relative contribution of different carbon pools (i.e. inflow water, vegetation, soils) to the DOC in the outflows of 18 flow-through wetland mesocosms. These mesocosms consisted of fiberglass tanks (6 m x 1 m x 1 m) planted in a randomized block design with the following six treatments: sawgrass (*Cladium jamaicense*), waterlily (*Nymphaea*), cattail (*Typha domingensis*), submerged aquatic vegetation - SAV (*Najas guadalupensis/Charas spp.*), water lily/*Eleocharis* mixture, and an unplanted control left to self-design. The inflow water is the main source of DOC exported from the mesocosms with.contributions of aboveground biomass to these exports similar in most of the treatments (~10 %) except for a lower effect from submerged aquatic vegetation (~5%). These results suggest that exports of DOC can be reduced in wetlands with submerged vegetation which in turn have implications for wetland design and management in south Florida.

Contact Information: Jorge A. Villa, Wilma H. Schiermeier Olentangy Wetland Research Park, The Ohio State University, Columbus, OH 43202, USA, Phone: 614-688-8410, Email: villa-betancur.1@osu.edu

HORIZONTAL AND VERTICAL VARIABILITY IN SOIL BULK DENSITY AND ORGANIC MATTER ACROSS COASTAL LOUISIANA WETLANDS DETECTED BY THE COAST-WIDE REFERENCE MONITORING SYSTEM (CRMS)-*WETLANDS*

Hongqing Wang[1], *Gregory D. Steyer*[1], *Sarai C. Piazza*[1], *Guerry O. Holm, Jr*[2]., *Camille L. Stagg*[3], *John M. Rybczyk*[4], *Craig J. Fischenich*[5], *Brady R. Couvillion*[1], *Ronald G. Boustany*[6], *Michelle R. Fischer*[1] and *Leigh A. Sharp*[7]

[1]U.S. Geological Survey, Baton Rouge, LA, USA
[2]CH2M HILL, Baton Rouge, LA, USA
[3]U.S. Geological Survey, Lafayette, LA, USA
[4]Western Washington University, Bellingham, WA, USA
[5]U.S. Army Corps of Engineers, Vicksburg, MS, USA
[6]U.S. Department of Agriculture, Lafayette, LA, USA
[7]Louisiana Governor's Office of Coastal Protection and Restoration, Baton Rouge, LA, USA

The horizontal and vertical variability in wetland soil bulk density (BD) and organic matter (OM) affect our ability to predict changes in spatial patterns of vertical accretion, surface elevation and soil organic carbon (SOC) sequestration under future climate change, sea level rise, and water and sediment management associated with coastal ecosystem restoration. Detecting the large scale horizontal and vertical variability in BD/OM is crucial for coastal Louisiana where complicated interaction of natural and anthropogenic factors impact physical and biological processes at the sediment surface and subsurface, and eventually the formation of wetland soils. There are few studies that examine the coast-wide horizontal and vertical variability in BD/OM. Previous studies have been limited by insufficient sample sizes, inconsistent sampling and analysis methods, and lack of updated BD/OM data needed for restoration assessment purposes. Soil data collected during 2006-2008 from the Coast-wide Reference Monitoring System (CRMS) allow us to study the horizontal and vertical variability in BD/OM by hydrologic basins and vegetation types, and as influenced by hurricanes, restoration activities, and land loss rates across coastal Louisiana.

We classified CRMS soil data from 330 sites into nine hydrologic basins and six vegetation types. Within these areas, impacts of hurricane (directly and indirectly impacted), restoration (within and outside restoration projects) and wetland loss rates (low, medium and high) on the horizontal and vertical variability in BD/OM across coastal Louisiana were assessed using three-way and two-way ANOVA.

Variations in horizontal BD/OM reflect the broader spatial variability in contributions of both mineral sediment and organic matter that influence vertical accretion and soil formation. Vertical variability in BD/OM, especially for saline marshes, demonstrates sedimentation dynamics and above- and below-ground organic growth that are affected by natural and anthropogenic disturbances at different spatial and temporal scales. Therefore, evaluating and modeling coastal wetland sustainability by assessing the impacts of SLR, subsidence and restoration on vertical accretion and surface elevation change should utilize spatially 'representative' BD/OM values owing to the BD/OM characteristics across coastal Louisiana: spatial non-stationarity and vertical non-equilibrium.

Contact Information: Hongqing Wang, Coastal Restoration Assessment Branch, National Wetlands Research Center, U.S. Geological Survey, c/o Livestock Show Office, Parker Coliseum, LSU, Baton Rouge, LA 70803 USA, Phone: 225-578-7482, Fax: 225-578-7927, Email: wangh@usgs.gov

HYDROLOGICAL DRIVERS OF ORGANIC MATTER QUALITY, MINERALIZATION, AND EXPORT IN A TROPICAL DAM-IMPACTED FLOODPLAIN SYSTEM

***Roland Zurbrügg*[1,2]**, *Stephan Suter*[1], *Moritz F. Lehmann*[3], *Bernhard Wehrli*[1,2] and *David B. Senn*[1,2]
[1]ETH Zürich, Institute of Biogeochemistry and Pollutant Dynamics, Zürich, Switzerland
[2]Eawag, Swiss Federal Institute of Aquatic Science and Technology, Surface Waters - Research and Management, Kastanienbaum, Switzerland
[3]University of Basel, Institute of Environmental Geosciences, Basel, Switzerland

Tropical floodplains are ecologically valuable and highly productive wetlands, that are known to produce, transform, and export large quantities of organic carbon (OC) and organic nitrogen (ON) to downstream systems. Hydrological exchange between the river and the floodplain (river-floodplain exchange) has been identified as a key process for mobilization and transformation of organic matter (OM) in temperate floodplains. However, linked biogeochemical and hydrological processes are still poorly understood in tropical floodplain systems.

We studied how OC and ON dynamics are related to hydrological processes in the Kafue Flats, a 6,500-km^2 floodplain along the Kafue River, the largest tributary to the Zambezi River in Southern Africa. Since the 1970s, the extent and duration of flooding in the Kafue Flats has been altered by upstream and downstream dams. The goal of the study was to explore the source and quality of OC and ON, and how river-floodplain exchange influences the net export of OM, its composition, as well as system-scale OM mineralization. We collected samples along a 410 km transect along the Kafue River within the Kafue Flats in 2009 and 2010 to measure dissolved gases, concentrations and stable isotopes of dissolved and particulate OC (DOC, POC) and ON (DON, PON), as well as spectrofluorometric properties of dissolved OM (DOM).

During the flooding period, the Kafue Flats and Kafue River undergo intense river-floodplain exchange, illustrated by >80% of the stream flow passing through the floodplain. As a result, DON and DOC loads increased 2.5-fold along the main river channel, while POC and PON loads decreased. The vast majority of fixed nitrogen was present as organic N (80% DON and 14% PON). Despite the large contribution of floodplain-derived DOM, measured variables of DOM quality remained relatively constant (DOC:DON = 20±2 δ^{15}N-DON = +1.5±1.0‰) along the river. Spectrofluorometric results suggest that DOM was primarily of terrestrial origin and DOM composition remained fairly constant along the river, despite quantitative injection of floodplain-derived DOM. Particulate OM properties (δ^{13}C-POC = -28.3±0.8‰, δ^{15}N-PON = +2.8±1.2‰, and POC:PON = 9±1) differed considerably with respect to DOC and DON, indicating different sources of DOM and particulate OM, which we found largely consisted of microbial biomass from the upstream reservoir and the floodplain.

Despite considerable OM exports from the Kafue Flats, the vast majority of the floodplain primary production, is buried or mineralized in the floodplain as suggested by the O_2-depleted (<20 µM) floodplain waters during inundation. Intense exchange with these floodplain waters resulted in an annually recurring, steep decline in river-O_2 concentration from 160 µM to <30 µM over a 20 km river reach. Continuous hypoxic floodplain-water inflows maintained low dissolved O_2-levels for additional 150 km. Due to high river-floodplain exchange in this system, this integrated oxygen deficit and the consequent CO_2 supersaturation was used to estimate OM mineralization on a system-scale.

This presentation explores the potential causes for the fairly constant DOM composition and the distinct DOM and POM pools, and how the draining river can be used as integrator to constrain of physical and biogeochemical floodplain processes.

Contact Information: Roland Zurbrügg, ETH Zürich, Institute of Biogeochemistry and Pollutant Dynamics (IBP), Universitätstrasse 16, 8092 Zürich, Switzerland¨. Phone: +41 44 632 37 33, Mobile: +41 79 262 03 32, Email: roland.zurbruegg@env.ethz.ch

BIOGEOCHEMISTRY AND MICROBIAL ECOLOGY - LINKAGES BETWEEN MICROBIAL ECOLOGY AND BIOGEOCHEMICAL FUNCTIONS

THE EFFECT OF SALTWATER INTRUSION ON MICROBIAL COMMUNITY STRUCTURE AND FUNCTION IN A TIDAL FRESHWATER MARSH

David J. Berrier[1], *Rima B. Franklin*[1], *Joseph M. Battistelli*[2] and *Scott C. Neubauer*[3]

[1]Virginia Commonwealth University, Department of Biology, Richmond, VA, USA
[2]University of Virginia, Department of Environmental Science, Charlottesville, VA, USA
[3]University of South Carolina, Baruch Marine Field Laboratory, Georgetown, SC, USA

Sea level rise is a climatic stressor that has a unique impact on tidal freshwater wetlands. It causes saltwater intrusion into environments historically dominated by freshwater flows, where even modest increases in salinity can adversely affect plant community composition and productivity, and potentially change ecosystem-scale carbon dynamics. In addition, microbial activity in the wetland soils may also be affected because the influx of sulfate offers a new substrate for anaerobic microbial respiration, shifting redox conditions and changing pathways of carbon mineralization. The objective of this research was to determine microbial community responses to elevated salinity associated with a long-term field study in a tidal freshwater marsh in South Carolina, where *in situ* manipulation consistently raised porewater salinities from freshwater to oligohaline levels (~2-5 ppt).

At the end of the three-year field manipulation, soil cores were collected and extracellular enzyme assays (EEA) were performed for several labile (β-1,4-glucosidase and 1,4-β-cellobiosidase) and recalcitrant (β-D-xylosidase, phenol oxidase, and peroxidase) components of the soil carbon pool. Saltwater addition did not have a consistent effect on EEA of the labile substrates, but activity decreased dramatically for the more recalcitrant substrates. For example, the activity of phenol-oxidase and peroxidase enzymes in the saltwater-added plots were 10-20% of the activity in the control plots. This could be important due to potential long-term effects on organic matter decomposition, which may play a role in wetland sediment accretion and net carbon storage in wetlands. These changes in microbial activity were coincident with changes in microbial community structure as assayed using whole-community DNA fingerprinting. Specifically, terminal restriction fragment length polymorphism (T-RFLP) demonstrated a significant shift in community composition in response to saltwater addition for all four microbial groups that were studied: bacteria, archaea, methanogens, and sulfate reducers. Combined with the observed changes in biogeochemical rate measurements describe elsewhere, this research not only demonstrates a link between community structure and function, but signifies a community response to global change capable of affecting ecosystem-level processes. Furthermore, these results demonstrate that not only do the individual functional groups undergo alterations, but the microbial communities' net activity is altered by global change stimuli.

Contact Information: Rima B. Franklin, Virginia Commonwealth University, Department of Biology, 1000 W Cary Street, Richmond, VA 23284 USA, Phone: 804-828-6753, Fax: 804-828-0503, Email: rbfranklin@vcu.edu

CHARACTERIZATION OF MICROBIAL CARBON CYCLERS USING STABLE ISOTOPE APPROACHES

***Lindsay Darjany**, Christine Whitcraft* and *Jesse Dillon*
California State University Long Beach, Long Beach, CA, USA

Organic matter within salt marshes originates from a variety of sources including algal mats, vascular plants, phytoplankton and terrestrial inputs. All of these forms of carbon can be decomposed or transformed by microorganisms under both aerobic and anaerobic conditions, making microbes the primary drivers of carbon degradation and export in these systems. However, very little is known about the role of microbes in the biogeochemistry of southern California salt marshes, especially those that have been impacted by human development. Most models of salt marsh carbon cycling place microbial processes in a "black box", linking microbes with their function only by correlation or spatial association. The goal of this study was to use novel and traditional stable isotope approaches to directly identify key microbial decomposers in a restored salt marsh.

We examined carbon utilization by microbes and infauna in the Talbert salt marsh in Huntington Beach, California, which possesses *Spartina foliosa*, a common Cordgrass, and microalgal mats. DNA stable isotope probing (SIP) of bacteria and fungi utilizing ^{13}C labeled lignocellulose, a major component of *S. foliosa*, was used to identify sediment microbes responsible for macrophyte degradation. Cloned 16S rRNA sequences of labeled bacteria include representatives in the following groups: Oceanospirillales, Rhizobiales, Bdellovibrionales, Desulfuromonadales, Spirochaetales, and Acidimicrobiales. Fungal DNA was not amplifiable from heavy fractions, but was easily amplified from light fractions, suggesting that fungi were present in the sample, but did not utilize the lignocellulose. In addition, carbon enrichment of algal mats and nitrogen enrichment of *S. foliosa* was used to identify invertebrate infauna utilizing algal versus macrophyte derived carbon, respectively. Algal mats were directly labeled with ^{13}C bicarbonate and *Spartina* was labeled with ^{15}N ammonium sulfate. Data show high nitrogen enrichment of insect larva from labeled *S. foliosa* and high carbon enrichment of tubificid oligochaetes and capitellid polychaetes from labeled microalgae.

This study is among the few to examine both the microbial and infauna consumption of primary production simultaneously in a southern California salt marsh. If these organisms are selectively degrading abundant plant material, carbon export could be dependent on them or the source they are degrading.

Contact Information: Lindsay E. Darjany, Department of Natural Sciences and Mathematics, California State University Long Beach, 1250 Bellflower Blvd. Long Beach, CA 90840 USA, Phone: (562) 706-4571 Email: lindsay.darjany@student.csulb.edu

TRANSFER AND BIODEGRADATION OF CHLOROACETAMIDE HERBICIDES IN LAB-SCALE WETLANDS

Gwenaël Imfeld[1], *ElodieMaillard*[1], *Omniea Elsayed*[1], *Hans Richnow*[2] and *Stéphane Vuilleumier*[3]
[1]Laboratory of Hydrology and Geochemistry of Strasbourg (LHyGeS), University of Strasbourg/ENGEES, CNRS, Strasbourg Cedex, France
[2]Department of Isotope Biogeochemistry, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany
[3]Laboratory of Molecular Genetics, Genomics and Microbiology, University of Strasbourg, CNRS, Strasbourg cedex, France

Chloroacetamide herbicides are extensively used in the U.S. and in Europe in a variety of crops, including maize, sugar beet or sunflower. The major attenuation process of chloroacetamides in water and soil ecosystems is biodegradation. Biodegradation can be enantioselective, hereby changing the enantiomeric signatures of chiral chloroacetamide pesticides. However, knowledge on the transfer and biodegradation of chloroacetamides in wetlands in relation with changes in the biogeochemical conditions and the enantiomeric signatures is scarce. Here we examine the transfer and in situ biodegradation of metolachlor, alachlor and acetochlor in lab-scale wetlands by combining hydrochemical and biomolecular approaches with enantiomeric and compound-specific isotope analysis (CSIA). Changes in prevailing biogeochemical conditions were evaluated using redox-sensitive species.

A gradient of dissolved oxygen (DO) from the inlet to the outlet was observed in the wetlands, with DO ranging from 6.8 ± 0.8 to 0.7 ± 1.3 mg L-1. Changes in the herbicides, their enantiomeric signatures and their degradation products were quantified over the flow path and over time. A CSIA method was developed and applied for the first time to assess the occurrence of in situ biodegradation of chloroacetamide herbicides in wetlands. Changes in the carbon isotope composition of chloroacetamides in the wetland was significant ($\Delta\delta 13C > 1$ ‰), which indicates their in situ biodegradation. In parallel, PCR-T-RFLP analyses of 16S rRNA bacterial genes was used to reveal spatial and temporal variations in the structure of the pore water bacterial communities in the lab-scale wetlands.

Based on a multiple-method approach, the results show the linkage between the microbial communities, changes of hydrochemical conditions and degradation of chloroacetamide herbicides in wetlands. This comprehensive approach can help in assessing and better understanding the transfer and the biodegradation of chloroacetamide herbicides in biogeochemically complex and dynamic environmental systems, such as wetlands.

Contact Information: Gwenael Imfeld, Laboratory of Hydrology and Geochemistry (LHyGeS), University of Strasbourg/ENGEES, CNRS, 1 rue Blessig, 67084 Strasbourg Cedex, France, Phone: + 333-6885-0407, Email: imfeld@unistra.fr

METHANE EMISSION AND MICROBIAL COMMUNITIES OF THE METHANE CYCLE IN NATURAL AND DRAINED PEATLANDS

Irina K. Kravchenko[1], *Anna K. Kizilova*[1] and *Andrey A. Sirin*[2]
[1]Winogradsky Institute of Microbiology RAS, Moscow, Russia
[2]Institute of Forest Science RAS, Uspenskoe, Moscow region, Russia

Atmospheric methane produces the second-largest radiative forcing among the long-lived greenhouse gases after CO_2. Since wetlands are considered to be the major natural sources of methane, estimation of the relative contribution and biological controls of different methane sources to the atmospheric concentration of CH_4 is an important task in addressing the problem of Global warming.

Field measurements, including year-round ones, of methane, carbon dioxide and other greenhouse gases' fluxes, have been performed on natural peatlands, different elements of drainage network and flooded zones of roads and other linear constructions in testing regions of European Russia (Tver and Moscow Regions). We found an increase of methane and carbon dioxide emissions with rising of mineral and organic content. The key effect of water flow rate on water degassing which increase GHG flux rates from channels was found, and this phenomenon was confirmed by observations in upstream and downstream waters of dams and barriers of various origins. Calculations revealed the fact that contribution of drained peatlands to methane emission considering only drainage network emissions could reach or even exceed 1/3 of emissions from natural peatlands

Changes in microbial communities, involved in methane cycle, have been detected. The study assessed the diversity of methanogenic and methanotrophic populations in natural and drained peats using PCR - based approaches targeting functional genes, i.e. *pmoA* (α-subunit of the particulate methane monooxygenase) for methanotrophy and *mcrA* (α-subunit of the methyl-coenzyme M reductase) for methanogenesis as well as the phylogenetic 16S rRNA genes. Our results demonstrated that methanogens in natural peatlands were almost exclusively composed of hydrogenotrophs, whereas both hydrogenotrophs and acetotrophs were almost equivalent in the drained peats. The study revealed striking difference between methanotrophs of natural and drained peatlands. Sequence analysis of markers, pmoA and the 16S rRNA genes, suggested that methanotrophic *Alphaproteobacteria* with *Methylocystis* as most close relative dominate in natural peatlands. In the drained peats *Methylobacter* may be an important group actively involved in CH_4 oxidation.

Contact Information: Irina Kravchenko, Laboratory of Microbial Survival, Winogradsky Institute of Microbiology RAS, Prospekt 60-let Oktyabrya 7/2, 117312, Moscow, Russia. Phone: 7-499-1357573, Fax: 7-499-1356530.
Email: irinakravchenko@inbox.ru

LINKING ORGANIC MATTER BREAKDOWN TO ABUNDANCE AND COMMUNITY COMPOSITION OF DENITRIFICATION AND DNRA MICROORGANISMS IN TIDAL WETLANDS

Ember M. Morrissey, *Joseph C. Morina, Jaimie L. Gillespie* and *Rima B. Franklin*
Biology, Virginia Commonwealth University, Richmond, VA, United States

Wetland systems have the capacity to remove excess nitrate from surface waters, preventing downstream eutrophication and coastal hypoxia. The two main microbial processes that reduce nitrate are denitrification (DNF), which transforms nitrate to dinitrogen gas, and dissimilatory nitrate reduction to ammonium (DNRA). The relative impact of each process is believed to be influenced by soil organic matter quality and availability, but uncertainty remains as to the causes and consequences of these relationships. To address this question, we sampled ten tidal freshwater wetlands associated with three river systems in Chesapeake Bay watershed and examined the effects of soil conditions, and organic matter breakdown on the distribution and abundance of DNF and DNRA bacteria. Extracellular enzyme assays were used to measure the degradation of both labile (β-1,4-glucosidase and 1,4-β-cellobiosidase) and recalcitrant (β-D-xylosidase, phenol oxidase) components of the soil organic carbon pool. Molecular methods were used to examine the DNF and DNRA communities for functional group abundance (qPCR) and differences in community composition (T-RFLP).

Sites differed significantly with respect to sediment characteristics and extracellular enzyme activity (EEA). Principal components analysis revealed that EEA associated with labile organic compounds was higher in sediments characterized by a low C:N ratio, while EEA of recalcitrant compounds was higher in sediments with abundant soil organic matter. The DNF community composition was correlated with labile carbon degrading extracellular enzyme activity (1,4-β-cellobiosidase; $r=0.23$, $p=0.001$). Conversely, DNRA community composition was related to recalcitrant (β-D-xylosidase, phenol oxidase) and labile (β-1,4-glucosidase) organic matter degrading enzyme activity (all $p <0.02$). These results suggest DNF and DNRA communities may be reliant on different types of organic matter for heterotrophic nitrate reduction.

Overall, this work indicates DNF and DNRA microbial communities in wetlands are regulated by the biotic ecosystem characteristics such as organic matter breakdown. A greater understanding of which process occurs, and under what conditions, is important as the balance determines whether N stays in the ecosystem for further cycling (DNRA) or leaves to the atmosphere as gaseous end products (DNF) preventing downstream eutrophication.

Contact Information: Ember Morrissey, Virginia Commonwealth University, Department of Biological Sciences, 1000 W Cary St, Richmond, VA 23284, Phone: 804-828-0125, Fax: 804-828-0503, Email: morrisseyem@vcu.edu

LIFE AT THE FRONT: MICROBIAL ECOLOGY OF SHIFTING NUTRIENT LIMITATIONS AND METHANOGENESIS IN THE NORTHERN EVERGLADES

***Andrew Ogram*[1]**, *Hee-Sung Bae*[1], *Beth Huettel*[2], *Z. He*[3], *J. Chanton*[2] and *J. Zhou*[3]
[1]University of Florida, Gainesville, FL USA
[2]Florida State University, Tallahassee, FL USA
[3]University of Oklahoma, Norman, OK USA

Much of the ecosystems of the Florida Everglades are adapted to extreme phosphorus limitation, and are characterized by relatively low primary productivity, low peat accumulation rates, and low methanogenesis rates. In recent years, however, the marshes of the northern Everglades have been exposed to relatively high concentrations of phosphorus in runoff from the adjacent Everglades Agricultural Area. Phosphorus, and to a lesser extent sulfate, are moving south into the interior of Water Conservation Area 2A (WCA-2A), resulting in ecosystem-level changes occurring around the nutrient front. These changes are characteristic of alleviation of the original phosphorus limitation, and include displacement of native sawgrass (*Cladium jamaicense*) by cattail (*Typha sp*.) and increases in peat accumulation. Concomitant with the increased carbon input to WCA-2A soils are well-documented increases in microbial biomass and rates of methanogenesis, anaerobic respiration, sulfate reduction, and nitrogen fixation.

Changes in rates and pathways for plant decomposition and biogeochemical cycles are ultimately controlled and reflected in soil microbial communities. We are employing a suite of tools to investigate potential shifts in microbial community structure and function at various locations along the nutrient gradient in WCA-2A with the goal of developing a greater mechanistic understanding of the impacts of nutrient enrichment on methane production in wetlands.

Increased rates of biogeochemical cycling associated with the advancing nutrient front in WCA-2A are strongly linked to changes in microbial community structure that reflect increased functional catabolic diversity in addition to increases in biomass. Approximately 888 different genes related to carbon metabolism were detected by the functional microarray GeoChip in transition area soils compared to 290 genes in unimpacted soils, representing a 306% increase in genetic diversity. This increase in genetic diversity indicates that alleviation of the phosphorus limitation allowed a significant expansion of catabolic diversity, which likely contributed to more rapid plant decomposition, which in turn led to greater rates of methane production.

As expected from the higher rates of methane produced in transition soils relative to unimpacted soils, numbers of methanogenic Archaea are significantly higher in transition soils. In addition, the phylogenetic affiliations of the dominant methanogens in the two areas are significantly different, with a relatively greater proportion of hydrogenotrophic methanogens to acetrophic methanogens in the transition area soils than in the low phosphorus soils. This shift in composition is also reflected in the $\delta^{13}CH_4$, which indicates a shift toward greater contribution of hydrogenotrophic methane. These differences in composition are consistent with depth from 1 cm to 10 cm. The mechanisms controlling the shift from a primarily acetotrophic pathway toward a hydrogenotrophic pathway is not clear at this time, and is the focus of ongoing research.

Contact Information: Andrew Ogram, Soil and Water Science Dept., PO Box 110290, University of Florida, Gainesville, FL 32611 USA, Phone: 352-392-1951, Fax: 352-392-3902, Email:aogram@ufl.edu

LINKAGES BETWEEN MICROBIAL BIOMASS AND LITTER DECOMPOSITION IN TIDAL FORESTED WETLANDS

Kathryn N. Pierfelice[1], *B. Graeme Lockaby*[1], *Gregory B. Noe*[2] and *Ken W. Krauss*[3]
[1]Auburn University, Auburn, AL, USA
[2]U.S. Geological Survey, Reston, VA, USA
[3]U.S. Geological Survey, Lafayette, LA, USA

Tidal wetlands are unique and productive ecosystems in the southeastern United States, and are highly susceptible to ecological changes. Many of these wetlands are vulnerable to rising sea level and developmental impacts; however they have not been researched to the extent of other wetlands. Consequently, considerable ambiguity exists in regard to their belowground biogeochemical processes and impacts on nutrient cycling. Sustainability of forested systems relies on nutrients derived from the breakdown of organic matter by microbes. To study these processes, litter decomposition and microbial biomass are examined across three sites along a salinity gradient on the Waccamaw River in South Carolina, from continuously freshwater to intermediately salt-impacted to fully salt-impacted tidal forested wetlands. Primary objectives of this study include quantifying microbial biomass C and N, determine rates of litter decomposition, and compare changes along the salinity gradient utilizing biogeochemical indices.

Preliminary data suggest that differences exist along the salinity gradient and that seasonal trends in microbial biomass also were prevalent. Microbial biomass C and N tended to decline along the salinity gradient from freshwater to fully salt-impacted. The intermediate and fully salt-impacted sites were significantly different from each other in terms of microbial biomass C in the winter and spring of 2011. The intermediate site measured 607 ug-C g-1 dry soil-1 in the winter then declined to 533 ug-C g-1 dry soil-1 in the spring. The fully salt-impacted site's microbial biomass C also declined during these seasons from 371 ug-C g-1 dry soil-1 to 357 ug-C g-1 dry soil-1. Seasonal trends for the freshwater site and intermediate sites showed maximum microbial C and N during the summer with declines through the next spring. The fully salt-impacted site was an exception with microbial N peaking at 30 ug-N g-1 dry soil-1 in the autumn of 2011. The litter decomposition study implemented in spring 2011 suggests the intermediate site had the least amount of mass remaining (65%) at week 12 compared to both freshwater (71%) and fully salt impacted (73%) sites. Microbial biomass C and N, at this time, was highest on the freshwater site, in contrast to highest rates of decomposition at the intermediate site. Also, at this time immobilization of N and P occurred at all sites and N/P ratios declined at both intermediate and fully salt-impacted (6 and 8, respectively) while increasing at the freshwater site (6 to 7). This study suggests that significant differences in microbe and decomposition processes occur along the salinity gradient, thus providing Information vital in understanding the impacts of sea level rise on tidal forested wetlands and their role in global biogeochemical cycles.

Contact Information: Kathryn N. Pierfelice, School of Forestry and Wildlife Sciences, 602 Duncan Dr., Auburn University, Auburn, AL 36849 USA, Phone: 740-973-2455, Email: knp0004@auburn.edu

MICROBIAL STRUCTURE AND FUNCTION IN FENS: RESPONSES TO CLIMATE CHANGE

***Lucia Sekulová*[1,2]**, *Luca Bragazza*[1,3,4] and *Alexandre Buttler*[1,3,5]
[1]EPFL, Lausanne, Switzerland
[2]Masaryk University, Brno, Czech Republic
[3]WSL- Swiss Federal Institute for Forest, Snow and Landscape Research, Lausanne, Switzerland
[4]University of Ferrara, Ferrara, Italy
[5]University of Franche-Comté, Besançon, France

Peatlands play an important role as sinks of atmospheric carbon (C). However, the enhanced microbial decomposition of organic matter in peatlands due to climate change could turn these ecosystems to potential C sources. The structure and function of microbial communities play then a key role in determining the rate of organic matter decomposition. The proximate agents of organic matter decomposition are the extracellular enzymes. A better knowledge about enzymatic processes is crucial for understanding the climate change effects on organic matter decomposition.

The effects of climate warming on soil microbes for nutrient acquisition, microbial diversity and variation in the enzymatic activities were investigated in rich fens along an altitudinal gradient in the Swiss Alps ranging from 815 to 2080 m a.s.l. so to simulate a natural gradient of increasing peat soil temperature. Chemical properties of the peat, microbial diversity, microbial nutrient content and enzymatic activities of five extracellular enzymes (phenol oxidase, β-glucosidase, phosphatase, chitinase and leucine aminopeptidase) were determined at two different depths along the soil profile: upper aerated organic layer and lower anoxic and more humified layer.

Following hypotheses will be discussed:
(i) Microbial biomass and diversity is higher at lower altitudes, which is reflected in higher enzymatic activities.
(ii) Nutrient uptake by microbes decreases with altitude and soil depth.
(iii) Microbial enzymatic activity is inversely correlated with the microbial nutrient biomass for each specific nutrient.
(iv) Microbial enzymatic activity is positively correlated with the microbial abundance.

Contact Information: Lucia Sekulová, EPFL, Laboratory of Ecological Systems, Bâtiment GR, Station 2, CH-1015 Lausanne, Switzerland, Phone: +41216933767; Email: lucia.sekulova@epfl.ch

TEMPERATURE SENSITIVITY OF ENZYME ACTIVITY AT DEPTH IN A BOG AT MARCELL EXPERIMENTAL FOREST, MN, USA

J. Megan Steinweg[1], *Joel E. Kostka*[2], *Paul J. Hanson*[1] and *Chris W. Schadt*[1,3]
[1]Oak Ridge National Laboratory, Oak Ridge, TN, USA
[2]Georgia Institute of Technology, Atlanta, GA, USA
[3]University of Tennessee, Knoxville, TN, USA

Enzymes activities are a useful metric of bog microbial community function because they are the direct agents of decomposition for specific substrates in peat. Thus, it is important to examine the response of enzyme activities to climate change parameters in order to improve our ability to predict nutrient fluxes under future climate regimes. The SPRUCE (Spruce and Peatland Under Climate and Environmental Change) project is a temperature and CO_2 manipulation experiment at the S1 bog in Marcell Experimental Forest, MN, USA. It is currently under construction but we are assessing baseline enzyme activities to understand the distribution of enzymes both horizontally and vertically in space since the SPRUCE experiment will warm the peat from the surface down to two meters belowground. We are currently investigating the temperature sensitivity of enzyme activities involved in different nutrient cycles and how they may change as temperatures increase during the experiment.

Enzymes involved in carbon, nitrogen and phosphorus cycling were assayed at multiple temperatures ranging from 4 to 45°C. Soil cores were extracted from 0-200cm below the bog surface and split into 10cm increments. The Arrhenius equation was used to estimate the activation energy, or temperature sensitivity, for each enzyme at each depth.

As expected, hydrolytic and oxidative enzyme activities were the greatest and most variable in the top 20cm, and the activities below 50 cm were reduced by 80-90% compared to surface activities. Soil temperatures in the top 50cm of peat are quite variable throughout a single day and over the course of a year. Below 100cm the peat temperature does not deviate by more than 0.4°C in a single day and ranges from only 4-9°C throughout the year. In general the responsiveness of the enzymes to increased temperature was greatest in the top 50cm, which may be due to a large pool of isoenzymes (enzymes with different environmental optima) that have higher temperature optima than enzymes in the cooler, more temperature-stable subsurface. As the warming experiment progresses, the temperature optima of enzymes at lower depths may shift upwards, while the higher responsiveness of the enzymes in the upper surface layers may lead to increased depolymerization of organic matter resulting in faster nutrient cycling rates.

Contact Information: J. Megan Steinweg, Oak Ridge National Laboratory, PO Box 2008, MS 6038, Oak Ridge, TN 37831, USA, Phone: 865-241-3776, Fax: 865-574-6442 , Email: steinwegjm@ornl.gov

MICROBIAL COMMUNITIES IN RESTORED FRESHWATER WETLANDS

Susannah G. Tringe[1], *Shaomei He*[1], *Mark Waldrop*[2] and *Lisamarie Windham-Myers*[2]
[1]DOE Joint Genome Institute, Walnut Creek, CA, USA
[2]U.S. Geological Survey, Menlo Park, CA, USA

Belowground microbial communities have critical roles in wetland carbon cycling yet relatively little is known about the biotic and abiotic factors that govern microbial community structure and function in these ecosystems. We aim to characterize the microbes inhabiting restored freshwater wetlands and their metabolic potential using high-throughput sequencing tools, and ultimately identify community patterns, indicator species, genes or pathways that are associated with peat accretion rates and CH_4 flux.

A pilot study conducted by the USGS on Twitchell Island in the Sacramento/San Joaquin Delta has demonstrated that controlled shallow flooding can reverse land surface subsidence and potentially act as an environmental carbon sink. The site is continuously fed by water from the San Joaquin River, and is primarily vegetated with cattails (*Typha* spp.) and tules (*Schoenoplectus acutus*). We selected three sites for microbial community analysis that have varied proximity to the inflow, thus exhibiting gradients in physicochemical conditions and peat accretion rates. From each site, we collected three sample types, including the bulk decomposed material, cattail rhizomes and tule rhizomes. Pyrosequencing of amplified V8 regions of 16S rRNA genes was used to generate microbial community profiles. In parallel, mesocosm anaerobic incubation was conducted to evaluate CO_2 and CH_4 flux.

Our sequencing data indicate that wetland community composition is primarily governed by sampling site, and secondarily by sample type, in a manner consistent with the physicochemical gradients along these sites. The mesocosm incubation experiments showed that CO_2 flux was significantly higher in rhizome samples than in bulk samples, while CH_4 flux was more correlated to sample site. Low CH_4 flux communities were found closest to the inflow, where electron acceptors such as sulfate and nitrate were more abundant; these samples harbored larger populations of microbial lineages likely to be reducers of these electron acceptors than the high CH_4 flux samples. Sites further from the wetland inflow, which have shown higher peat accretion rates, demonstrated higher CH_4 flux and harbored more abundant methanogenic archaeal populations than low CH_4 flux communities. Comparative metagenomic analyses are under way to confirm these differences and generate community functional profiles.

Contact Information: Susannah G. Tringe, DOE Joint Genome Institute, 2800 Mitchell Drive, Walnut Creek, CA 94598, USA, Phone: 925-296-5813, Email: sgtringe@lbl.gov

ENZYME ACTIVITY IN LAKE SEDIMENTS AND ITS RELATION WITH EUTROPHICATION FROM EAST PLAIN REGION

Yu Zhang[1], *Baoshan Cui*[1], *Shengrui Wang, Yan Lan*[1] and *Zhen Han*[1]
[1]Beijing Normal University, State Key Joint Laboratory of Environmental Simulation and Pollution Control, Beijing, China
[2]Chinese Research Academy of Environmental Sciences, Beijing, China

To reveal the biochemical mechanism of decomposition and synthesis of the nutrients in eutrophic lakes, the relationships among the contents of nitrogen, phosphorus, organic matter, the activity of hydrolase and oxidoreductase were studied in eight shallow lakes along the eastern plains. The results showed that 1) in the lakes seriously polluted by farming activities, such as the Datong Lake, Shanpo Lake and Saicheng Lake, the urease activity in sediments was significantly higher than that in the lightly polluted large lakes, such as the Poyang Lake and Dongting Lake. And it showed significantly positive correlation with total nitrgen (TN) and orgnic matter (OM) in sediments. And alkaline phosphatase also showed a positive correlation with total phosphorus (TP); 2) the changing trends of the activities of catalase, polyphenoloxidase and peroxidase were similar in lake sediments. And their distribution had a close relation with the degree of pollution and human activities; 3) among the microoganisms in lake sediments, bacteria were dominant, actinomycetes were next and fungi were the least. There was little discrepancy of the number of ammonium bacteria in all the lakes, while the number of denitrifying bacteria was quite different. So, denitrifying bacteria might be an important bio-indicator factor which could reflect whether nitrogen accumulated or not in the lake sediments, and also reflect the degree of eutrophication.

Contact Information: Yu Zhang, School of Environment, Beijing Normal University, State Key Joint Laboratory of Environmental Simulation and Pollution Control, No. 19 Xinjiekouwai Street, Beijing 100875, China Phone: + 86 10 58802079, Fax: + 86 10 58802079; Email: waterandtea@126.com

BIOGEOCHEMISTRY AND MICROBIAL ECOLOGY - MICROBIAL DIVERSITY AND FUNCTIONS

MANY WETLANDS CAPABLE OF ANAEROBIC DECHLORINATION

***James P. Amon**, Tracy Collins* and *David Duell*
Department of Biological Sciences, Wright State University, Dayton, Ohio, USA

Samples from fens, marshes, waste treatment facilities, groundwater and a bioremediation wetland actively removing perchloroethene (PCE) and trichloroethene (TCE) revealed that bacterial communities from all these were capable of dechlorinating these compounds. qPCR using bacterial 16S gene fragments demonstrated communities of about 10^7 bacteria per gram of soil from surface (0-20 cm), intermediate (75 cm) and deep (150 cm) samples. In addition, groundwater from a low concentration PCE plume (30 ppb) revealed similar levels of bacteria. At all of these sites about 0.1% of the community contained *pce*A genes know to degrade PCE anaerobically. Sludge samples from local waste treatment plants contained slightly lower levels of the *pce*A gene. We conclude that much of the natural environment contains bacteria capable of this type of dechlorination activity and that construction of bioremediation wetlands can use microbial flora common to locally available wetlands and groundwater as an inoculum.

Contact Information: James P. Amon, Department of Biological Sciences, Wright State University, 3640 Col Glenn Hwy, Dayton, OH 45435, USA, Phone 937-775-2632, Fax 937-775-3320, Email: james.amon@wright.edu

MICROBIAL COMMUNITY RESPONSES TO NUTRIENT ENRICHMENT IN WETLAND SOILS

Wyatt H. Hartman[1], *Curtis J. Richardson*[1], *Scott C. Neubauer*[2] and *P.V. Sundareshwar*[3]

[1]Duke Wetland Center, Nicholas School of the Environment, Duke University, Durham NC, USA

[2]Baruch Field Laboratory, University of South Carolina, Columbia SC, USA

[3]South Dakota School of Mines and Technology, Rapid City SD, USA

Soil microbial communities are responsible for catalyzing biogeochemical transformations underlying critical wetland functions, including cycling of carbon and nutrients, and emissions of greenhouse gasses. Alteration of nutrient availability in wetland soils may commonly occur as the result of anthropogenic impacts, including runoff from human land uses in uplands, alteration of hydrology and atmospheric deposition. However, the impacts of altered nutrient availability on microbial communities in wetland soils are poorly understood.

To assess these impacts, soil microbial communities were determined in replicate experimental nutrient addition plots (control, +N, +P, +NP) across several wetland types, including pocosin bogs (NC), freshwater tidal marshes (GA), and tidal salt marshes (SC). Microbial communities were determined by pyrosequencing (Roche 454) extracted soil DNA, targeting both bacteria (16S rDNA) and fungi (LSU) at a depth of ca. 1000 sequences per plot.

Communities of bacteria and fungi clearly differed among wetland types, while nutrient additions did not appear to change the overall composition of microbes within each wetland, given variability among replicate plots. However, common statistical approaches to ordinate or cluster communities do not account for subtle shifts in responsive taxa that may account for a relatively small percentage of community dominance. Preliminary analyses indicate that some individual taxa do respond to nutrient addition, and we emphasize that closer analysis of community composition beyond major phyla may be required to assess anthropogenic impacts (further requiring use of deep sequencing methods like pyrosequencing).

Additional efforts are required to assess the functional implications of nutrient enrichment, including comparisons to soil and microbial element pools, and microbial functional genes related to element transformations and greenhouse gas emissions. We will present additional data and discussion on these functional aspects of microbial communities, and their relation to nutrient enrichment and microbial community composition.

Contact Information: Wyatt H. Hartman, Duke Wetland Center, Nicholas School of the Environment, Duke University, Box 90328, Durham NC 27708 USA. Phone: (919) 672-2177, Email: whh3@duke.edu

VARIATION OF SOIL MICROBIAL COMMUNITY STRUCTURE AND ACTIVITY ALONG ECOHYDROLOGICAL GRADIENTS

Pascal Boeckx[1], *B.L. Wajira K. Balasooriya*[1], ***Dries Huygens***[1, 2], *Niko Verhoest*[1] and *Karolien Denef*[3]
[1]Ghent University, Gent, Belgium
[2]Universidad Austral de Chile, Valdivia, Chile
[3]University of Colorado, Boulder, CO, USA

It is generally agreed that eco-hydrological drivers such as water table, redox potential, plant communities and fertility status affect microbial community structure in wetlands. However, the link between both as well as the consequences for C cycling remains largely elusive. We investigated the microbial community and activity in natural moist grassland in Belgium and low land rice fields in Sri Lanka. In the natural wetland we investigated the effect of spatial (topography) and temporal (season) fluctuations in redox potential and plant growth. In the rice fields we investigated the effect of rice variety (low vs. high yielding), fertilizer type (organic vs. inorganic) and plant growth (vegetative, flowering, maturity). Microbial community structure and activity were identified via phospholipid fatty acid stable isotope probing (PLFA-SIP) following $^{13}CO_2$ pulse-labeling. Differences in relative abundance and relative ^{13}C concentration of PLFA biomarkers were analyzed via PCA and MANOVA.

The microbial community structure and activity in the natural wetland was significantly affected by redox fluctuation and plant growth. Typically wet sites or periods were characterized by a higher abundance of PLFA biomarkers for Gram-positive bacteria (G+) and actinomycetes (ACT), while the abundance of Gram-negative bacteria (G-) and arbuscular mycorrhizal fungi (AMF) was increased in the dry sites or periods. For the wet sites and periods there was no coupling between abundance and activity of the microbial community, while this coupling was in general present for the dry sites and periods (except for saprotrophic fungi, SAPF).

For the rice fields the abundance of fungal PLFA's was not significant. PCA and MANOVA analyses showed a very significant effect of plant growth stage, rice variety, fertilizer type and its interaction on both microbial abundance and activity. G+ and G- bacteria characterized the vegetative and maturity stage of the rice-growing period, respectively. However, the coupling between microbial abundance and activity was less pronounced, and only observed during maturity for G- when the rice fields were drained and soil redox potential was increased.

In conclusion, we showed that ecohydrology, including management, affects the microbial structure and activity in wetlands. However, both microbial traits were affected mostly independently. However, to improve our understanding of wetland biogeochemistry, the link between microbial activity and specific functions should be developed.

Contact Information: Pascal Boeckx, ISOFYS, Faculty of Bioscience Engineering, Ghent University, Coupure Links 653, 9000 Gent, Belgium, Phone: +32 9 264 60 00, Fax: +32 9 264 62 42, Email: pascal.boeckx@ugent.be

METHANOTROPHIC COMMUNITY IS DIFFERENT IN NATURAL AND DRAINED PEATLANDS

A.K. Kizilova[1]*, I.K. Kravchenko*[1] and *A.A. Sirin*[2]
[1]Winogradsky Institute of Microbiology RAS, Moscow, Russia
[2]Institute of Forest Science RAS, Uspenskoe, Moscow region, Russia

Russia is rich is wetlands with peat soil, which have been either left intact or drained for various purposes, like peat extraction or agricultural purposes. Human impact on peatlands showed up as extensive drainage networks with drain ditches, submergence zones and other hydrological elements, as well as abandoned peateries. Biogeochemical properties of these elements were showed to be different from those of natural peatlands.

The experiment consisted of sampling a number of peat soils from natural and anthropogenically affected peatlands during fieldwork in Moscow Region (European part of Russia), measuring rates of potential methane oxidation at these sites, and studying microbial population of methanotrophs in order to better understand how methanotrophic community has changed in peats, which have been used by human beings in some way.

Highest methane oxidation rates were shown for natural peatland, covered with thick blanket of *Sphagnum* mosses, and lowest – for lower parts of drainage network elements, those, which had high moisture content. Amplification of *pmoA*, beta-subunit of pMMO, particulate methane monooxygenase, key enzyme of methane oxidation, participating in conversion of methane to methanol and present in almost all known methanotrophs, allowed us to detect methanotrophs in all collected samples. Applying DGGE (denaturing gradient gel electrophoresis) allowed us to gain insight into structure of methanotrophic communities of natural peatlands and hydrological elements.

The study revealed striking difference between methanotrophs of natural peatlands and hydrological elements. Methane-oxidizing bacteria of natural peatlands belonged to aerobic Alphaproteobacteria with *Methylocystis* as most close relative among cultivated organisms. Some Alphaproteobacteria were shown to be responsible for oxidizing methane in very low concentrations, close to atmospheric values. Methanotrophs from soils of hydrological elements appeared to belong to gammaproteobacterial methanotrophs, most closely related to *Methylobacter tundripaludum*. The shift from Alpha- to Gammaproteobacteria may indicate the loss of the ability to remove methane from atmosphere, thus making hydrological elements of peatlands less useful in fighting methane's contribution to global greenhouse effect, but even more hazardous from this point of view.

Contact Information: Anna Kizilova, Laboratory of Microbial Survival, Winogradsky Institute of Microbiology RAS, Prospekt 60letiya Oktyabrya 7/2, 117312, Moscow, Russia. Phone: 7-499-1357573, Fax: 7-499-1356530; Email: alegrria@gmail.com

THE EFFECT OF HYDROLOGY ON THE DISTRIBUTION OF AMMONIA-OXIDIZING BETAPROTEOBACTERIA IN IMPOUNDED BLACK MANGROVES (*AVICENNIA GERMINANS*)

Hendrikus J. Laanbroek[1,2,3,*], *Rosalinde M. Keijzer*[1], *Jos T.A Verhoeven*[2,3] and *Dennis F. Whigham*[3]
[1]Department of Microbial Ecology, Netherlands Institute of Ecology (NIOO-KNAW), Wageningen, the Netherlands
[2]Institute of Environmental Biology, Utrecht University, Utrecht, the Netherlands
[3]Smithsonian Environmental Research Station, Edgewater, MD, USA

The distribution of species of aerobic chemolitho-autotrophic microorganisms such as the ammonia-oxidizing bacteria will be governed by pH, salinity and temperature as well as by the availability of oxygen, ammonia, carbon dioxide and other inorganic elements required for growth. Impounded mangrove forests in the Indian River Lagoon, a coastal estuary on the east coast of Florida, are dominated by mangroves, especially black mangrove (*Avicennia germinans*), that differ in size and density. In March 2009 the management in one of the impoundments was changed for purpose of insect control, by pumping water from the adjacent estuary. We collected soil samples in three different black mangrove habitats in this and an adjacent impoundment in 2008, 2009 and 2010, always in March, to determine the pre- and post-management effects of summer flooding on the distribution of 16s rRNA genes belonging to ammonia-oxidizing betaproteobacteria (β-AOB).

At the level of 95% mutual similarity in the 16s rRNA gene, 11 different Operational Taxonomic Units were identified; the majority related to the lineages *Nitrosomonas marina* (57% of the total), *Nitrosomonas* sp. Nm143 (23%) and *Nitrosospira* cluster 1 (18%). Higher salinities of interstitial water, probably due to severe winter drought, had a significant effect on the composition of the β-AOB in March 2009 compared to March 2008. *Nitrosomonas* sp. Nm143 was replaced as second important lineage by *Nitrosospira* cluster 1. Simultaneously with the community change, the level of potential ammonia-oxidizing activities decreased by an average of 67%. Long-term summer flooding in 2009 reduced the percentage of *N. marina* by half in favor of the two other major lineages, but decreased again the potential ammonia-oxidizing activities by 41% on average. No significant differences were observed between the flooded and non-flooded impoundment. There were differences in the community composition of the bacteria in the three black mangrove habitats. *N. marina*, *Nitrosospira* cluster 1 and *Nitrosomonas* sp. Nm143 were more important in the sites dominated by dwarf, sparse and dense black mangroves, respectively, and progressively less important in the two other habitats. About 15% of the variation in the distribution of β-AOB among the three black mangrove habitats can be explained by differences in pore water iron, magnesium and phosphate and potential ammonia oxidation activities.

Contact Information: Hendrikus J. (Riks) Laanbroek, Department of Microbial Ecology, Netherlands Institute of Ecology (NIOO-KNAW), Droevendaalsesteeg 10, 6708 PB Wageningen, the Netherlands, Phone: +31.317473480,
E-mail: r.laanbroek@nioo.knaw.nl

SPECIES-SPECIFIC EFFECTS OF VEGETATION ON THE ABUNDANCE OF DENITRIFYING BACTERIA IN FRESHWATER WETLANDS

Joseph C. Morina, *Ember M. Morrissey* and *Rima B. Franklin*
Biology, Virginia Commonwealth University, Richmond, VA, USA

Wetland ecosystems are characterized by hydric soils and hydrophilic vegetation, both of which can influence the composition and function of wetland microbial communities. While the presence of plants generally increases microbial process rates, this varies depending on plant community composition and the microbial function of interest. This study considers the abundance of denitrifying bacteria in the rhizosphere of wetland plants in order to develop a more nuanced understanding of the relationship between the above- and below-ground communities. A species-specific effect of plants is expected due to differences in carbon supply from root exudates, wherein plants vary in their capacity to fuel denitrification. Further, differences in root ventilation may impact denitrification as the process proceeds only in low levels of dissolved oxygen.

Three plant species were selected based on their prevalence and unique rhizosphere structures: *Typha latifolia, Peltandra virginica*, and *Juncus effuses*. Four different tidal freshwater wetlands, including three natural sites and one constructed wetland, were sampled late in the growing season of 2011. At each site, five replicate samples were collected for each of the three plant species. Soil characteristics were significantly different across the four wetlands. Sediment organic matter and redox potential were interactively dictated by plant and site (two-way ANOVA, $p<0.02$). However, some trends persisted across sites, for instance *Juncus effuses*-associated sediments consistently exhibited higher redox potentials. Abundance of denitrifiers was determined by qPCR of the functional gene *nirS*, and appeared to also be affected by plant-site interactions. Furthermore, relationships between denitrifier abundance and soil organic matter differed depending on the plant species present. This is one of the first studies to utilize molecular methods to investigate the relationships between the abundance of denitrifiers and plant species rhizospheres. These results are relevant to understanding the ecology of denitrification bacteria with implications for predicting ecosystem nitrate reduction capacity.

Contact Information: Ember Morrissey, Virginia Commonwealth University, Department of Biological Sciences, 1000 W Cary St, Richmond, VA 23284, Phone: 804-828-0125, Fax: 804-828-0503, Email: morrisseyem@vcu.edu

MICROBIAL COMMUNITY CHANGES DURING RESIDENCE OF TREATED WASTEWATER IN A CONSTRUCTED WETLAND

B.T.M. Mulling*, A.M. Soeter, H.G. van der Geest* and *W. Admiraal*
Department of Aquatic Ecology and Ecotoxicology, Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Amsterdam, the Netherlands

Constructed wetlands are widely used to polish treated wastewater to reduce impact on receiving surface waters. Pollutants like nutrients, metals, oxygen demand and pathogens, are often efficiently reduced by constructed wetlands. However the change in the microbial communities in these wetlands is not well known, even when pathogens are known to be retained. The aim of this study is to investigate 1) if changes occur in the microbial community abundance, composition and functioning as treated wastewater flows through a horizontal surface flow constructed wetland and 2) to investigate if these changes represent the transition from treatment plant communities to microbial communities in surface waters.

Water samples were taken at several locations in a horizontal surface flow constructed wetland from inflow to out flow and six reference locations differing in water type, use and quality. FISH-CLSM was used to determine the suspended microbial abundance and partial orientation (clusters, suspended particle associations), DGGE was performed to determine the suspended microbial community composition and community level physiological profiling (CLPP) to determine the activity and functioning of the suspended microbial community. The results showed that the activity and function of the suspended microbial community in treated wastewater was relatively high and decreased during residence in the constructed wetland. Although the suspended microbial diversity remained relatively stable the community composition changed completely during residence in the constructed wetland. Simultaneously the suspended microbial abundance increased indicating that the microbial community changed from relative low abundance and high activity to relative high abundance and low activity. The microbial community of the treated wastewater after passing through the constructed wetland was comparable with urban surface waters exposed to human impact. It is concluded that the constructed wetland promoted the transformation of the microbial communities from treatment plant communities to microbial communities in surface waters

Contact Information: B.T.M.Mulling, Institute for Biodiversity and Ecosystem Dynamics, P.O. Box 94248, 1090 GE Amsterdam, The Netherlands, Phone: 0031205258265, Fax: 0031205257832, Email: b.t.m.mulling@uva.nl

CHANGES IN MICROBIAL POPULATIONS AFFECTED BY OIL SPILL IN GULF OF MEXICO

Joong-Wook Park and *Astha Gupta*
Troy University, Troy, AL, USA

The Gulf of Mexico oil spill in 2010 damaged properties and the environment, devastated the tourism and seafood industries, and caused health problems for humans in the affected communities. It revealed serious weaknesses in the ability of oil industry, federal, state and local governments to respond in a coordinated manner. In addition, the oil spill underscored the weaknesses of current technologies for remediation of the cleanup: costly, time-consuming, and ineffective. In this project, microbial community structures in oil-contaminated sediments were investigated to search and identify the microorganisms that possess an oil-degradation activity. Sediment samples were collected from three different sites at Lake Pontchartrain (New Orleans, LA) and the presence of oil in one sample was visually confirmed. Culture-independent molecular techniques were used to analyze total microbial community structure and to identify the major microbial species. In brief, total environmental DNAs were extracted and analyzed by PCR-DGGE to monitor microbial community structures. DGGE bands of interest were sequenced and phylogenetically analyzed by bioinformatic tools. Our data help to refine techniques to isolate oil-degrading microorganisms, to understand oil degradation pathway, and to develop new bioremediation strategies.

Contact Information: Joong-Wook Park, Department of Biological and Environmental Sciences, Troy University, 601 University Avenue, Troy, AL 36082 USA, Phone: 334-808-6416, Fax: 334-670-3662, Email: jwpark@troy.edu

CYANOBACTERIA SPECIES FROM FLORIDA EVERGLADES FLOC

Barry H. Rosen[1], *Jaroslava Komárková*[2] and *Jiří Komárek*[3]

[1]U.S. Geological Survey, Orlando, FL, USA

[2]Hydrobiolgical Institute, Academy of Science, Třeboň, Czech Republic

[3]Institute of Botany, Academy of Science, Třeboň, Czech Republic

Suspended aggregates ("floc") in the Everglades provides habitat for numerous species of cyanobacteria that have previously not been identified. Floc was collected in the area partitioned by canals and levees between water conservation areas 3A and 3B, an area known as the "pocket". This area is dominated by saw grass ridge and slough habitats, tree islands and marl-forming periphyton. In addition to direct observation of the cyanobacteria in and on the floc, sediments and overlying water were cultured over three months to have enough of each organism to adequately characterize morphology features needed to discern species.

Over 36 species were identified from the orders Chroococcales, Oscillatoriales, and Nostocales. Several species were common to other sub-tropical marl wetlands, such as those found in Belize, while others have not been described in the literature and may represent new species. In the Chroococcales, morphology ranged from individual cells to large, multicellular colonies. The numbers of species was greatest in order Oscillatoriales and many of these were motile, and measured gliding from 0.2-5 um/sec. Although none of the species were planktonic, several contained aerotopes (gas vesicles) that typify a genus. The members of the Nostocales had heterocysts that provide this group with atmospheric nitrogen fixation capabilities.

Many of the Oscillatoriales and Chroococcales observed possess a mucilaginous sheath, which is important in protecting the cells from desiccation. This was confirmed by air-drying floc samples to a constant weight for 30 days, rehydrating them and observing what species were able to grow. The majority of species that survived this treatment had sheaths.

Four distinct species of the genus *Schizothrix* were observed, which characterized by filaments with complex sheath and intertwining. The sheath of one species of *Schizothrix* was the site of calcium carbonate precipitation, a phenomenon known to be biologically-mediated by cyanobacteria. The milieu created by the sheath and its associated bacteria, was observed as the site of calcium carbonate crystals formation using ultraviolet epifluorescent microscopy. The cyanobacterial cells within the sheaths coated with calcium carbonate observed with this technique and they retained their photosynthetic pigments. Cyanobacterial cells are known to leak compounds, and it is likely theses cells produce extracellular compounds that permeate the mucilaginous sheath and assist in the mediation of calcium carbonate precipitation.

The typical pigments associated with cyanobacteria, phycocyanin, phycoerythrin and chlorophyll *a,* gave the organisms observed the full array of colors, from bright green to dark brown. Using ultraviolet epifluorescent microscopy to excite these pigments, a preliminary assessment of their physiological status was observed. Unexpectedly, variation in fluorescence within an individual colony indicated that cells were not in a homogenous condition.

<u>Contact Information</u>: Barry H. Rosen, Office of the Southeast Area Regional Executive, U.S. Geological Survey, 12703 Research Parkway, Orlando, FL 32826 USA, Phone: 407-803-5508, Fax: 407-803-5501, Email: brosen@usgs.gov

MICROBIAL DEGRADATION OF PESTICIDES IN WETLANDS: EFFECTS OF SEASON BOUND CHANGES

Pieter Vandermeeren*, François Moesen, Jan Diels* and *Dirk Springael*
Division Soil and Water Management, Katholieke Universiteit Leuven, Belgium

Pesticides are used in agriculture but pose a problem as surface water and drinking water pollutants. Yet, microorganisms can adapt to degrade xenobiotic organic pollutants such as pesticides. Pesticides might infiltrate wetland ecosystems directly through runoff, drainage or drift from an agricultural field or indirectly by river flooding. Mitigation of pesticide pollution in wetlands has been mainly studied for pesticides that sorb strongly. Less is known about the behavior of moderately sorbing pesticides. In this study, we investigated the degradation of the moderately sorbing herbicides 2-methyl-4-chlorophenoxy acetic acid (MCPA) and isoproturon (IPU) in wetlands and examined whether season bound changes in weather conditions (*i.e.* a freezing period and a drought period) can affect degradation, hypothesizing that pesticide degrading microbial populations may decay or shift in composition during drought and freezing periods. The study was performed using both a controlled laboratory microcosm and a field study approach. The studied wetlands were a floodplain of the Odense River (Denmark) and of the Melsterbeek (Sint-Truiden, Belgium), which were shown to contain the microbial capacity to mineralize MCPA and IPU, respectively. In the lab microcosms, MCPA and IPU mineralization activity, as demonstrated by the production of $^{14}CO_2$ from either added ^{14}C-MCPA or ^{14}C-IPU, survived both a freezing period and a drying period, but mineralization was slower and to a lower extent after the freezing/drying period compared to control series. The populations that underwent freezing/drying probably had reduced in size, as suggested by e.g., a sudden increase of $^{14}CO_2$, probably originating from dead degraders, released from the system directly after freezing. Parallel, kinetics of mineralization of ^{14}C-MCPA and ^{14}C-IPU were determined for field samples. Thus far, samples from the floodplain of the Melsterbeek were taken in August and December 2011. Mineralization kinetics were spatially heterogeneous across the wetland. A soil sampling campaign planned in January/February 2012 will reveal insights into the influence of a freezing period on the mineralization of MCPA and IPU in wetland soils.

Contact Information: Pieter Vandermeeren, Division Soil and Water Management, Department Earth and Environmental Sciences, K.U.Leuven, Kasteelpark Arenberg 20, 3001 Heverlee, Belgium, Phone: +32-16-329675,
Email: pieter.vandermeeren@ees.kuleuven.be

MICROBIAL DEGRADATION OF PESTICIDES IN WETLANDS: INFLUENCE OF PHOTOSYNTHESIZING ALGAE

Pieter Vandermeeren*, François Moesen, Jan Diels* and *Dirk Springael*
Division Soil and Water Management, Katholieke Universiteit Leuven, Belgium

Pesticides that are used in agriculture might infiltrate wetland ecosystems directly through water runoff, drainage or drift from a field or indirectly by river flooding. After prolonged pesticide exposure, soil microorganisms in wetlands may develop the potential to degrade these xenobiotic organic pollutants, which mitigates the threat of the latter to surface, ground and drinking water. Therefore, wetlands can have a cleaning function. However, since microbial degradation of many pesticides is linked to oxygen consumption, these processes are restricted to oxic water and sediment layers of a wetland. When hydrophytes introduce oxygen into the anoxic sediment through their roots, aerobic degradation of pesticides may be stimulated. In this study, we investigated the microbial degradation of the moderately sorbing herbicides 2-methyl-4-chlorophenoxy acetic acid (MCPA) and isoproturon (IPU) in wetlands and examined to which extent photosynthesizing algae influence these processes. In soil microcosms, incubated in the laboratory in a diurnal light-dark cycle, concentrations of dissolved oxygen increased in the water column as well as in the sediment due to photosynthesis by an algal mat that had formed at the sediment surface. No $^{14}CO_2$ was released from the system. In contrast, controls incubated in the dark produced a significant amount of $^{14}CO_2$ from either added ^{14}C-MCPA or ^{14}C-IPU. However, a considerable fraction of the originally added ^{14}C was found in the algal biomass. This suggests that CO_2 produced in the course of pesticide mineralization by the soil microorganisms, is incorporated into the algal cells during photosynthesis. Additionally, we hypothesize that diffusion of MCPA and IPU into anaerobic sediment layers may be decreased due to an extension of the oxic layer and hence an increase of the microbial degradation potential.

Contact Information: Pieter Vandermeeren, Division Soil and Water Management, Department Earth and Environmental Sciences, K.U.Leuven, Kasteelpark Arenberg 20, 3001 Heverlee, Belgium, Phone: +32-16-329675, Email: pieter.vandermeeren@ees.kuleuven.be

CLIMATE CHANGE - CARBON SEQUESTRATION

INCORPORATING CARBON MANAGEMENT FOR CLIMATE CHANGE MITIGATION INTO COASTAL MANAGEMENT PLANNING

Richard F. Ambrose[1] and *Stephen Crooks*[2]
[1]University of California, Los Angeles, CA, USA
[2]ESA PWA, San Francisco, CA, USA

Carbon management has become an increasingly important factor in global environmental policies, with an explosive growth in interest in carbon management over the past few years. At the same time, there has been increasing recognition of the threats to coastal marine resources worldwide. However, coastal planners have generally not considered carbon management issues, and incorporating carbon management into coastal planning will require a new approach to how coastal activities are managed.

Most coastal planning is currently project-based. Although new approaches to managing marine resources being implemented (e.g., marine protected areas, ecosystem-based management, coastal and marine spatial planning), planning for carbon requires a spatial and temporal scale that is larger than most current planning activities. For example, the planning time frame for carbon management is on the order of 100 years, compared to the currently more typical 10-year planning horizon. Carbon management plans must accommodate sea level rise and other environmental changes that might occur over the next century to ensure that sequestered carbon stays sequestered. In addition, carbon management requires a regional or larger spatial planning scale to avoid leakage (where displaced activities simply move to a nearby area, so there is no net increase in carbon sequestered). Regional planning is also needed to ensure that restoration in one location does not capture sediment that results in habitat loss somewhere else.

Carbon management needs will reinforce good planning practices, but carbon management projects may conflict with other coastal uses. Besides competition for a particular location, the long-term nature of carbon management could conflict with short-term needs for ecological benefits. Moreover, an emphasis on carbon management could focus restoration efforts on areas with the greatest potential for long-term carbon persistence (e.g., high availability of mineral sediment, high tidal range) to the exclusion of restoration in other areas of high ecological potential but lower carbon sequestration potential. Similarly, an excessive focus on carbon sequestration could lead to a reduction in other ecological values (e.g., endangered species) or ecosystem services in a wetland. Although this may be appropriate for particular wetlands, it would not be appropriate for all of the wetlands in a region. A coastal and marine spatial planning effort could help ensure a balance among different uses, including natural ecological functions.

With several important international scientific and policy activities in progress (e.g., IPCC assessing inclusion of coastal wetlands in national GHG accounting procedure, and connection to carbon markets), now is a critical time to begin integrating carbon management and coastal planning.

Contact Information: Richard F. Ambrose, Department of Environmental Health Sciences, Box 951772, Room 46-078 CHS, University of California, Los Angeles, CA 90095-1772 USA, phone: 310-825-6144, fax: 310-206-3358, email: rambrose@ucla.edu.

CHANGES IN FORESTED WETLAND COMPOSITION, STRUCTURE, AND PROCESSES ALONG A TIDAL GRADIENT ON THE APALACHICOLA RIVER, FL, USA

Christopher J. Anderson and *B. Graeme Lockaby*
School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL, USA

Many river systems in the Southeastern U.S. and around the world include a freshwater tidal zone as they approach the coast. As riparian forested wetlands become more tidally influenced, there tends to be a related shift in biotic communities, physiochemical conditions, and hydraulic relations (although it is unclear how much these shifts coincide). To better understand this transition, we summarized a series of studies examining forested wetlands along a tidal gradient on the Apalachicola River, FL, USA. For this research, a series of 17 transects were established in forested wetlands across a tidal gradient along the lower river, including major tributary/distributary creeks. Beginning in 2007, forests were monitored for over three years with data collected on wetland hydroperiod, species composition, tree basal growth, soil chemistry, and foliar nutrient cycling. Based on wetland hydrographs, tidal forests were readily identified and had distinct differences in flooding frequency and timing compared to non-tidal wetlands. Hydrologic differences between tidal and non-tidal wetlands were most apparent during seasonal shifts in river discharge and tidal range. Four distinct forest communities (two tidal and two non-tidal) were detected based on tree species importance values. Forest communities aligned closely with *a priori* hydrologic classifications of wetlands based on previous hydrology data. Sampling canopy foliage and litter from a subset of these forests, tidal wetlands showed evidence of greater P-limitation than non-tidal forests based on significantly higher N:P ratios of foliage (28.9 ±3.0 v. 19.5 ±1.5), P-resorption efficiency (47.3 ±7.3 v. 22.0 ±5.6), and the frequency of trees demonstrating complete P-resorption proficiency. Forest structure also differed between wetlands based on hydrology with non-tidal wetlands having greater basal area (63.1 ±2.7 v. 46.4 ±2.2 m^2 ha^{-1}) and lower tree density (967 v. 1745 stems ha^{-1}). From our results, we explored the seasonal role of these wetlands to estuarine ecosystems and their susceptibility to change from water management practices.

Contact Information: Christopher Anderson, Auburn University, 3301 Forestry and Wildlife Sciences Building, Auburn AL, 36849, United States; PH 334-844-1033; Email: andercj@auburn.edu

A WETLAND CARBON BIOSEQUESTRATION DEMONSTRATION PROJECT IN THE SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA, USA – WETLAND CARBON FARMING

Brian A Bergamaschi[1], *Frank Anderson*[1], *Robin Miller*[1], *Lisa Windham-Myers*[2], *David Krabbenhoft*[3] and *Roger Fujii*[1]

[1]United States Geological Survey California Water Science Center, Sacramento, CA, USA
[2]United States Geological Survey National Research Program, Menlo Park, CA, USA
[3]United States Geological Survey Wisconsin Water Science Center, Madison, WI, USA

Agricultural production in the Sacramento-San Joaquin Delta oxidizes the peat soils, emitting >7 Mt carbon dioxide (CO_2) per acre and causing >1 cm of land subsidence per year. A century of agriculture has resulted in subsidence of over 500,000 acres of agricultural lands in the Delta. Based on Information from two 7 acre pilot wetlands established in 1997, it appears possible to reverse these carbon emissions and restore the land surface elevation by removing carbon from the atmosphere through photosynthetic production, and then transferring it into organic soil material as buried biomass, humus, and, eventually, peat. This long-term study has demonstrated that it is feasible to accelerate carbon accretion rates and increase land-surface elevation by controlling the depth of water in the wetland and the composition of wetland vegetation. Biomass accumulation rates combined with emissions reduction result in a net global warming potential (GWP) benefit of over 30 Mt CO_2e per acre per year, larger than many other established means of terrestrial biological carbon sequestration. Although CH_4 emissions at this site are among the highest reported for wetlands, the CO_2 uptake more than offset the higher CH_4 GWP for the period of measurement.

It seems possible that wetlands of this type could be used to “farm” carbon. California’s recent landmark Greenhouse Gases laws are expected to establish a market for carbon sequestration trading, so “wetland carbon farming” at a large scale could provide a viable economic return to the Delta farming communities while at the same time reduce the public risk management costs associated with subsidence. We have examined fundamental wetland biogeochemical processes for the purpose of developing wetland management approaches that maximize carbon sequestration and subsidence reversal, as well as minimizing the potential for adverse outcomes and environmental consequences. Quantifying the processes and factors affecting accretion and sequestration are essential for determining management scenarios that maximize these effects, and for establishing protocols that will allow the resulting benefits to be realized in carbon markets and offset programs.

<u>Contact Information</u>: Brian Bergamaschi, U.S. Geological Survey, California Water Science Center, 6000 J St., Sacramento, CA 95819-6129 USA. Phone: 916-278-3000. Fax: 916-278-3071. Email: bbergama@usgs.gov

CARBON SEQUESTRATION IN TROPICAL WETLANDS OF COSTA RICA

Blanca Bernal and *William J. Mitsch*
Wilma H. Schiermeier Olentangy River Wetland Research Park, The Ohio State University, Columbus, OH, USA

Wetlands are highly productive ecosystems that accumulate large amounts of organic matter in the soil, functioning as significant carbon sinks and having an important role in global carbon budgets. Their ability to sequester carbon, however, varies with the type of wetland and the climatic regime. Most of the studies of carbon in wetlands are focused on boreal peatlands, one of the least productive wetland ecosystems. Little is known about the role of tropical wetlands as carbon sequestering systems, and their capacity to accumulate carbon in the soil remains for the most part unknown. The objective of this study is to determine the carbon sequestration rate of three tropical wetlands in Costa Rica in three different settings — a riverine flow-through wetland with a marked wet and dry season, an isolated wetland in a rainforest, and a slow-flowing slough — with the intention of finding conditions that favor soil carbon accumulation. Triplicated soil cores were extracted in three different communities (open water, emergent and edge) in each if these wetlands, and analyzed for total carbon content to determine the wetland soil carbon pool. Sediment accretion and carbon sequestration rates were determined by radiometric dating with Cs^{137} and Pb^{210}. Preliminary results indicate that these wetlands are significant carbon sinks compared to their respective uplands. The riverine wetland communities have the lowest carbon sequestration rate (86 gC $m^{-2}y^{-1}$), with a total carbon content in the upper 30 cm that ranges from 65 to 26 gC kg^{-1}. The slough has the greatest sequestration rate (255 gC $m^{-2}y^{-1}$), about 45% more than the isolated wetland (176 gC $m^{-2}y^{-1}$). The peat accumulating sites of these wetlands have the highest soil carbon content of all the communities studied, ranging from 75 to 455 gC kg^{-1}. These results indicate the importance of differentiating between wetland communities and settings when determining the ability of tropical wetlands sequestering carbon, and the need to include them in global carbon budgets as significant natural carbon sequestering systems.

<u>Contact Information</u>: Blanca Bernal, Wilma H. Schiermeier Olentangy River Wetland Research Park, The Ohio State University, 352 W. Dodridge Street, Columbus, 43202 OH, USA; Phone: +1 614 688 8410, fax: +1 614 292 9773.
Email: bernal.19@buckeyemail.osu.edu

STRENGTHENING THE CENTURY-SCALE GLOBAL ESTIMATE OF MANGROVE ORGANIC CARBON BURIAL RATES

Joshua L. Breithaupt[1], *Joseph M. Smoak*[1], *Thomas J. Smith III*[2], *Christian J. Sanders*[3] and *Armando Hoare*[1]
[1]University of South Florida, Environmental Science, St. Petersburg, FL, USA
[2]U.S Geological Survey, Southeast Ecological Science Center, St. Petersburg, FL, USA
[3]Universidade Federal de Fluminense (UFF), Departamento de Geoquímica, Niterói-RJ, Brazil

As coastal wetlands that have historically been overlooked in terrestrial and marine carbon budgets, in recent decades mangroves have increasingly been studied for their high rates of organic matter production and subsequent sedimentary burial. Since the last literature review (2003) of direct measurements of organic carbon (OC) burial in mangrove sediments, the amount of available data has more than doubled. Our objective is to recalculate the century-scale burial rate of OC at both the local and global scales. Quantification of these rates enables better understanding of the current carbon sink capacity of mangroves, as well as helping to quantify and/or validate the other aspects of the mangrove carbon budget such as import, export, and remineralization. Methods consisted of reviewing published burial rates calculated using ^{210}Pb, and subsequently determining the most appropriate statistical measure of a central tendency. Using the geometric mean, mangroves are found to bury 163 g OC m^{-2} yr^{-1}. When scaled globally the burial rate is 26.1 Tg per year over the course of a century. This equates to a 42% increase over the most recent global estimate, and represents 10-15% of the estimated annual production of mangrove organic matter. Additionally, the implication of the global value is that 8 to 15% of all OC buried annually in marine settings is buried in mangrove sediments.

Contact Information: Joshua L. Breithaupt, University of South Florida, 140 7th Avenue South, St. Petersburg, FL, 33701. U.S.A., Email: jlbreith@mail.usf.edu

QUANTIFYING WETLAND CARBON SEQUESTRATION POTENTIAL IN THE GREAT PLAINS FOR THREE GREENHOUSE GAS EMISSION SCENARIOS

Kristin Byrd[1]*, Jamie Ratliff*[1]*, Omar Abdul-Aziz*[2]*, Norman Bliss*[3]*, Anne Wein*[1]*, Ben Sleeter*[1] and *Terry Sohl*[4]
[1]Western Geographic Science Center, USGS, Menlo Park, CA, USA
[2]Florida International University, Miami, FL, USA
[3]ARTS, contractor to USGS EROS, Sioux Falls, SD, USA
[4]EROS, USGS, Sioux Falls, SD, USA

We present a method to quantify potential for wetland carbon sequestration and greenhouse gas (GHG) flux in the Great Plains ecoregion of the United States that considers suitability of land for competing uses. This research is part of the on-going USGS LandCarbon project, a nation-wide assessment of current and projected future biological carbon storage (http://www.usgs.gov/climate_landuse/land_carbon).

The assessment applies land use change projections and biogeochemical modeling within an Intergovernmental Panel on Climate Change emissions scenarios framework to produce spatially-explicit estimates of carbon pools and GHG fluxes. Particular attention is paid to wetlands because of their large soil carbon pools, high methane emissions, and potential for carbon sequestration in peat formation, sediment deposition, and biomass accumulation. We consider wetland mitigation opportunities of avoided wetland loss and wetland restoration. Carbon balances are highly variable among wetland types, and these differences influence the spatial distribution of possible mitigation activities that would maximize carbon sequestration. To distinguish among wetlands with different carbon pools and fluxes, we developed a wetland map of the coterminous United States that differentiates the carbon-relevant wetland types described by Bridgham and others (2006), which includes peatlands, freshwater mineral soil wetlands, and estuarine wetlands. We conducted a sensitivity analysis to understand how the area and distribution of land made available for wetlands can influence carbon sequestration potential and GHG emissions. Knowing that not all land can be converted for carbon sequestration enhancement due to competing demands for agriculture, development, and other uses, we analyzed multiple cases that tested incremental areal and spatial allocation of land for wetland mitigation. This spatially-based sensitivity analysis was informed by spatial datasets such as U.S. Department of Agriculture Soil Survey Geographic Database data on land capability and prime farmland, a wetland potential map of the likely presence of wetlands before European settlement, and a map of wetlands potentially protected under Section 404 of the Clean Water Act. For each test case, the optimal distribution of wetland avoided loss and restoration by wetland type was selected for net carbon sequestration given competing land use demands. Results include maps that identify where current and projected wetlands are most beneficial for carbon sequestration in the context of land use and land cover change associated with different emission scenarios.

Contact Information: Kristin Byrd, Western Geographic Science Center, USGS, 345 Middlefield Road MS-531, Menlo Park, CA 94025 USA, Phone: 650-329-4279, Email: kbyrd@usgs.gov

CARBON SEQUESTRATION BY A TEMPERATE SEDGE-GRASS MARSH

Hana Cizkova [1,2], *Jiri Dusek* [1] and *Stanislav Stellner*

[1]Czech Globe – Global Change Research Centre, Ceske Budejovice, Czech Republic

[2]Faculty of Agriculture, University of South Bohemia, Ceske Budejovice, Czech Republic

The seasonal and inter-annual variation of carbon sequestration was studied during a period of four consecutive years (1996-1999) in a sedge-grass marsh dominated by a tall sedge (*Carex acuta*). The marsh is part of a large acidic fen Mokré Louky (Wet Meadows) located in the Trebon Basin Biosphere Reserve, Czech Republic. The water level at the site keeps near the surface for most of the time, though it can increase up to 2 m during irregular floods.

Gross ecosystem production (GEP), net ecosystem production (NEP) and ecosystem respiration (Re) were estimated using the eddy covariance technique (open path infrared gas analyzer Licor 7500 LI-COR, USA). In addition, the seasonal courses of aboveground biomass were assessed using methods of production ecology.

The marsh acted as a sink of carbon within the four years of monitoring. GEP was the highest in the driest year of 2007 (1375 g C m^{-2} y^{-1}) and lowest in the wet years of 2006 and 2009 (1090 g C m^{-2} $y^{-1}$and 1075 g C m^{-2} y^{-1}, respectively). The highest NEP was recorded in the dry year of 2007 (209 g C m^{-2} y^{-1}) in spite of a high Re. The lowest NEP (41 g C m^{-2} y^{-1}) was recorded in 2008 although favorable meteorological conditions promoted the highest aboveground primary production. The low NEP was caused by high carbon losses from soil due to a low water level.

Comparison of seasonal courses of GEP and live aboveground biomass revealed that while the seasonal maximum of GEP per day occurred in June, the maximum rates of carbon fixation per unit of carbon contained in live aboveground biomass were highest (over 0.15 g^{-1}.day^{-1}) at the beginning of the growing season and declined thereafter. This documents that GEP is determined not only by the amount of live aboveground biomass, but also by its physiological age. Inter-annual comparisons have shown that the physiological performance of plant was also modified by the seasonal courses of precipitation and water level.

Contact Information: Hana Cizkova, Faculty of Agriculture, University of South Bohemia, CZ-37005 Ceske Budejovice, Czech Republic, Phone: +420-38-777-2750; Email: hana.cizkova@gmail.com

THE RAPIDLY EVOLVING SCIENCE OF COASTAL BLUE CARBON- WHAT'S KNOWN AND WHAT DO WE WANT TO KNOW?

Stephen Crooks
ESA PWA, San Francisco, CA, USA

Coastal Blue Carbon is a term that reflects the potential contribution to climate change mitigation activities offered by the improved management of natural biogeochemical processes performed by coastal wetlands. Three forms of coastal wetlands – tidal marshes, mangroves and sea grass meadows - are in particular focus because of the removal of CO_2 from atmospheric and coastal water circulation and long-term burial within organic-bearing soils. Anthropogenic disturbance to these deposits may not only halt the gradual process of carbon sequestration but also release, within a years to decades, stocks of carbon that took centuries or millennia to accumulate. Poorly constrained estimates suggest that emissions due to coastal wetland conversion and disturbance may be significant in a climate change context.

In this presentation I shall review the status of our knowledge with regards coastal blue carbon. Our knowledge is patchy but improving. We have relatively good understanding of sequestration and sedimentation processes and activities related to wetland restoration (though this knowledge is not well distributed). Basic mapping of wetland distribution, rates of conversion and soil characteristics are lacking. Understanding of biogeochemical cycling across the salinity gradient is improving but remains a complexity that is poorly quantified. Emissions factors associated with conversion of wetlands to other land-uses are critically needed to support inclusion within national GHG accounts.

Contact Information: Stephen Crooks PhD. Climate Change Services Director, ESA PWA, San Francisco, California 94941. Phone: 415 262 2300. Email: SCrooks@esassoc.com

CARBON SEQUESTRATION IN CONSTRUCTED WETLANDS TREATED WITH SWINE WASTEWATER

Gudigopuram B. Reddy[1], *Patrick G. Hunt*[2], *Kyoung Ro*[2] and *Ariel Szogi*[2]   *Presented by:* ***Johnsely Cyrus***[1]
[1]North Carolina A&T State University, Greensboro, NC, USA
[2]USDA-ARS, Coastal Plains, Soil, Water and Plant Research Center, Florence, SC, USA

In swine operations, the waste is flushed from the animal houses into an anaerobic lagoon and periodically the lagoon wastewater is sprayed on the land. These practices have a potential to contaminate the surface and ground water with nutrients. Constructed wetlands have been demonstrated to reduce the nutrients concentration in swine wastewater and effluents could be used for irrigation. During the treatment years, the lagoons and constructed wetlands sequestered carbon (C). The C sequestration depends on the hydraulic load, nitrogen load, and total C load received by the constructed wetlands. The constructed wetlands: marsh-pond-marsh (MPM) and continuous marsh (CM) have been in operation since 1997 at NC A&T State University Farm to treat lagoon swine wastewater. The marsh area of these wetlands was planted with broad leaf cattail (*Typha latifolia*, L.) and American bulrush (*Schoenoplectus americanus* (Pers)). Sequestered C in the constructed wetlands was measured in 2006 and 2010 in three depths. The soil C was fractionated in to different components: cold and hot water extraction C, biomass C, intermediate C, and recalcitrant C. Plant C was also calculated over the years. The sequestered C decreased with the soil depth. The C fractionation series showed the following order: labile < intermediate < passive. Also, the green house gases (GHGs) emitting from the wetlands have been measured and fluxes were calculated to assess the potential of these type of wetlands' contribution to global warming or mitigation of global warming gases.

Contact Information: Johnsely Cyrus, North Carolina A&T State University , Carver Hall, Greensboro , NC 27411, United States , PH 336-334-7779; EMAIL: jscyrus@ag.ncat.edu

CARBON STORAGE AT MANAGED AND NATURAL MARSHES IN THE WACCAMAW NATIONAL WILDLIFE REFUGE, SOUTH CAROLINA, USA

Judith Z. Drexler[1], *M. Craig Sasser*[2], *Ken W. Krauss*[3], *James Orlando*[1], *Amber M. Powell*[1] and *Christopher M. Swarzenski*[4]

[1]U.S. Geological Survey, California Water Science Center, Sacramento, CA, USA
[2]U.S. Fish and Wildlife Service, Georgetown, SC, USA
[3]U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, USA
[4]U.S. Geological Survey, Louisiana Water Science Center, Baton Rouge, LA, USA

Carbon sequestration is an important ecosystem service provided by wetlands, wherein carbon is stored in organic soil, thus reducing greenhouse gas emissions to the atmosphere. Although tidal freshwater marshes are known to have high rates of carbon sequestration, it is unknown whether impounded (managed) freshwater marshes store carbon at similar rates. The objective of this study was to determine carbon storage in six freshwater marshes: 2 naturally tidal, 2 deeply flooded (~90 cm) and impounded, and 2 under a moist soil (impounded) management regime. Two soil cores were collected from each marsh, sectioned into 3-cm intervals, and analyzed for % organic carbon, % total carbon, and bulk density. In addition, due to a strong manure odor from one of the naturally tidal cores, 3 core sections at various depths were analyzed for fecal coliform content using DNA fingerprinting techniques. In the top 16 cm of the cores, organic carbon content was approximately 35% at the naturally tidal sites, 16% at the moist soil impounded sites, and 33% at the deeply flooded impounded sites. Organic carbon densities were approximately 3 g cm^{-3} at the naturally tidal sites, 4.5 g cm^{-3} at the moist soil impounded sites, and 2 g cm^{-3} at the deeply flooded impounded sites. Bulk densities were an order of magnitude greater in the moist soil impounded sites than the naturally tidal sites, with deeply flooded impounded sites falling between the two extremes. The fecal coliform test indicated the presence of manure from cattle and/or deer at depth ranges of 0-3 cm, 9-12 cm, and 30-33 cm in the tidal marsh. On-going work includes ^{137}Cs and ^{210}Pb dating of core sections, which will enable cross-site comparisons of recent carbon sequestration rates. The results of this study not only show differences between impounded and natural freshwater marshes in carbon storage, but also suggest that the components of the carbon sink may not be fully understood. Further work is planned to determine whether tidal marshes may be long-term sinks and possible sources of bacterial contamination.

<u>Contact Information</u>: Judith Z. Drexler, U.S. Geological Survey, California Water Science Center, 6000 J Street, Placer Hall, Sacramento, CA 95819 USA, Phone: 916-278-3057; Email: jdrexler@usgs.gov

AN INCONVENIENT 'WETLAND' TRUTH – THE NEED TO CONSIDER PEATLAND-GEOENGINEERING SCHEMES

***Christian Dunn**, Nathalie Fenner* and *Chris Freeman*
Wolfson Carbon Capture Laboratory, School of Biological Sciences, Bangor University, Gwynedd, UK

Peatlands currently store 455 Pg of carbon, with 0.096 Pg more being sequestered every year. However, by harnessing the natural biogeochemical cycles in peat it has been estimated they have the potential to store an additional 2 Pg yr^{-1} of carbon: equivalent to around a third of global transport emissions. Whilst peat-forming restoration is vital, achieving such globally significant figures requires the use of geoengineering techniques to take advantage of the 'enzymic latch'. By reducing the activity of phenol oxidase and increasing the concentration, and type of phenolic compounds in peat it is possible to inhibit the activity of hydrolase enzymes, responsible for the decomposition of organic matter and thereby preventing the further break-down of peat. We propose peatlands can offer a safer, more cost effective geoengineering scheme than many other methods currently being considered. Under UN guidelines it is hoped the sequestration of carbon, using such methods, can be incorporated into carbon markets and national greenhouse gas accounting schemes. But the benefits of removing such levels of carbon from the atmosphere for our planet's environment may well be immeasurable, and we argue it is the moral obligation of the wetland scientific community to consider peatland-geoengineering schemes.

Contact Information: Chris Freeman, Wolfson Carbon Capture Laboratory, School of Biological Sciences, Bangor University, Deiniol Road, Bangor, Gwynedd LL57 2UW, Phone: +44 (0) 1248 382353, Email: c.dunn@bangor.ac.uk

CREATING A BLUE CARBON ASSET UNDER THE VERIFIED CARBON STANDARD

Igino M. Emmer
Silvestrum, The Netherlands

Most international carbon standards focus on GHG emission reduction and removal initiatives that operate as individual projects. The Verified Carbon Standard (VCS) is an international standard that has advanced the requirements for Agriculture, Forestry and Other Land Use (AFOLU) projects and methodologies. The purpose of the standard is to assist project proponents, project developers, methodology developers and validation/verification bodies in developing and auditing projects and methodologies in order to get carbon credits for specific projects.

The VCS has recently included specific requirements for 'peatland rewetting and conservation' and is now extending these requirements to include a wider definition of wetland: Wetland Restoration and Conservation (WRC). The standard provides guidance on, amongst others, 1) eligible project categories, 2) GHG sources and carbon pools, 3) baseline determination, 4) leakage calculation and 5) GHG emission reductions and removals calculation. AFOLU project categories that are eligible for carbon credits include Afforestation, Reforestation and Revegetation (ARR), Agricultural Land Management (ALM), Avoided Conversion of Grasslands and Shrublands (ACoGS), Improved Forest Management (IFM), Reduced Emissions from Deforestation and Degradation (REDD) and Peatland Rewetting and Conservation (PRC); this last category will be included in the WRC in 2012. The WRC requirements must be applied across all AFOLU categories when they occur on wetlands, e.g. mangrove restoration, avoided deforestation of peatswamp forest or mangroves. In addition, WRC project activities can stand alone and receive credit, e.g. rewetting of drained tidal marshes or non-forested peatland.

The various issues concerning AFOLU project development and implementation are addressed at three different levels: 1) AFOLU requirements, 2) methodologies, and 3) project descriptions. The AFOLU requirements define how projects and methodologies can comply with the VCS standard. Methodologies are step-by-step explanations of how emission reductions or removals are to be estimated in line with the requirements following accepted scientific practice. Project description or design documents provide Information on how a specific project complies with the requirements and applies the methodology. This presentation will first present the new WRC requirements that are likely to be adopted by the VCS in 2012. Next we will discuss current initiatives developing carbon methodologies for blue carbon in compliance with the VCS AFOLU requirements, including WRC. Finally, we'll examine issues determining the success of project approval, such as land eligibility, additionality, and verifiability of emission reduction claims.

Contact Information: Igino Emmer, SIlvestrum, Dorpsstraat 4, 1546 LJ Jisp, The Netherlands, Phone: +31-653699610, Email: igino.emmer@silvestrum.com

BLUE CARBON STORED IN THE SEAGRASS BEDS OF THE WORLD

James W. Fourqurean[1], *Hilary A. Kennedy*[2], *Nuria Marbà*[3], *Miguel A. Mateo*[4], *Gary A. Kendrick*[5] and *Carlos M. Duarte*[3,5]

[1]Florida International University, North Miami, FL, USA
[2]Bangor University, Bangor, Anglesey, UK
[3]Center for Advanced Studies, Spanish High Council for Scientific Research, Blanes, Spain
[4]Mediterranean Institute for Advanced Studies, Spanish High Council for Scientific Research, Esporles, Mallorca, Spain
[5]University of Western Australia, Perth, WA, Australia

The importance of reducing anthropogenic greenhouse gas emissions to mitigate anthropogenic climate change has led to efforts to protect terrestrial organic C (C_{org}) stores through forest conservation (e.g. (REDD+). Recent realization of the extent of C_{org} stores in coastal ecosystems has led to similar initiatives to protect these “Blue Carbon” stores. For the first time, we have quantified organic carbon (C_{org}) stocks in two large seagrass-dominated ecosystems, Shark Bay in Western Australia and Florida Bay in Florida, USA. We used this data, combined with literature derived data to make a novel estimate of the global Corg stock in seagrass ecosystems. Soils from Florida Bay had significantly higher dry bulk density (DBD) than sediments from Shark Bay, corresponding with significantly lower loss on ignition (LOI) of Florida Bay sediments compared to Shark Bay sediments. The lower DBD, higher LOI sediments from Shark Bay had, on average, C_{org} values 0.6 ± 0.1% higher than the Florida Bay sediment. In the top meter of the soil profile, the Florida Bay core sites contained between 124.3 Mg C ha^{-1} and 210.4 Mg C ha^{-1}. The core sites in Shark Bay had higher storage of organic carbon in the soil, with a low value of 115.3 Mg C ha^{-1} and a high of 335.1 Mg C ha^{-1}. The amount of C_{org} stored in the top meter of the soil was far greater than the organic content in the living plant biomass.

We used literature data from 946 distinct sampling locations worldwide containing 3640 data points with estimates of Corg and/or dry bulk densityto estimate global patterns in Corg storage. While the global median soil Corg storage was 139.7 Mg C_{org} ha^{-1}, storage estimates from sites where the entire top m of soil was measured in Mediterranean Sea, Florida Bay, and Shark Bay had considerably higher values (115.3 to 829.2 Mg C_{org} ha^{-1}.) The top meter of seagrass soils contain (4.2 to 8.4 Pg C) orders of magnitude more C_{org} than the living seagrass plants (75.5 and 151 Tg C). These estimates make the C_{org} stored in seagrass soils roughly equal to the C_{org} stored in the world’s marine tidal marshes and mangrove forests, estimated to be ≈ 10 PgC. Although the top m of terrestrial soils contain 1500-2000 PgC, seagrass meadows store about twice the average per hectare C_{org} as terrestrial soils. When seagrass C_{org} stores are compared to stores in other ecosystems, two things are obvious: 1) seagrass biomass, which averaged 7.29 ± 1.52 MgC ha^{-1}, is small compared to forests, which range from 30 MgC ha^{-1} for boreal tundra woodlands to 300 MgC ha^{-1} for tropical rainforests; and 2) that soil C_{org} stores in seagrasses are large compared to terrestrial ecosystems and can rival the C_{org} stores of mangroves underlain by extensive peat deposits. Further, given the current rates of seagrass loss, predominantly caused by eutrophication of coastal water bodies, (as high as 7% yr^{-1}), seagrass Corg stores are at risk of remineralization.

Contact Information: James Fourqurean, Florida International University, MSB 350, 3000 NE 151st St, North Miami, FL 33181, United States; PH 305-348-4084; EMAIL: Jim.Fourqurean@fiu.edu

GREEN PAYMENTS FOR BLUE CARBON: ECONOMIC INCENTIVES FOR PROTECTING THREATENED COASTAL HABITATS

David Gordon[1]*, Brian C. Murray*[1]*, Linwood Pendleton*[1]*, W. Aaron Jenkins*[1] and *Samantha Sifleet*[1]
Nicholas Institute for Environmental Policy Solutions, Durham, NC, USA

The destruction of mangroves, tidal wetlands, and seagrasses is occurring at a rate of 0.7%-2% annually. Ecosystem services including biodiversity, flood control, and carbon sequestration, while intrinsically valuable, do not retain a market mechanism to express value to human society. Absent market mechanisms, a landowner will not fully consider ecosystem services when deciding on land use changes. Thus, measuring and monetizing the ecosystem services provided by coastal habitats may provide an opportunity to protect these systems. One such service already monetized in other habitats is carbon storage and sequestration for protection against climate change.

Payments for the carbon stored in coastal habitats, commonly known as blue carbon, has the potential to alter the economic incentives faced by landholders. Initiatives such as REDD+ have already shown that payments for stored carbon can protect forested land. Our study analyzes the payments necessary to alter an economic decision making process to favor protection through payments for carbon alone. The money needed to protect a coastal habitat depends on the opportunity cost of using that habitat for an alternative land use. While blue carbon payments maintain potential to protect land slated for agriculture and aquaculture conversion, protection stands less likely in areas of residential and tourist development.

Blue carbon habitats are unique in their ability to sequester much carbon in their soils. Including soil carbon, we find that mangroves and salt marshes store more carbon per hectare on average than tropical forests. Using a range of carbon sequestration data and a carbon price of $15t^{-1}, we find that salt marshes gross an average of $8,000ha^{-1} for its carbon. At this same carbon price, oceanic mangroves gross $18,000ha^{-1} and estuarine mangroves $13,000ha^{-1}.

Limited economic data constrains our ability to analyze net economic returns to only mangrove countries. Using cost data for the top mangrove-holding countries, we find that at a carbon price of $15t^{-1}, 85% of countries have a net positive return on mangrove protection for carbon alone. However, these mangrove countries have drastically different opportunity costs for protection. We use these variations in cost to provide a first-order supply curve detailing the habitat protection potential at various carbon prices. Important in this analysis is the fact that a carbon price of only $4t^{-1}, countries may supply approximately 40 million tonnes of mitigation supplying between 100,000 and 400,000 hectares of protected mangrove habitat annually.

These findings become limited not simply by data but by the current policy field. Voluntary markets and REDD+ protocols do not fully incorporate soil carbon. Absent this source of sequestration, the economics of blue carbon suffers. While initiatives are underway to include soil carbon, additional investments in data collection and monitoring are necessary before payments for blue carbon may become reality.

Contact Information: David Gordon, Nicholas Institute for Environmental Policy Solutions, Duke University, Box 90335, Durham, NC 27708, USA, Phone: 919-613-8721, Fax: 919-613-8712, Email: david.r.gordon@duke.edu

CARBON SEQUESTRATION IN COASTAL FRESHWATER WETLAND SOILS IN VERACRUZ MEXICO

Maria E. Hernandez[1], *Jose L. Marin-Muñiz J.L*[2] and *Patricia Moreno-Casasola*[1]
[1]Institute of Ecology, Xalapa, Veracruz México
[2]University of Veracruz, Xalapa, Veracruz, México

Wetland soils are an important carbon sink in the planet. However, there are few studies on carbon sequestration in tropical freshwater wetland soils. On the coastal plain of Veracruz State in southeastern Mexico, freshwater forested wetlands lie just upslope of mangrove swamps and sometimes grading into them, adjacent to freshwater swamps, large area of freshwater marshes are common. All these ecosystems are threatened by several anthropogenic activities. It is necessary to generate knowledge about the functions of these tropical ecosystems to promote their conservation and restoration.

The aim of this study was to compare carbon sequestration in the soils of freshwater marshes and swamps on in Veracruz. The study sites were: Estero Dulce, Tecolutla (20º 17' 53'' N, 96º52'19''W), Laguna Chica, Vega de Alatorre (20º 05' 47.8'' N 96º 41' 23.8' 'W) and Boquilla de Oro, Alto Lucero (19º 49' 47'' N, 96º 26' 59'' W). The annual carbon accumulation was estimated analyzing organic carbon content and bulk density in 2 cm layer of soil profiles (80 cm). Three soil profiles were sampled in each type of wetland in all sites. Short term soil accretion (one-year) was calculated using glitter and colored sand markers horizons.

Organic carbon content ranged from 30 to 4 % with higher values in the upper layers (30 cm). Carbon accumulation was significantly higher in swamp soils (23.96 ± 6.6 Kg C m^{-2} $año^{-1}$) than in marsh soil (12.5 ±1.5 Kg C m^{-2} $año^{-1}$) in the marshes and swamp soils. The results indicated that theses tropical ecosystems provide an important service as carbon sinks.

Contact Information: Maria E. Hernández. Biotechnological Resource Management Network, Institute of Ecology, Carretera antigua a Coatepec 351, El Haya, Xalapa 91070, Veracruz, México; Phone 52 (228) 8421849, 8421800 ext. 6210; Fax 52 (228) 8187809; Email: elizabeth.hernandez@inecol.edu.mx

SPRUCE-PEATLAND RESPONSES UNDER CLIMATIC AND ENVIRONMENTAL CHANGE: AN *IN SITU* WARMING BY CO_2 MANIPULATION OF A CHARACTERISTIC HIGH-CARBON ECOSYSTEM

Colleen M. Iversen[1], *Paul J. Hanson*[1], *Randall K. Kolka*[2], *Stephen D. Sebestyen*[2], *Richard J. Norby*[1], *Joanne Childs*[1], *Brian Palik*[2], *Peter Thornton*[1], *Jeffrey Warren*[1], *Stan D. Wullschleger*[1] and *Les Hook*[1]

[1]Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA
[2]USDA Forest Service, Marcell Experimental Forest, Grand Rapids, Minnesota, USA

Identification of critical environmental response functions for terrestrial organisms, communities, and ecosystems to rapidly changing climate conditions are needed to evaluate ecological consequences and feedbacks. Such research has the most 'real-world' relevance when conclusions are drawn from controlled manipulations operating in natural field settings. We are constructing an experimental platform to address climate change response mechanisms in a *Picea*/*Larix*/*Sphagnum* ombrotrophic bog ecosystem located in northern Minnesota. This ecosystem, which is located at the southern extent of the spatially expansive boreal peatland forests, is hypothesized to be especially vulnerable to climate change and to have important feedbacks on the atmosphere and climate. The replicated experiment will allow us to test mechanisms controlling vulnerability of organisms and ecosystem process changes for multiple levels of warming (up to +9°C) combined with elevated CO_2 exposures (900 ppm). New methods for whole-ecosystem warming at a 12-m diameter plot scale have been developed for this ecosystem.

Direct and indirect effects of these experimental perturbations will be tracked and analyzed over a decade. We will quantify thresholds for organism decline or mortality, limitations to regeneration, biogeochemical limitations to productivity, and changing greenhouse gas emissions to the atmosphere. The experiment will allow for the evaluation of responses across multiple spatial scales including: microbial communities, bryophyte populations, various higher plant types (above- and belowground), and some faunal groups. Minirhizotron technology was used to quantify root production, mortality, and depth distribution dynamics in the bog prior to experimental manipulation. We found that: (1) minirhizotron technology, which is rarely used in bogs, facilitates the quantification of ephemeral root dynamics and should be used in other wetland systems, (2) root standing crop and production varied across a gradient of *Picea* density, and (3) root standing crop and production associated with raised hummock topography was much greater than that in hollow depressions. Measurements taken prior to experimental manipulation will be used to parameterize ecosystem and land surface models in order to develop and test hypotheses regarding the expected effects of warming and elevated CO_2 on ecosystem carbon and nitrogen cycling in the forested bog.

Contact Information: Colleen M. Iversen, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA, Phone: 865-241-3961, Fax: 865-574-9501, Email: iversencm@ornl.gov

EXCEPTIONALLY HIGH CARBON STOCKS OF MANGROVES AND THEIR POTENTIAL CONSERVATION THROUGH GLOBAL CARBON MARKETS

J Boone Kauffman[1], *Maria Fenanda Adame*[2] and *Daniel Donato*[3]
[1]Oregon State University, Corvallis, Oregon, USA
[2]CINVESTAV-IPN, Mérida, Yucatán México
[3]University of Wisconsin, Madison, WI USA

Mangroves provide a number of ecosystem services including habitats for many species of fish and shellfish, storm protection, positive influences on water quality, wood, aesthetics, and biodiversity. Perhaps the least investigated ecosystem service of mangroves is that of a C sink. We have measured the ecosystem carbon stocks in mangroves across the Asia Pacific and found them to range from 500 to 1200 Mg C/ha which is a CO_2 equivalence of 1603 to 4404 Mg/ha. Similarly, in Mexico we have found that carbon stocks range from 600-1200 Mg/ha in dwarf/scrub mangrove and 1000-2000 to Mg/ha in mangrove forests. This far exceeds the size of carbon stocks measured in Mexican upland tropical forests (<400 Mg/ha). While the stature and aboveground mass of upland forests may exceed that of mangroves, the carbon-rich soils of mangroves result in the large ecosystem carbon stocks reported here. Many mangroves contain peat layers (histic epipedons) and/or deep soils with consistently high carbon concentrations to bedrock.

Because the numerous values of mangroves are well known, it is ironic that rates of deforestation largely relating to land use/land cover change are among the highest of any forest type on earth exceeding that of tropical rain forests. Land conversion has resulted in the loss of over 35% of mangroves between 1980 and 2000. Dominant causes of degradation and loss include conversion to aquaculture (shrimp), agricultural conversion, coastal development, and hydrological and sediment supply disruptions from upstream developments. The carbon emissions arising from conversion of mangroves would be exceptionally high and a significant source of greenhouse gasses to the atmosphere. Further, global climate change impacts that may exacerbate mangrove losses include sea-level rise, changes in tropical storm (cyclone) intensity, and changes in stream and ground water flows that discharge into mangroves.

Our results suggest that C stocks of mangroves are among the highest of any forest type on Earth. As such there is a great potential for mangrove conservation through carbon marketing strategies referred to as “reduced emissions from deforestation and degradation – REDD” and other financial incentives that are derived from the conservation of standing forests. REDD is a mechanism to mitigate global greenhouse gasses by compensating countries for avoiding deforestation or degradation. Because of their large ecosystem carbon stocks which are so vulnerable to land use as well as the numerous other critical ecosystem services, mangroves are of increasing interest for participation in climate change mitigation strategies.

Contact Information: J Boone Kauffman, Oregon State University, 104 Nash Hall, Corvallis, OR 97331, United States; PH 541-737-5509; Email: boone.kauffman@oregonstate.edu

CARBON MANAGEMENT IN COASTAL WETLANDS: A COLLABORATIVE APPROACH TO QUANTIFYING GHG FLUX TO SUPPORT DEVELOPMENT OF A GHG PROTOCOL AND ECONOMIC ASSESSMENT

Alison S. Leschen
Waquoit Bay National Estuarine Research Reserve, Waquoit, MA, USA

Excess nitrogen and climate change are two of the most pressing issues facing coastal communities today. This project, funded by the NOAA NERRS Science Collaborative, is a joint effort by multiple scientists and "end-users" from both private and public institutions designed to address the nexus of these two issues. Towns are struggling with how to pay for massive wastewater treatment projects to remove septic nitrogen from groundwater and clean up algae-choked embayments. Meanwhile, increasingly intense storm events and sea level rise, caused by rising atmospheric concentrations of anthropogenically-derived greenhouse gases (GHG), threaten coastal infrastructure and economies. Efforts to ameliorate GHG levels include the protection and restoration of ecosystems that act as net "sinks" of these gases. Voluntary and mandatory carbon offset markets are developing to incentivize such protections. Critical barriers to management of carbon (C) stocks in coastal wetlands, including incorporation into C markets, include a lack of data and knowledge regarding GHG fluxes in wetlands to support model development and prediction of project outcomes, and absence of GHG offset protocols that set guidelines for monitoring and verification requirements for wetlands projects. Project scientists will examine GHG flux in salt marshes, and the effect that nitrogen has on that flux. By developing GHG budgets in coastal tidal wetlands with differing N loads, we will quantify not only sequestration rates but whether these rates are significantly altered by high levels of N typical of impacted areas, as their preliminary data indicate. These results will be incorporated into a GHG protocol for salt marshes by Restore America's Estuaries and collaborators, which will enable inclusion of this important "Blue Carbon" ecosystem into C offset markets. A user-friendly model will be developed enabling resource managers, town boards and others to estimate GHG storage in their salt marshes, and whether the presence of N significantly alters this storage. An economic model will be developed to monetize these results and determine whether reducing inputs of N could add "value" to a salt marsh. Such findings could provide financial incentives for regions to deal with N-loading problems. Local end users will be included from the beginning of the project to ensure that results will meet local coastal management needs. We will describe the development of the project, including how inclusion of end-users from the outset helped shape the science and improve the project.

Contact Information: Alison S. Leschen, Waquoit Bay National Estuarine Research Reserve, 149 Waquoit Hwy, Waquoit, MA 02536 USA, Phone: 508-457-0495, ext. 103; Fax: 617-727-5537; Email: alison.leschen@state.ma.us

IDENTIFICATION AND ENHANCEMENT OF THE ECOSYSTEM SERVICES FROM CREATED AND RESTORED WETLANDS: OLENTANGY RIVER WETLANDS TO THE FLORIDA EVERGLADES TO THE PLANET

William J. Mitsch
The Ohio State University, Columbus, OH, USA

The Olentangy River Wetland Research Park at the Ohio State University has completed its 20th year of formal research and teaching. Its impact has been at the regional level where studies of primary succession of vegetation, soil development, and nutrient retention of a pair of created wetlands have been investigated over 17 years (1994-2010). A planted wetland had higher community diversity every year while the naturally colonizing wetland was more productive in the first 7 years and overall still has more carbon retention. Wetland soils turned hydric within a few years, soil organic carbon more than doubling in 10 years. Nutrient retention was statistically similar in the two wetlands in most years for nitrogen and phosphorus. The wetlands are effective carbon sinks, with rates comparable to or even higher than those from natural wetlands. As a result of successful wetland creation and restoration at this 20-ha site, it was named the 24th Ramsar Wetland of International Importance in the USA in 2008. The influence of the ORWPR goes well beyond the site in Ohio with studies investigating the phosphorus retention and carbon sequestration in wetlands in the Florida Everglades, wetland biogeochemistry in Costa Rica, Botswana, and China, and an overall assessment of the net radiative forcing of wetlands in the world. This influence is amplified by the over 80 graduate students and post-docs who have learned their wetland ecology at the ORWRP and earlier programs at Ohio State University, many of whom have gone on to productive careers in wetland science at other universities, research facilities, consulting firms, and state and Federal agencies.

Contact Information: William J. Mitsch, Olentangy River Wetland Research Park, The Ohio State University, 352 W. Dodridge Street, Columbus, Ohio 43202 USA, Phone: 614 292 9774; Fax: 614 292 9773; Email: mitsch.1@osu.edu

FORECASTING BLUE CARBON IN TIDAL MARSHES: THE BALANCE BETWEEN CARBON SEQUESTRATION AND METHANE EMISSIONS

***J. T*. Morris**[1] and *J. P. Megonigal*[2]
[1]Belle Baruch Institute for Marine & Coastal Sciences, University of South Carolina, Columbia, USA
[2]Smithsonian Environmental Research Center, Edgewater, MD, USA

Tidal marshes, mangroves and seagrass beds – so-called blue carbon ecosystems – are hotspots of net carbon sequestration in soils because of high carbon burial in soils and relatively low emissions of methane. In order to advance policies on the management of these systems for their climate services, models need to be developed that adequately forecast the balance between greenhouse gas sources and sinks over periods ranging from 20-100 years. Here we present several enhancements of the Marsh Equilibrium Model (MEM) developed to facilitate such forecasts. Soil carbon sequestration in MEM was modified to make depth distributions of root biomass and soil organic matter more explicit. Initial tests of the model suggest that it can now reproduce soil organic matter profiles for soils ranging from highly mineral to highly organic. Methane emissions from tidal marshes can offset a significant fraction of the carbon these systems sequester in soils. We also modified the Marsh Equilibrium Model (MEM) to account for methane emissions from tidal marshes in order to forecast the balance between methane emissions and soil carbon sequestration in tidal marshes, particularly as it relates to sea level rise. We adopted a parsimonious approach by using a few simple rules to calculate methane production based on parameters MEM already incorporates for forecasting soil carbon sequestration. In particular, methane production was a function of soil elevation, tidal range, root productivity and methane yield. Model predictions were compared to observations of methane emissions from an "organ" experiment in which marsh monoliths were exposed to different tidal regimes in the field. We found that measured rates of methane emissions (8-23 g CH_4 m^{-2} yr^{-1}) could be reproduced when the computed rate was proportional to depth-specific root production and decay, and when the duration of soil saturation exceeded a threshold. For a marsh platform situated near the top of the tidal frame, an acceleration of the rate of sea-level rise will increase primary production, methane production and carbon sequestration as relative marsh elevation declines. However, the system switches from increasing production to a state of declining primary production and methanogensis as sea-level rise pushes the wetland beyond a tipping point. The tipping point time depends on the trajectory of sea-level rise, the tide range and the present elevation of the marsh platform within the tidal frame. Considering the fresh to salt water continuum, sea-level rise will shift the zone of tidal influence and methane production upstream, and methane production at the tidal freshwater end of the gradient probably will increase with tidal flooding at first, and then decline with time and continued increase in flooding.

<u>Contact Information</u>: James Morris, Baruch Institute, University of South Carolina, Columbia, SC 29208 USA, Phone: 803-777-5288, Email: morris@inlet.geol.sc.edu

CARBON CREDITING FOR TIDAL MARSHES: PROJECTS IN MARYLAND

Brian A. Needelman[1] and *J. Patrick Megonigal*[2]
[1]University of Maryland, College Park, MD, USA
[2]Smithsonian Environmental Research Center, Edgewater, MD, USA

Carbon sequestration is one of the many important ecosystem services provided through tidal marsh restoration and conservation and may be a source of initial and long-term income for these projects. Academic and state-agency scientists in Maryland are participating in local and national efforts to bring tidal marsh restoration and conservation projects into carbon markets. Results will be presented from ongoing field research being conducted in coastal marshes restored using dredged material at two sites (the Blackwater National Wildlife Refuge and Cove Point Marsh) and restored using ditch remediation at two sites on the Delmarva Peninsula. The ditch remediation study is designed to validate and develop the Marsh Equilibrium Model (MEM) for carbon sequestration and methane emission estimation. We will discuss challenges associated with quantifying greenhouse gas balances including soil sampling methodology and intensity, methane emissions, estimating state-level carbon sequestration potential, avoided losses, greenhouse gas balance modeling, and determination of the belowground refractory fraction for the MEM model. We have found that the brackish marshes at the Blackwater National Wildlife Refuge are emitting significant quantities of methane (13 to 18 g $CH^4/m^2/yr$), which equates to a global warming potential of approximately 50% of the observed carbon sequestration rate in these systems. We will also discuss policy challenges including carbon value and multiple benefit accounting. Overcoming these science and policy challenges is critical to accurately measure and value the benefits derived from carbon sequestration in these ecosystems. The results from these field and modeling studies will be used to support the development of carbon crediting methodologies for the measurement and valuation of greenhouse gas mitigation in tidal marshes.

Contact Information: Brian A. Needelman, Department of Environmental Science and Technology, University of Maryland, College Park, MD, 20737 USA, Phone: 301-405-8227, Fax: 301-314-2763, Email: bneed@umd.edu

PHOTOSYNTHESIC RESPONSES TO TEMPERATURE IN THE GENUS PHRAGMITES. (POACEAE): AN IMPORTANT MEDIATOR OF CLIMATE RESPONSES?

Nguyen X. Loc*, Brian K. Sorrell, Carla Lambertini* and *Hans Brix*
Department of Bioscience, Plant Biology, Aarhus University, Aarhus, Denmark

Although climate change is expected to alter species composition and productivity of wetland ecosystems, there is little Information for key primary producers on their physiological responses to temperature, which are necessary for understanding and predicting responses to future climate scenarios. One of the most important primary producers in wetlands is the cosmopolitan genus Phragmites. It has high genetic variation and wide ecological adaptability, and may tolerate and acclimate well to varying temperature due to its plasticity in photosynthetic parameters such as enzymatic activity and stomatal aperture regulation. The genus includes three tropical species: P. mauritianus (Africa), P. frutescens (Mediterranean), and P. karka (Asia); one temperate species, P. japonicus (Far East); and the cosmopolitan P. australis.

We tested the photosynthetic responses of these species to temperature. Twelve genotypes were grown from rhizomes under controlled environmental conditions in two growth chambers at 20oC and 36oC. The activities of the main carboxylating enzymes ribulose -1,5 diphosphate carboxylase/oxidase (Rubisco) and phosphoenolpyruvate carboxylase (PEPcase) were analysed. In addition, CO2 response curves, light response curves, pigment content and specific leaf area (SLA) were measured.

Dark respiration rate, light saturation point, water use efficiency, SLA and Rubisco activity all varied significantly with temperature, and responses differed between genotypes. Correlations amongst measured parameters also differed between 20oC and 36oC. The results have identified a set of reactions and interactions dependent on temperature, and reveal a wide range of ecophysiological solutions that have evolved within the genus. We intend to use these highly specific physiological responses to classify the various Phragmites taxa into groups that show similar temperature preferences and responses, and expect them to be widely applicable in modeling changes in distribution and productivity in warmer climates.

Contact Information: Nguyen X. Loc, Department of Bioscience, Plant Biology, Aarhus University, Building 1135, Ole Worms Alle 1, DK-8000 Aarhus C, Denmark, Phone: +45-87156581, Email: nguyen.xuan@biology.au.dk

BLUE CARBON: A TRANSFORMATIONAL TOOL FOR MARINE MANAGEMENT AND CONSERVATION GLOBALLY

Emily Pidgeon
Conservation International, Arlington, VA, USA

Coastal "blue" carbon – carbon stored in the coastal ecosystems of mangroves, seagrasses and tidal marshes – has strong potential to transform management and conservation of coastal ecosystems. Coastal ecosystems are the fastest disappearing ecosystems on Earth - on average 2 % are lost every year - a result of poorly-managed development, clearing for aquaculture and pollution. Losing these ecosystems means losing the coastal protection and food security that they provide, services that are the foundation of resilience to climate change for the over 20 % of the world's population that live within 20 miles of a coast. Further, we now know that destruction of coastal systems not only erodes our capacity to adapt to climate change but is also a cause of climate change in itself. Policy and management that conserves coastal systems rich in blue carbon is an urgent priority.

A growing number of governments and organizations are exploring coastal management, policy, and conservation approaches that address the carbon emissions from degradation and destruction of coastal ecosystems. Many existing policy agreements and carbon financing mechanisms are immediately applicable, but challenges remain. For example, how should blue carbon be integrated into the United Nation Framework Convention on Climate Change (UNFCCC) and related activities such as the Reducing Emissions from Deforestation and Forest Degradation (REDD) mechanism? Can other international conventions and agreements such as the Convention for Biological Diversity support blue carbon-based conservation of coastal systems? How can carbon markets incorporate blue carbon based credits?

Conservation International (CI), the International Union for Conservation of Nature (IUCN), and the Intergovernmental Oceanic Commission (IOC) of UNESCO are currently working with partners to build the Blue Carbon Initiative. The initiative addresses urgent policy, management and science needs such as providing a robust scientific basis for coastal carbon conservation and management and developing policy designed to support incentives for coastal blue carbon-based management.

Globally we are critically dependant on the health of our coastal ecosystems to provide both climate change adaptation and mitigation. Blue carbon provides a fundamental new tool to coastal management for conserving the most threatened natural systems on Earth.

Contact Information: Emily Pidgeon, Conservation International, 2011 Crystal Dr, Suite 500, Arlington, VA 20222, United States, Phone: 703-341-2481, Email: epidgeon@conservation.org

CARBON SEQUESTRATION IN COASTAL FRESHWATER PEATLANDS: A MARKET CREDIT TOOL FOR RESTORATION

Curtis J. Richardson[1], *Neal Flanagan*[1,] *Hongjun Wang*[1], *Sara Ward*[2] and *Tom Augspurger*[2]

[1]Duke University, Durham NC, USA

[2]U.S. Fish & Wildlife Service, Raleigh NC, USA

Millions of hectares of former peatlands in the U.S. have been drained and converted to agriculture and forestry. However, draining promotes the decomposition of the organic matter in the soil, leading to accelerated soil subsidence, severe carbon losses, and accelerated transport of nutrients to adjoining ecosystems. Pocosins (shrub bogs) in the SE USA cover millions of hectares and are characterized by a very dense growth of mostly broadleaf evergreen shrubs with scattered pond pine. The typically thick layer of peat soils 1-3 m (Histosols) underlying Pocosins store nearly 300 Mt of carbon in NC alone. With hundreds of thousand of hectares of drained former Pocosin peatlands lying fallow after failed agriculture the potential for contributions to greenhouse gas emissions is enormous. For example, Bridgham and Richardson (1992) incubated peat from Pocosins in anaerobic conditions and found very low CH_4 production potentials relative to other peatlands, but CO_2 increased greatly in aerobic soils found under drainage or drought conditions; a climate scenario predicted to happen in the southeastern U.S. (IPCC 2007). Our current field study in restored and natural Pocosins found increases in CH_4 gas under higher water levels, more CO_2 release under dryer soils but only immediately after drainage and seasonal fluxes of CO_2 flux to the atmosphere, further suggesting that climate induced drought or drainage will change the magnitude and form of GHG fluxes.

These studies suggest the most immediate and predictable net benefit from restoring drained peatlands is the interruption of CO_2 release to the atmosphere that results from aerobic peat respiration. The scientific goals of our project are to 1) Quantify the change in soil carbon storage and flux and nitrogen dynamics in response to the restoration of natural hydrological conditions to drained Histosols at Pocosin Lakes NWR Refuge (PLNWR), 2) Complete a carbon, nitrogen budget to determine storage and losses from the natural state, drained state, and restored state of peatlands, and 3) From the data in objectives 1 and 2, quantify carbon and nitrogen sequestration benefits of the restoration work and compare these to the sequestration benefits of other climate change projects (re-forestation, conservation tillage) to demonstrate the relative merits of peatland restoration as a climate change solution. It is predicted that restored sites will retain and reduce excessive runoff of nitrogen and DOC into adjacent estuaries. There are also important opportunities to expand restoration of drained peatlands, on-and off-refuge, because over sixty percent of these lands have been degraded or drained and converted to agriculture.

Comparative field studies of GHG fluxes in 2010 in replicated drained, restored and reference blocks indicate that losses were greatest for CO_2, and N_2O and lowest for CH4. The amount of carbon retained that otherwise would be lost without restoration (stop loss), the amount retained in peat as soil genesis is re-established, and the amount retained in the above ground biomass indicates that total carbon stored by restoration could reach nearly 7,300 kg/ha/yr. However, fire is the greatest threat to these ecosystems under climate-induced drought. A recent fire in the Pocosins Lakes Wildlife Refuge during the severe drought of 2008 burned 16,500 ha of abandoned peatlands, releasing an estimated 22 million metric tons of carbon to the atmosphere. It is hypothesized that proper hydrologic restoration would enhance carbon and nitrogen sequestration in these peatlands. This study will provide wetland restoration science to facilitate restoration partnerships and sound management decisions regarding carbon and nitrogen sequestration potential under managed and unmanaged hydrologic conditions.

Contact Information: Curtis J. Richardson, Duke Wetland Center, Duke University, Durham, NC 27708 Phone: 919-613-8006, Fax: 919-613-8101, Email: curtr@duke.edu

MODELING SEA-LEVEL RISE EFFECTS ON TIDAL WETLAND DISTRIBUTION IN THE SAN FRANCISCO BAY ESTUARY

Lisa M. Schile[1], *John C. Callaway*[2], *James T. Morris*[3] and *N. Maggi Kelly*[1]
[1]University of California, Berkeley, Berkeley, CA USA
[2]University of San Francisco, San Francisco, CA USA
[3]University of South Carolina, Columbia SC USA

Sea-level is expected to rise between 55 and 140 cm in the next century and is likely to have significant effects on the distribution and maintenance of tidal wetlands; however, little is known about the effects of increased sea level on Pacific coast tidal marshes carbon sequestration and storage as well as their ability to keep pace with sea-level rise. These marshes comprise the majority of existing tidal wetland habitat in the San Francisco Bay Estuary and are particularly susceptible to increased sea-levels due to lack of upland habitat for future marsh migration. The development and calibration of a model that incorporates both physical and biological parameters is critical for investigating the predicted effects of sea-level rise. We examined the applicability and accuracy of the Marsh Equilibrium Model (MEM), a zero-dimensional model that models organic and inorganic accretion rates under a given rate of sea-level rise. MEM was calibrated using data collected from salt and brackish marshes in the San Francisco Bay Estuary. Above- and below-ground biomass from dominant salt marsh vegetation collected along an elevation gradient combined with results from a large marsh organ experiment simulating sea-level rise on two cosmopolitan tidal marsh species were used to calibrate the biological inputs. The marsh organ results show dramatic significant decreases in both above and below-ground productivity with increased inundation in one species but little to no response with the other. Under current sea-level rise conditions, MEM accurately modeled both organic and inorganic contributions to marsh accretion, and the model was run for each marsh type altering century sea-level rise and suspended sediment concentrations. Preliminary results suggest that changes in the suspended sediment concentration had more of an influence on marsh accretion rates than changes in the contribution of plant biomass and that marsh area decreases with increased sea-level rise. With few upland areas remaining for marsh migration combined with the fact that the majority of remnant marshes are islands, the future extent of tidal wetland and the ability to sequester carbon is predicted to decrease.

Contact Information: Lisa M. Schile, Department of Environmental Science, Policy, and Management. University of California, Berkeley, 130 Mulford Hall #3114, Berkeley, CA 94720-3114 USA, 415-378-2903; Email: lschile@berkeley.edu

LEVERAGING CARBON SERVICES FOR HABITAT CONSERVATION: NOAA'S BLUE CARBON INTERESTS

Ariana E. Sutton-Grier[1], *Roger Griffis*[2] and *Meredith Muth*[3]

[1]Office of Habitat Conservation, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Silver Spring, MD, USA

[2]Office of Science and Technology, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Silver Spring, MD, USA

[3]Climate Program Office, Oceanic and Atmospheric Research, National Oceanic and Atmospheric Administration, Silver Spring, MD, USA

Ecosystem services are a potentially powerful framework for improving natural resource management and policies. By explicitly accounting for these services in policies and activities, and in some cases developing a market to pay for these services, it may be possible to achieve additional habitat conservation and environmental benefits.

When considering carbon in coastal habitats, particularly salt marsh, mangroves, and seagrasses, there is a growing interest in accounting for the carbon stored and sequestered annually in coastal habitats in order to provide additional incentives for conservation of these threatened habitats around the world. If these ecosystems could be included in voluntary or compliance carbon markets, new revenue streams would develop to support the protection and restoration of these ecosystems. However, protocols need to be developed in order for coastal ecosystems to be included in carbon markets. NOAA is helping to support the development of these protocols.

In addition to the potential for carbon markets to support habitat conservation efforts, there are also opportunities for policy implementation changes if we explicitly account for carbon services in these habitats. NOAA is collaborating with other US government agencies to advance both science and policy relevant blue carbon activities, both domestically and internationally. For example, the National Environmental Policy Act implementation guidance is being revised to incorporate climate impacts of federal agency projects in the decision making process about project design and approval. If carbon services of ecosystems, including coastal habitats, can be explicitly included in this revised guidance, it could significantly impact the way agencies make decisions (i.e. which projects are selected and how those projects are designed and built). Thus, NOAA is working with other federal agencies to include carbon services, and other ecosystem services, into federal policies including the NEPA guidance and the Principles and Guidelines for Federal Water Projects. Other examples of federal policies where carbon services could be considered during implementation and could result in additional habitat conservation include the Clean Water Act and the Natural Resources Damage Assessment process.

NOAA is interested in supporting blue carbon science and policy because these efforts have the opportunity to promote coastal conservation, protecting and restoring some the most threatened habitats in the world. Protecting the carbon in these systems will have the added benefit that many other important ecosystem services, including flood protection, water purification, and nursery habitat, will also be protected in these critical habitats.

Contact Information: Ariana Sutton-Grier, Office of Habitat Conservation, SSSM3 14700, National Oceanic and Atmospheric Administration, Silver Spring, MD, 20910 USA Phone: 301-427-8626, Fax: 301-713-0184, Email: ariana.sutton-grier@noaa.gov

MECHANISMS OF BIOGENIC CARBON STORAGE IN SEASONAL WETLANDS FROM BRAZILIAN PANTANAL AND COLOMBIAN LLANO

Luisa F. Vega[1]*, Karl-Otto Rothaupt*[1]*, Catia Nunes da Cunha*[2]*, Marcelo Z. Moreira*[3] and *Matthias Wantzen*[4]

[1]Limnologisches Institut, Universität Konstanz, Konstanz / Egg, Germany

[2]Laboratório de Ecologia Vegetal (NEPA), Instituto de Biociências, Universidade Federal de Mato Grosso, Cuiaba, MT, Brazil

[3]Laboratorio de Ecologia Isotopica, CENA/USP - Piracicaba/SP,Brazil

[4]Université Francois Rabelais, Parc Grandmont, Tours, France

Seasonal wetlands fulfil both functions; they act as sinks and sources in the Carbon Cycle, depending on several factors, specially primary production and hydrological regime. Wetlands are characterized to have high primary production and therefore to be carbon sinks. In spite of their productivity, seasonal wetlands decrease their size or even disappear during dry season. The periodic drying leads to aeration and quick decomposition of deposited organic matter, becoming carbon sources. To assess the carbon sink or source character of neotropical seasonal wetlands and their mechanisms of biogenic carbon storage, we carried out a study in five shallow lakes from Pantanal and five shallow lakes from the Llano, during wet and dry season. We evaluated vegetation abundance (biomass gr/cm²) as principal organic carbon source. Dead wood and leaf litter was not considered here, as they have a minor importance in these open (unforested) savannas' floodplains. Hydrologic regime, soil carbon and nitrogen contents and bathymetric profile of the shallow lakes were also assessed. We found a similar pattern between mean values of biomass and soil carbon and nitrogen. The seasonal nature of the shallow lakes from Pantanal was more pronounced, having longer dry seasons that decrease their aptitude to store carbon. In contrast, the shorter dry period of shallow lakes from Colombian Llano allows them to keep carbon during the whole year and even increasing carbon stocks during the small dry period.

Contact Information: Luisa F. Vega, Limnologisches Institut, Universität Konstanz, Mainaustraße 252, 78464 Konstanz / Egg, Germany, Phone: +49 7531 883124; Fax: +49 7531 883533; Email: luisa.vega@uni-konstanz.de

CARBON STORAGE IN PIERMONT MARSH, HUDSON RIVER ESTUARY

Destiny Torres[1]*, Rossibel Fernandez*[1]*, Areej Haroon*[1]*, Amira Chowdhury*[1]*, Shiying Feng*[1]*, Cristal Lopez*[1]*, Marshalee Lopez*[1]*,* ***Susan Vincent***[1] and *Katherine Allen*[2]

[1]The Young Women's Leadership School of East Harlem, NY, USA

[2]Lamont Doherty Earth Observatory, Columbia University, NY, USA

The carbon storage potential of coastal wetlands is high due to rapid sediment accumulation rates and high plant productivity. Carbon sequestration in tidal salt marshes has been estimated at 210 g CO_2 m^{-2} yr^{-1}, an order of magnitude greater than carbon storage per unit area in peatlands (Chmura et al., 2004). Here, we present both surface and down-core (~1,000 year) sediment records of organic carbon storage from Piermont Marsh (73˚54'W, 41˚02'N), located ~ 50 km above the mouth of New York's Hudson River Estuary. Carbon weight percents for 30 samples were measured by Elemental Analyzer and combined with organic matter content determined by Loss-On-Ignition methods (LOI) to establish a site-specific LOI - %C calibration (organic matter ≈ 62% carbon). We applied this calibration to the rest of our sediment samples (n=80), and created a map of surface carbon content that extends from the Hudson River bank through the interior marsh. Organic carbon increases from 5 % near depositional stream banks up to 34 % near stable pools within the central marsh. We also compare carbon storage in areas dominated by different plant species: *Phragmites australis(common reed), Typha angustifolia* (narrow-leaved cattail), *Spartina alterniflora* and *Spartina patens* (native saltwater cordgrasses). Carbon density ranges from 0.01 – 0.04 g C cm^{-3}. If we assume sediment accumulation rates of 0.3 cm yr^{-1} (Pederson et al., 2005), this translates into as much as 147,600 kg C stored in the marsh per year. Collectively, this Information improves our understanding of modern carbon cycle dynamics in the Hudson River Estuary, and may enable better global estimates of the role of brackish marshes as future carbon sinks.

Contact Information: Katherine Allen, Lamont Doherty Earth Observatory, 61 Route 9W, Palisades, NY 10964, USA, Phone: 845-365-8668, Email: katallen@ldeo.columbia.edu

POLYPHENOL INHIBITS CO_2 EMISSIONS UNDER PROLONGED DROUGHT IN AN UNSATURATED POCOSIN SHRUB PEATLAND

Curtis J. Richardson, ***Hongjun Wang*** and *Mengchi Ho*
Duke University Wetland Center, Duke University, Durham, NC, USA

Many peatlands are experiencing increased frequency and severity of drought due to climate change. It is commonly predicted and observed that drought can unlock historical stored carbon in boreal peat and release more CO_2. However, some studies also show that drought does not affect CO_2 emission in some peatlands where the initial water level is below the ground surface. These results suggest that some controlling factors or substrate conditions exist in unsaturated peats, allowing them to resist accelerated decomposition and CO_2 losses under drought conditions. Here, a mesocosm experiment was conducted to simulate the effects of prolonged drought on C losses in natural, drained and restored unsaturated shrub peatlands (pocosin) in the Southeast. The results showed that drought-induced high dissolved polyphenol, which contribute about 10% of dissolved organic carbon (DOC), blocked CO_2 emission. The simulated drought did not increase CO_2 emission although DOC significantly increased in all sites. The largest long-term draining effect on CO_2 emission occurred early during the incubation and was ameliorated over time, indicating that drainage only changed the size and/or quality of a smaller labile carbon pool. This study suggests that high polyphenol in unsaturated peatlands can play a dominant role in keeping CO_2 emissions low under climate induced drought and anthropogenic drainage.

Contact Information: Hongjun Wang, Duke University Wetland Center, Nicholas School of the Environment, Box 90333, Duke University, Durham, NC 27708-0333 USA, Phone/fax: 919-613-8009,
Email:hw93@duke.edu

HYDROLOGIC MODIFICATION AND PEAT DYNAMICS IN THE EVERGLADES RIDGE-SLOUGH MOSAIC

Danielle L. Watts[1]*, Matthew J. Cohen*[1]*, James B. Heffernan*[2,3]*, Todd Z. Osborne*[1] and *Michael John Carnavale*[1]

[1]University of Florida, Gainesville, FL, USA
[2]Florida International University, Miami, FL, USA
[3]Duke University, Durham, NC, USA

The Everglades in South Florida is a large subtropical peat wetland where hydrologic modification over the last century has lead to the widespread loss of the historic ridge-slough patterning that was characteristic of the pre-drainage Everglades. Recent work has suggested that the distribution metrics in peat elevations are indicators of landscape stability and early indicators of landscape degradation. These distribution indicators suggest that point-scale processes control the existence of two stable ecosystem states, although they do not speak to the geometry, abundance, and distribution of the ridges and sloughs. Thus the loss of pattern is possibly best understood as a change in peat accretion dynamics leading to loss of soil elevation bimodality; altered water levels have increased respiration (drained conditions) or decreased productivity (impounded conditions). These changes would profoundly alter the feedbacks that previously maintained distinct patches. We therefor hypothesize a core mechanism for maintenance of two distinct elevation modes is that there are two ecological community configurations, one at higher elevation (ridges) and one at lower elevations (sloughs) that achieve the same long term peat accretion rate. These configurations are bi-stable in the sense that elevations markedly different from the two equilibrium levels (i.e., deep and shallow configurations with equal peat accretion rates) are, over time, unstable as they accrete more quickly or slowly than the long-term landscape average. Further, we hypothesize recent hydrologic modification has disrupted this bi-stability in carbon budgets.

This paper presents investigations into the point-scale CO_2 flux processes along a gradient of hydrologic impairment to test the above-mentioned hypotheses regarding Everglades ridge-slough maintenance and degradation. First, we present two years of bimonthly ecosystem respiration (soil and water column) measurements taken along a gradient of hydrologic conditions in Water Conservation Area (WCA) 3A. Second, we present ongoing, ecosystem-level net ecosystem CO_2 exchange measurements for ridges and sloughs. A multivariate model is presented for each, predicting CO_2 fluxes based on hydrologic attributes (inundation probability, median water depth) and other environmental covariates (water temperature, pH, community type), showing the control water levels have over ecosystem CO_2 dynamics. Third, we present a simple model describing net carbon accretion in response to hydrologic forcing, parameterized by the field studies, evaluating interactions among localized carbon budgets, water depths, and stochastic transition probabilities over long time scales.

Contact Information: Danielle L. Watts, School of Natural Resources and Environment, University of Florida, 327 Newins-Ziegler Hall, Gainesville, FL 32611-0410 USA, Phone: 352-318-0676, Fax: 352-846-1277, Email: tropical@ufl.edu

CARBON DYNAMICS IN HIGH LATITUDE PEATLANDS: EFFECTS OF PERMAFROST THAW

Kimberly P. Wickland[1], *Jonathan A. O'Donnell*[1], *Jennifer W. Harden*[2], *M. Torre Jorgenson*[3], *Mikhail Z. Kanevskiy*[4], *Stephanie A. Ewing*[5], *Carmel Johnston*[5]

[1]U.S. Geological Survey, Boulder, CO, USA
[2]U.S. Geological Survey, Menlo Park, CA, USA
[3]Alaska Ecoscience, Fairbanks, AK, USA
[4]University of Alaska-Fairbanks, Fairbanks, AK, USA
[5]Montana State University, Bozeman, MT, USA

Arctic and boreal peatlands store huge amounts of carbon (C), with a significant fraction residing in frozen peat deposits (permafrost). Permafrost strongly influences peatland C dynamics by protecting deep C stores from decomposition, and by controlling hydrology and vegetation composition which influence C accumulation, loss, and storage in unfrozen surface peat. Recent climate warming has resulted in localized thawing of permafrost across northern regions, which can dramatically modify the landscape by changing surface topography and water distribution. For example, thawing of ice-rich permafrost can convert lowland forests to collapse-scar bogs and fens, altering soil drainage, thermal regimes, and vegetation composition on relatively short time scales. A central question is how are the complex impacts of permafrost thaw affecting C accumulation, loss, and storage in high latitude peatlands?

We address this question using multiple approaches, including field and laboratory studies, and mass-balance models, to study C dynamics of peatland ecosystems in interior Alaska where permafrost degradation is actively occurring. Study sites are located in the Koyukuk and Innoko National Wildlife Refuges, in vast lowlands having variable extents of peat deposits and permafrost. A common trajectory with permafrost thaw occurs at both sites, where small circular depressions form within forested peat plateaus underlain by permafrost. These collapse bogs expand laterally over time, and successional shifts in vegetation occur. This results in the flooding and burial of forest-derived peat by bog-derived vegetation and peat. We established thaw chronosequences at the sites based on this trajectory that included forested "permafrost plateau", and two to three ages collapse bogs determined by bog size and vegetation. The chronosequence study design effectively captures changes in processes over decadal to millennial time scales, which are relevant to both permafrost thaw and C cycling. We sampled the chronosequence for total C stocks, forest peat-derived and bog peat-derived C stocks, radiocarbon age, and laboratory incubations to assess relative lability.

We found similar trends in C stocks at both chronosequences. When permafrost plateaus thaw and a collapse bog forms there is rapid accumulation of bog-derived peat at the surface which slows with time. At the same time, the submerged forest peat C stock dramatically declines during the first ~100 years post-thaw. These changes result in a net loss of C even with new bog peat accumulation. Laboratory incubations support this finding, showing that forest peat lability increases by up to 2.5 times after it is buried in the young bog. Together these results provide increased understanding of permafrost thaw effects on C dynamics.

Contact Information: Kimberly P. Wickland, National Research Program, U.S. Geological Survey, 3215 Marine St., RmE127, Boulder, CO 80303 USA, Phone: 303-541-3072, Fax: 303-541-3014, Email: kpwick@usgs.gov

WETLAND CARBON DYNAMICS IN THE EASTERN TIBETAN PLATEAU

Li Zhang[1], *Zhiming Lv*[2] and *Zhejiang Zhou*[3]
[1]Olentangy River Wetland Research Park, The Ohio State University, Columbus, Ohio, USA
[2]Northeast Normal University, Changchun, China
[3]Sichuan University, Chengdu, China

An investigation was conducted to measure soil carbon, nitrogen and phosphorus for alpine natural and restored wetlands in the eastern Tibetan Plateau in order to better understand wetland carbon dynamics. The dominated plant communities with Carex muliensis, Equisetum fluviatile, Caltha polustris and Kabresia setchwanensis were selected for the study area. Soil samples with peat depths (0 ~ 30 cm) in natural and restored wetlands were collected and total organic carbon (TOC), total nitrogen (TN) and total phosphorus (TP) were estimated. The preliminary results showed that there was no significant difference in water level between natural and restored wetlands. There were significant differences in TOC, TN and TP at soil depths (0-8 cm, 8-16 cm, 16-24 cm) between natural and restored wetlands. Much higher TOC concentration was found in natural wetland ranging from 35% to 40%, while higher TP concentration for restored wetlands ranged from 1007 mg/kg to 720 mg/kg. Ratio of TOC/TN (20.67 ± 0.3) in natural wetland was higher than ratio of TOC/TN (14.65 ± 0.5) in restored wetlands. It is suggested that restoring hydrology is a key for wetland restoration.

Contact Information: Li Zhang, Olentangy River Wetland Research Park, The Ohio State University, Columbus, USA, Phone:614-292-1098, Fax:614-292-9773, Email:zhang.326@osu.edu

CLIMATE CHANGE - EXTREME EVENTS

WETLAND FUNCTION AND COMPOSITION IN NOVEL SWAMP ENVIRONMENTS

Beth A. Middleton
U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, USA

Novel ecosystems may form in wetlands in the future in environments altered by climate change. On the North American continent, wetland ecosystems may have higher CO_2, temperature, and episodes of extreme flooding and drought according to the Intergovernmental Panel on Climate Change (IPCC). Novel ecosystem function and species composition may develop in these wetlands.

Species differ in their inherent ability to survive environments altered by climate change. Species may be able to survive short-term unsuitable conditions via storage in the seed bank or through migration. For example, the regeneration responses of species of *Taxodium distichum* swamps are more influenced by changes in levels of water and salinity than temperature and CO_2. While some aquatic species can persist for years in seed banks, little is known about how species may regenerate in the environments predicted under various climate change scenarios. In particular, supra-seasonal droughts may become more frequent in the center of North America by 2050 according to the IPCC. The biodiversity of wetlands in Australia shifted in response to supra-seasonal droughts in the previous decade. Species extirpation and colonization will depend on inherent species differences in seed longevity, dispersal, and regeneration capability in environments altered by climate change.

Ecosystem function also may shift in environments altered by climate change. For example, primary production and decomposition may be lower during either supra-seasonal drought or severe flooding, with subsequent effects on secondary production. In *Taxodium distichum* swamps, annual primary production of above-ground biomass is lower during either severe drought or flood events. Annual tree diameter growth and root biomass vary in response during these events.

We can speculate on the nature of species composition and function of wetlands altered by climate change, but the outcome will depend on the inherent resilience of ecosystems, species, and chance combinations of events. Planning for wetland conservation and restoration will be more successful if viewed from the perspective of the inherent capabilities of species and ecosystems to respond to environments altered by climate change.

Contact Information: Beth A. Middleton, U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA 70506 USA, Phone: 337-266-8618, Fax: 337-266-8586, Email: middletonb@usgs.gov

CLIMATE MEANS, TRENDS AND EXTREMES IN THE EVERGLADES: HISTORICAL DATA AND FUTURE PROJECTIONS

Lydia Stefanova[1]*, Vasu Misra*[1,2] and *Thomas J Smith III*[3]

[1]Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, FL, USA
[2]Dept. of Earth, Ocean and Atmospheric Science, Florida State University, Tallahassee, FL, USA
[3]USGS, Southeast Ecological Science Center, St. Petersburg, FL, USA

Initial results of a climate future-cast for 2040-2070 indicate a warmer and dryer Florida. Is the anticipated future climate warming the result of elevated average daytime highs or nighttime lows or increased number of warm spells, or a combination of these? What is the seasonal distribution of these effects? Similarly, how are changes in precipitation accounted for by changes in precipitation frequency, duration, and intensity?

Since a mandatory first step in planning for anticipated climate change is obtaining a clear understanding of the climate behavior of the recent past, we analyze the historical record from long-term meteorological and hydrological observing stations in the Everglades region in order to quantify the historical variability of ecologically relevant climate parameters. Next, we analyze the projected changes in these parameters' variability obtained from a set of global and regionally downscaled multi-model climate projections. We address the expected changes in climate means as well as the underlying statistical distribution shifts and changes in extreme values and event frequencies and put them in a historical perspective.

Contact Information: Lydia Stefanova, Center for Ocean-Atmospheric Prediction Studies, Florida State University, 2035 E Paul Dirac Dr., 225 RM Johnson Bldg., Tallahassee, FL 32306-2840, USA. Phone: 850-644-6951, Fax: 850-644-4841, Email: lstefanova@coaps.fsu.edu

EXTREME CLIMATE EVENTS AND THE RECURRENT SUDDEN DIEBACK AND RECOVERY OF SALT MARSHES IN THE RAPIDLY SUBSIDING MISSISSIPPI RIVER DELTA, LOUISIANA

Christopher M. Swarzenski[1], *Tommy Michot*[2], *Camille L. Stagg*[3] and *Richard H. Day*[3]
[1]United States Geological Survey, Baton Rouge, Louisiana, USA
[2]University of Louisiana, Lafayette, Louisiana, USA
[3]United States Geological Survey, Lafayette, Louisiana, USA

Extensive areas of salt marsh dominated by *Spartina alterniflora* are found near sea level in the Mississippi River Deltaic Plain (MRDP) in coastal Louisiana. Within large parts of the MRDP, interior marsh elevations vary only slightly (generally about 10–15 cm). Because of the microtidal environment, even these small differences may elicit significant responses in plant-soil interactions and ecological functioning. In late April 2000, and again in February 2009, complete dieback of existing vegetation and the absence of new growth were noticed in many interior marshes. The sudden dieback in 2000 was observed near the end of a prolonged severe drought. The 2009 dieback followed the passage of two closely spaced hurricanes in fall 2008, which generated an extended period of elevated water levels. After the sudden dieback event in 2000, vegetation response parameters, hydrology and surface elevation trends were measured across a regional hydrological and topographical gradient to determine factors contributing to the dieback. Monitoring of environmental and vegetative characteristics at research plots continued annually even after recovery of the initial dieback. Some but not all of the sites that died back in 2000 died back a second time in 2009. Patterns of dieback showed that the response to extreme drought occurred across the entire topographic gradient. In contrast, only the lower elevation marshes died back following the hurricanes.

Two points emerge from the observed response of the salt marshes: 1) extreme climate events, which are predicted to increase in frequency and intensity in the future**,** will not necessarily affect the coastal marshes uniformly, and 2) the marshes re-vegetated within two years after both diebacks, indicating a surprising resiliency for at least some salt marshes in an area that is better known for its rapid rates of apparent sea level rise and wetland loss.

Contact Information: Christopher M. Swarzenski, Louisiana Water Science Center, 3535 S. Sherwood Forest Blvd, Ste 120, Baton Rouge, LA 70816 USA, Phone: 225-298-5481 Email: cswarzen@usgs.gov

CLIMATE CHANGE - GREENHOUSE GAS EMISSIONS

SEASONAL CARBON AND ENERGY FLUXES FOR RESTORED WETLANDS IN THE SACRAMENTO – SAN JOAQUIN DELTA, CALIFORNIA, USA

Frank E. Anderson[1], *Brian Bergamaschi*[1], *Lisamarie Windham-Myers*[2] and *Roger Fujii*[1]
[1]U.S. Geological Survey, Sacramento CA, USA
[2]U.S. Geological Survey, Menlo Park, CA, USA

The effects of water management on carbon and energy fluxes from two 3–hectare restored wetlands on Twitchell Island in the Sacramento–San Joaquin Delta (Delta) are part of an ongoing, long-term study designed to mitigate subsidence through atmospheric carbon sequestration and soil carbon storage. The wetlands, established in 1997, feature a western wetland managed at a water depth of 25cm and an eastern wetland managed at a depth of 55cm. Over the past 14 years, the western wetland has developed into a dense canopy of emergent marsh species with some floating vegetation. The eastern wetland is a combination of the same emergent marsh species and floating vegetation as the western wetland, but it also includes areas of open water, submerged vegetation, and algae.

The Delta is a unique place as the temperate climate and clear summer skies are conducive for maximum daily carbon dioxide uptake rates to be approximately 30 µmol m^{-2} s^{-1} or higher. These elevated rates of carbon dioxide uptake were measured in the eastern wetland during 2002 through 2004, using the eddy covariance method. However, in 2010, maximum carbon dioxide uptake rates were only about 10 µmol m^{-2} s^{-1}. We hypothesize that large mats of accumulating senescent material have slowed or stopped the growth of the emergent marsh species, which were not present during the measurements taken in 2002 through 2004. In contrast to carbon uptake, anaerobic conditions created by permanent flooding resulted in methane flux in excess of 250 nmol m^{-2} s^{-1}. These methane fluxes are some of the highest observed compared to other Delta flux studies (rice, pasture, and natural wetlands), which yield measurements ranging from 10 – 100 nmol m^{-2} s^{-1}.

We tested our hypothesis in 2011 by moving the eddy covariance tower to the western wetland, where emergent marsh species are denser. Here we present results showing diurnal and seasonal trends of carbon dioxide fluxes for years 2002–2004 and 2010–2011, and methane fluxes for years 2010–2011. To understand the influence of seasonal variability, we normalized fluxes with abiotic and biotic conditions, such as air, leaf, and water temperatures, differences in humidity, and changes in daily and seasonal variations in solar radiation. We also present results from a footprint algorithm designed to examine seasonal variances in the footprint from the 2010–2011 flux measurements. Lastly, we show and compare results from other ongoing flux studies in the Delta.

Contact Information: Frank E. Anderson, California Water Science Center, U.S. Geological Survey, Sacramento CA 95819 USA, Phone: 916-278-3258, Fax: 916-278-3071, Email: fanders@usgs.gov

MANGROVE ECOSYSTEM FUNCTION AND RESPONSE TO CLIMATE CHANGE

Jordan G. Barr[1]*, Vic Engel*[1] and *Jose D. Fuentes*[2]
[1]Everglades National Park, Homestead, FL, USA
[2]Pennsylvania State University, University Park, PA, USA

Eddy covariance derived estimates of net ecosystem exchange (NEE) of carbon dioxide and vertical energy fluxes have been determined in a riverine mangrove forest in southwestern Everglades National Park since 2004. These fluxes have been used to 1) understand near real time environmental and hydrological controls on forest-atmosphere exchange, 2) quantify the carbon sequestration potential of mangrove forests, and 3) guide the development of light-use efficiency (LUE) models of productivity in response to environmental controls and management practices. Though this tall (15-20 m) forest is located within the subtropics, -NEE is seasonally variable with highest values of 100 to 130 g C m^{-2} per month during March to May when solar irradiance levels are maximal and before ecosystem respiration rates (R_E) have reached summertime peak values (120 to 160 g C m^{-2} per month) during July to September. Monthly -NEE is lowest (35 to 80 g C m^{-2} per month) during December to January resulting from seasonal minimum values of air temperature and solar irradiance. By combining gross primary productivity (GPP) estimates from –NEE data with satellite-based indices of ecosystem function and greenness, we have quantified the response of mangrove productivity to individual drivers of air temperature, salinity, and fraction irradiance absorbed by green vegetation. These LUE-based models are now being implemented to quantify productivity across the entire mangrove ecotone in southwest Florida. Advantages of this modeling framework include the ability to track both seasonal and inter-annual changes in ecosystem function using spatially explicit satellite-derived metrics of physiology (e.g., greenness, normalized difference vegetation index (NDVI), and enhanced vegetation index (EVI)), and to determine changes in productivity attributed to salinity levels. Given projected changes in salinity with sea level rise at the coast and/or changes in fresh water flow through Shark River Slough, LUE-models may be used to quantify the resulting changes in productivity. In addition, repositories of satellite multispectral reflectance data exist for the last decade and three decades in the case of MODIS and LANDSAT, respectively. Data analyses using these products will prove essential for understanding changes in mangrove functioning already in progress.

Contact Information: Jordan G. Barr, South Florida Natural Resource Center, Everglades National Park, 950 N. Krome Ave., Homestead, FL 33030 USA, Phone: 305-224-4254; Fax: 305-224-4147, Email: Jordan_Barr@nps.gov

SOIL CO_2 AND CH_4 EMISSIONS AND CARBON BUDGETING IN DRY FLOODPLAIN WETLANDS

Jackie Batson[1], *Gregory B. Noe*[1], *Cliff R. Hupp*[1], *Ken W. Krauss*[2], *Nancy B. Rybicki*[1] and *Edward R. Schenk*[1]
[1]National Research Program, U.S. Geological Survey, Reston, VA, USA
[2]National Wetlands Research Center, U.S. Geological Survey, Lafayette, LA, USA

An understanding of river-floodplain carbon cycling is important for assessing the controls on greenhouse gas emissions and the potential for floodplain carbon sequestration. The goals of this study were to quantify carbon fluxes through soil CO_2 and CH_4 emissions, to determine the controls on soil aerobic and anaerobic respiration, and to develop an urban floodplain carbon budget along lateral and longitudinal gradients of hydrologic connectivity. We will also compare CO_2 flux results using an infrared gas analyzer and gas chromatograph. This study was conducted in Difficult Run, an urban Piedmont watershed (151 km^2) in Virginia, USA. Six floodplain sites were chosen along a longitudinal gradient from headwaters to mouth, and sampling plots were then distributed on transects across lateral geomorphic zones (levee, backswamp, and toe-slope) at each site. In 2011, CO_2 fluxes were measured every three weeks at each plot (n=34) using an infrared gas analyzer (LI-COR LI-8100), with soil moisture, temperature, pH, and redox measured simultaneously. For 2012, CH_4, N_2O, and CO_2 fluxes also will be collected quarterly with the LI-COR chamber and measured on a gas chromatograph. We hypothesized that carbon dioxide fluxes would vary along the lateral and longitudinal gradients, with higher rates in intermediately wet areas that receive organic flood deposits.

Across all sites, average annual sedimentation rates were 125 g C m^{-2} y^{-1}, litterfall+herbaceous production rates were 243 g C m^{-2} y^{-1}, and CO_2 emission rates were 1296 g C m^{-2} y^{-1}. Emissions varied significantly (α=0.05) with longitudinal and geomorphic position, and their interaction, with a general trend of decreasing backswamp and toe-slope emissions downstream and relatively level emissions on the high levees throughout. Levee emissions (1530 g C m^{-2} y^{-1}) were significantly higher than both backswamp (1197 g C m^{-2} y^{-1}) and toe-slope (1112 g C m^{-2} y^{-1}) rates. Intra-annual variations in CO_2 fluxes were most strongly controlled by soil temperature (r=0.889). Average annual CO_2 emissions did not correlate with sediment C, litter C, or herbaceous C, but were negatively correlated with water-filled pore space (r=-0.633), NH_4 mineralization rates (r=-0.537), and soil total phosphorous (r=-0.405) and positively correlated with percent silt (r=0.450), percent nitrification (r=0.446) and litterfall C:P ratio (r=0.395). These variables are related to soil moisture gradients; annual CO_2 rates were best predicted by water-filled pore space ($p<0.001$, R^2=0.394). Annual aerobic respiration was thus largely controlled by hydrology in these dry floodplain wetlands, and while C losses through respiration exceeded C inputs, the input from belowground production remains unknown. Further, we believe that CH_4 emission rates will also vary along lateral and longitudinal gradients and will correlate with soil moisture, though positively.

<u>Contact Information</u>: Jackie Batson, National Research Program, U.S. Geological Survey, 430 National Center, Reston, VA 20192 USA Phone: 703-648-5472, Email: jbatson@usgs.gov

DO TIDAL SALT MARSHES RELEASE GREENHOUSE GASES DURING THE SPRING THAW?

Gail L. Chmura[1] and *Lisa Kellman*[2]
[1]Department of Geography and Global Environmental and Climate Change Centre, McGill University, Montreal QC, Canada
[2]Environmental Sciences Research Centre, St. Francis Xavier University, Antigonish, NS, Canada

Tidal salt marsh soils have exceptional rates of carbon sequestration. Field studies have shown that tidal marsh soils with salinities greater than 18 release negligible amounts of methane and those with low nutrient levels release negligible nitrous oxide. These low rates of greenhouse gas emissions would make these ecosystems one of the world's most efficient carbon sinks. However, most field studies monitoring greenhouse gas fluxes have focused on the growing season and the few that provide seasonal measurements have been conducted in warm temperate climates such as those of the Chesapeake Bay and the Gulf of Mexico. Although the spring thaw has been associated with pulses of greenhouse gas emissions in ecosystems with highly seasonal climates, it has yet to be investigated in tidal salt marshes. High nitrous oxide releases have been reported in pastures and grasslands and significant release of methane has been documented in freshwater wetlands. Since methane and nitrous oxide have global warming potentials of 25 and 289 times that of carbon dioxide, respectively, large seasonal releases could greatly reduce the value of the carbon stored in highly seasonal tidal marshes.

During Eastern Canada's cold winters the surface of marsh soil freezes and snow can accumulate on the surface. These conditions could provide an opportunity for gases to be trapped and released as frozen layers melt. We are investigating this possibility through studies of a marsh on a lagoon at Kouchibouguac National Park (46.8°N, 64.9°W) along the New Brunswick coast of the Gulf of St. Lawrence. Here the mean tidal amplitude is 1.0 m and average soil porewater salinity is >20. The dominant vegetation at this marsh is *Spartina patens*, typical of salt marshes on the northeastern coast of North America. Sediment analyses indicate that the marsh soils sequesters carbon at the rate of ~1000 CO_2 equivalents m^{-2} yr^{-1}. In this presentation we will report fluxes of carbon dioxide, nitrous oxide, and methane associated with the spring thaw at Kouchibouguac marsh and, by deriving an annual budget for greenhouse gas emission, assess the radiative feedback of the marsh.

Contact Information: Gail Chmura, Department of Geography, McGill University; 805 Sherbrooke St. W.; Montreal QC, H3A 2K6 Canada, Phone: 514-926-6854 Fax: 514-398-4958, Email:gail.chmura@mcgill.ca

QUANTIFYING HALOCARBON CONTRIBUTIONS TO GREENHOUSE GAS EMISSIONS FROM COASTAL WETLAND SOILS

***Alex T. Chow**, Jun-Jian Wang, William H. Conner*
Baruch Institute of Coastal Ecology & Forest Science, Clemson University, Georgetown, SC, USA

Naturally produced halocarbons such as methyl chloride, methyl bromide, chloroform, and bromoform are important sources of atmospheric inorganic halogen compounds, which are critical components in many stratospheric and tropospheric chemical processes, including global ozone loss. With increases of chloride and bromide concentrations in coastal wetlands due to sea level rise, halogenation of soil organic matter in wetland soils could be enhanced, resulting an increase of halocarbon emission to the atmosphere. In this study, we conducted both controlled laboratory and field experiments to evaluate the emissions of chloroform and bromoform along salinity gradient of a coastal wetland ecosystem in Winyah Bay, South Carolina. In the laboratory study, soils were mixed with leaf litter and incubated in glass reactors with different salinity levels for two weeks. Hydrogen peroxide and ferrous ion were also added to simulate abiotic halogenation through Fenton reaction. Associated with the laboratory study, gas chambers were installed in salt marsh, salt-impacted freshwater wetland, and freshwater wetland in Winyah Bay for field verification. Fluxes of greenhouse gases including CO_2, CH_4, N_2O, $CHCl_3$, and $CHBr_3$ were determined in both field and laboratory studies. The goal of the study was to verify the salinity effects on halocarbon formation in coastal wetlands and quantify their contributions on greenhouse gas emissions.

Contact Information: Alex Chow, Clemson University, PO Box 596, Georgetown, SC 29442, United States, Phone: 843-546-1013 ext.232, Email: achow@clemson.edu

USING HYDROGEOPHYSICAL METHODS TO CONSTRAIN SPATIAL AND TEMPORAL DYNAMICS OF BIOGENIC GAS DISTRIBUTION AND FLUXES IN PEAT SOILS OF THE EVERGLADES

Xavier Comas[1], *William Wright*[1] and *Anastasija Cabolova*[2]

[1]Department of Geosciences, Florida Atlantic University, Boca Raton, FL

[2]Department of Physics, Florida Atlantic University, Boca Raton, FL; currently at Department of Earth and Atmospheric Sciences, Cornell University, Ithaca, NY

Peatlands are well recognized carbon reservoirs that account for about 33% of the global soil carbon pool and influence climate by sequestering and releasing biogenic gases to the atmosphere, mainly as methane (CH4) and carbon dioxide (CO2). Most studies investigating biogenic gas dynamics (i.e. accumulation and/or releases) in peat soils are based on boreal peatlands while low-latitude systems like the Everglades have traditionally been less studied. Previous methods to investigate gas dynamics in the Everglades have been focused on discrete point measures (such as gas chambers) that provide little Information on spatial and temporal patterns in gas flux variability. In this study we present an array of hydrogeophysical techniques (including ground penetrating radar, GPR) to investigate the spatial and temporal patterns of distribution and release of biogenic gas from peat soils in the Everglades at several scales of measurement (i.e. laboratory and field-scale). This study highlights the potential of these methods for better constraining variability in biogenic gas production and rapidity of episodic ebullitive events in the peat soils of the Everglades.

Contact Information: Xavier Comas, Florida Atlantic University, 3200 College Ave, Davie, FL 33314, United States, Phone: 954-236-1569, Email: xcomas@fau.edu

MAPPING ORGANIC SOILS IN GERMANY IN THE FRAME OF CLIMATE REPORTING

***Holger Fell**, Niko Rosskopf* and *Jutta Zeitz*

Humboldt-Universität zu Berlin, Faculty of Agriculture and Horticulture, Division of Soil Science and Site Science, Berlin, Germany

Reporting greenhouse gas emissions from agriculturally or silviculturally used Organic Soils (according to the IPCC Guidelines 2006) requires a spatially precise as well as pedologically detailed data base. In Germany (and this applies surely to other countries too) we are facing some major problems. First, these data are not yet digitally available nationwide, second, they do not satisfy the desired pedological level of detail and third, they are taxonomically different to the IPCC definitions.

In the frame of the research project “Organic Soils”, funded by the Federal Ministry of Food, Agriculture and Consumer Protection, we developed a method to compile a new “Map of Organic Soils (MOS)” based on recent survey Information, historical data and additional groundtruthing.

The fundamental approach is to separate the spatial mapping of Organic Soils from their pedological characterization. This enables us to provide both, a spatially high resolved dataset and a detailed and homogenous pedological characterization. In a first step the available datasets describing Organic Soils of the required spatial resolution of 1.50.000 or higher are compiled into a single dataset. The following pedological characterization is based on the link between site specific genesis and hence resulting soils. It could be derived from nationwide available geomorphological, geological and hydrological background Information in combination with large borehole databases. For temperate Germany, nine types of site specific developments including paludification, terrestrialization and percolation could be distinguished.

The approach is actually adopted for the whole area of Germany. First results show considerable differences as compared to the Soil Map of Germany at a scale of 1:1.000.000 (BÜK1000), which up to now is the base for soil related climate reporting. The area of fens for example is overestimated by BÜK1000 about 10%. Taking land use into account, the result is even more noticeable. The BÜK1000 classifies approximately 30% of fen soils as arable land. In contrast our results show that a part of ~10% arable land is a reliable value. This proves the importance of a spatially and pedologically accurate database for climate reporting from agricultural and silvicultural used Organic Soils.

Contact Information: Holger Fell, Humboldt- Universität zu Berlin, Faculty of Agriculture and Horticulture, Division of Soil Science and Site Science, Albrecht-Thaer-Weg 2, 14195 Berlin, Germany, Phone: 0049 30 31471861, Fax: 0049 30 209346403 Email: holger.fell@agrar.hu-berlin.de

SPATIO-TEMPORAL DISTRIBUTION OF AIR-WATER CO_2 EXCHANGE IN DOÑANA WETLANDS (SPAIN)

S. Flecha[1]*, Edward P. Morris*[1]*, Jordi Figuerola*[2]*, Eduardo Costas*[3]*, Gabriel Navarro*[1] *Pablo Rodriguez*[4] and *I. Emma Huertas*[1]

[1]Instituto de Ciencias Marinas de Andalucía (CSIC), Puerto Real, Cádiz, Spain
[2]Estación Biológica de Doñana (CSIC), Sevilla, Spain
[3]Universidad Complutense de Madrid, Madrid, Spain
[4]Universidad de Murcia, Murcia, Spain

Doñana National Park is one of the most relevant wetlands in Europe and is included in the List of Wetlands of International Importance. It covers a surface of 60,000 ha in a marshy area at the right bank of the Guadalquivir river estuary in the southwestern coast of Spain, containing a great diversity of biotopes, such as lagoons, marshlands, fixed and mobile dunes, scrub woodland and maquis. The Park hosts five threatened bird species, is one of the largest heronries in the Mediterranean region and the wintering site for more than 500,000 water fowl each year. The habitat diversity of Doñana is determined by the presence of various and vast aquatic systems with a different origin. Water sources that feed the aquatic domain of the Park come from the Guadalquivir estuary tidal flows, ground-water discharges and river flows. However, specifically the marsh hydrology depends on the rainfall regime, thereby experiencing annual cycles of flooding (November to March) and subsequent desiccation (May to June) to become fully dried during midsummer. Dependence on rainfall makes inundation cycles highly variable and unpredictable, as rainfall distribution shows an important interannual variability that affects the relative duration of the dry and flooded phases. Despite its relevance in the biodiversity conservation, seldom studies have analyzed in details the biogeochemistry of the aquatic systems of Doñana and their influence on biological productivity and carbon fluxes.

Considering the significant role of wetlands in the carbon cycling at a global scale, a research program aimed at examining the spatio-temporal variability of some key hydrological variables, particularly those involved in the carbon system, is currently on going in Doñana. This study shows data gathered monthly in 11 representative aquatic sites of the Park over the period of one year (from January 2010 to February 2011) and presents the first analysis of the seasonal patterns of air-water CO_2 exchange in the region. Carbonate system parameters (total alkalinity, pH) along with dissolved organic carbon, suspended matter, dissolved oxygen, inorganic nutrients and chlorophyll were measured. Water pCO_2 was obtained from the total alkalinity (A_T) and pH data using the thermodynamic constants defined by Cai and Wang (2001) and CO_2 fluxes were calculated using several gas transfer velocity parameterizations available for near-shore systems. Calculated pCO_2 is also compared with *in situ* measurements of the dissolved pCO_2 collected by a SAMI-pCO_2 sensor that has been moored in a permanent lagoon.

Results indicate that even though the aquatic systems of Doñana are characterized by a high spatial and temporal variability in their biogeochemical properties, the majority of the region acts as a strong source of carbon dioxide to the atmosphere, particularly temporal freshwater marshland and permanent freshwater lagoons, with saltwater sites behaving exceptionally as CO_2 sinks.

Contact Information: S. Flecha, Departamento de Oceanografía de Ecosistemas, Instituto de Ciencias Marinas de Andalucía (ICMAN-CSIC), Campus Río San Pedro s/n, 11510 Puerto Real (Cádiz) SPAIN. Phone: 34-956-832612 - ext (0)255, Fax: 34-956-834701, Email: susana.flecha@icman.csic.es

INFLUENCES OF COLD AIR MASSES ON TRACE GAS EXCHANGE BETWEEN MANGROVES AND THE ATMOSPHERE

Jose D. Fuentes[1], *Vic Engel*[2] and *Jordan G. Barr*[2]
[1]Pennsylvania State University, University Park, PA, USA
[2]Everglades National Park, Homestead, FL, USA

Mangrove forests are pan-tropical, exhibit complex interactions with the atmosphere, and are influenced by multiple environmental stressors. Mangroves in the Florida Everglades can experience cold air masses that impair their ability to exchange trace greenhouse gases (e.g., carbon dioxide, water vapor, etc.) with the overlying atmosphere. During January 2010, a severe cold spell impacted the Everglades mangroves. For twelve consecutive days, the minimum air temperature remained below 10 ^{o}C and even reached the lowest temperature of 2.5 ^{o}C. Several ecosystem structure and surface radiative attributes changed as a result of the cold spell. The loss of foliage in the forest canopy was associated with substantial declines in surface albedo and mangrove net primary productivity. Thus, in this presentation, we will report on the responses of the mangrove forest ecosystem to the occurrence of this cold spell. We will also investigate the recovery process of the mangrove forest following the loss of foliage caused by the low air temperatures. The low (<10 ^{o}C) air temperatures caused reduced mangrove forest net ecosystem exchange (-NEE) due to decreased physiological activity of foliage and forest defoliation. The forest changed from a net sink of atmospheric carbon dioxide (positive -NEE) to a net source of carbon dioxide (negative -NEE). Trends in daily -NEE indicate that chronic cold stress forced the mangrove system to lose carbon. Physiological activity remained suppressed for serveral days following the cold event, indicating that mangroves require several days of recovery following the stress caused by the cold air mass. The cold period disturbances reduced -NEE by 36 g C m^{-2}. It took approximately two weeks, following the cold event, for the ecosystem to exhibit the onset of recovery. The present results suggest that cold events can hamper the mangrove productivity on monthly time scales. Within the broader context of mangrove sustainability, these results suggest that extreme atmospheric conditions associated with climate change dramatically impact the trace-gase exchange between the mangrove ecosystem and the atmosphere.

<u>Contact Information</u>: Jose D. Fuentes, Department of Meteorology, 508 Walker Building, The Pennsylvania State University, University Park, PA 16802 USA, Phone: 814-863-1585; Email: jdfuentes@psu.edu

CONSIDERING SCALE WHEN ASSESSING WETLAND METHANE EMISSIONS: WETLAND FOREST SOILS VERSUS WETLAND FORESTS

Vincent Gauci and *Sunitha R. Pangala*
The Open University, Milton Keynes, UK

Up to 60% of Earth's wetlands are forested and yet these ecosystems are quite poorly understood with respect to emissions of methane (CH_4). It is generally thought that CH_4 produced in waterlogged soils is emitted by a combination of three processes: 1) by diffusion through water-filled pores, 2) by abrupt release of bubbles, and 3) through internal spaces in the stems of herbaceous graminoids which are adapted to live in waterlogged soils. The capacity for trees to also emit CH_4 has received only limited attention, principally through investigations on seedlings or saplings grown under artificial conditions, where they are shown to emit significant quantities of CH_4 that is produced in the soil. It is hypothesized that there are two ways by which CH_4 produced in wet soils may be transported and emitted through trees: i) as a gas through air-filled tissue in trees that has formed as an adaptation to enable transfer of oxygen from the atmosphere to the tree's roots which are growing in oxygen-poor waterlogged soil, and ii) dissolved in sap and then liberated to the atmosphere when tree water is lost by transpiration through pores in tree stems and leaves.

Trees offer large surfaces of stem and leaf in wetland forest ecosystems and as such, even small fluxes relative to those measured at the soil surface may be important at the ecosystem scale. This presents a challenge to both accurately quantifying emissions that are routinely ignored in measurement campaigns and also in attributing fluxes measured at the large scale to separate emissions pathways in order to understand their relative importance. We present a range of approaches to quantifying CH_4 emissions from trees and soils *in situ* in both temperate and tropical forested wetlands. These include static and dynamic chamber approaches for measurement asynchronously (chamber samples retrieved and processed in the laboratory) and in real-time using cavity ring-down laser spectroscopy. We compare emissions at the wetland surface emitted via well understood pathways with those measured from trees and estimate their relative contributions to ecosystem flux.

Contact Information: Vincent Gauci, Centre for Earth, Planetary, Space and Astronomical Research (CEPSAR), Department of Environment, Earth and Ecosystems, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK, Phone: 00441908858137, Fax: 00441908655151, Email: V.Gauci@open.ac.uk

METHANE AND NITROUS OXIDE EMISSIONS IN FRESHWATER SWAMPS AND MARSHES IN SOUTHEASTERN MÉXICO

J. L. Marin-Muñiz[1], ***M. E. Hernández***[2] and *P. Moreno-Casasola*[2]
[1]University of Veracruz, Xalapa, Veracruz, Mexico
[2]Institute of Ecology, Xalapa, Veracruz México

Wetland soils are large sinks of carbon. However, they may also be significant sources of greenhouse gases (GHG), like methane (CH_4) and nitrous oxide. The Global Warming Potential (GWP) of CH_4 and N_2O are 20 and 300 times higher than CO_2. In tropical wetlands are fewer studies on GHG emissions than in temperate wetlands.

The goal of this study was to investigate CH_4 and N_2O emissions in freshwater wetland soils with different type of vegetation (swamps and marshes) on the coastal plain of Veracruz, Mexico. The study sites were: Estero Dulce, Tecolutla (20º 17’ 53’’ N, 96º52’19’’W), Laguna Chica, Vega de Alatorre. (20º 05’ 47.8’’ N 96º 41’ 23.8’ ’W) and Boquilla de Oro, Alto Lucero. (19º 49' 47'' N, 96º 26' 59'' W).

The GHG were measured bimonthly from April 2010 to October 2011, using a closed chamber technique. The average CH_4 emissions were 560.4 ±18.8 and 551.13 ±15.3 mg m^{-2} d^{-1} in marshes and swamps respectively. N_2O emissions were 4.25 ± 2.7 mg m^{-2} d^{-1} in marshes and 12.08 ± 4.6 mg m^{-2} d^{-1} in swamp soils. There was not significant differences in the emissions among type wetland (p=0.687 for CH_4) (p=0.956 for N_2O). However it was observed that other factors such as hydrology influence the GHG emissions in these coastal wetlands.

Contact Information: Maria E. Hernández. Biotechnological Resource Management Network, Institute of Ecology, Carretera antigua a Coatepec 351, El Haya, Xalapa 91070, Veracruz, Mexico, Phone: 52 (228) 8421849, 8421800 ext. 6210, Fax: 52 (228) 8187809, Email: elizabeth.hernandez@inecol.edu.mx

CAUSES OF METHANOGENESIS-LINKED CLIMATE FEEDBACKS IN A DISCONTINUOUS PERMAFROST PEATLAND

Jeffrey P. Chanton[1], ***Suzanne B. Hodgkins***[1], *Patrick M. Crill*[2], *Carmody K. McCalley*[3], *Scott R. Saleska*[3] and *Virginia Rich*[3]

[1]Florida State University, Tallahassee, FL, USA
[2]Stockholm University, Stockholm, Sweden
[3]University of Arizona, Tucson, AZ, USA

Biogeochemical processes in peatlands with permafrost are vulnerable to climate change because warming-induced thawing causes the peat to collapse, altering the hydrology and plant communities. This, in turn, influences both plant carbon uptake and peat chemistry, the latter of which controls the degree of peat respiration and anaerobic decomposition (including methane production). Permafrost thaw also releases previously-frozen organic matter to biodegradation into CH_4 and CO_2. Thus, whether permafrost thaw causes Arctic peatlands to become more of a source or a sink of greenhouse gases (GHG) depends on the bioavailability of the released organic matter as well as how the peat chemistry and plant community respond to the physical altering of the landscape. To predict these responses, various physical and biogeochemical parameters—including CH_4 and CO_2 concentrations in porewater (correlated with production rates), CH_4 and CO_2 isotopic data (correlated with CH_4 and CO_2 production mechanisms), pH, DOM concentration and quality, depth of permafrost and water table below peat surface, and temperature gradients—are being measured and correlated with sample depth and habitat type (as defined by permafrost thaw stage and plant community) within Stordalen Mire, a discontinuous permafrost peatland near Abisko, Sweden. Results of an analysis of peat and porewater biogeochemistry from the summers of 2010 and 2011 are presented here. These data will later be combined with direct flux measurements and microbial community composition to create a model of GHG responses to climate change.

<u>Contact Information</u>: Suzanne Hodgkins, Dept. of Earth, Ocean & Atmospheric Science, Florida State University, 117 N. Woodward Ave., Tallahassee, FL 32306 USA, Phone: 850-320-5006; Fax: 850-644-2581, Email: sbh10c@fsu.edu

PATTERN OF GREENHOUSE GASES EMISSION FROM RICE-FIELD WETLAND

Hwey-Lian Hsieh[1], *Lan-Feng Fan*[1], *Tsanyao Frank Yang*[2], *Chun-Han Huang*[1], *Chun-Ming Chiu*[2] and *Chang-Po Chen*[1]

[1]Academia Sinica, Taipei, Taiwan
[2]National Taiwan University, Taipei, Taiwan

To examine factors mitigating emissions of greenhouse gases, we applied different fertilizers in two rice fields, the compost rice field (CpR) and the conventional rice field (CvR), in northern Taiwan. During the cultivation period from March to July in 2011, we manipulated experiments in the fallowing, transplanting, active tilling, booting, ripening, and harvesting stages, to monitor emission rates of CO_2 and CH_4 from soil surface. We also recorded and compared the growth condition of rice vegetation, and gathered samples through soil profile to analyze concentration of CO_2 and CH_4 stored in the pore space, redox potential, water content, pH, and total organic carbon content (TOC).

Our results revealed that pore-space CH_4 and pore-space CO_2 in soil were the highest in both fields in the active-tilling stage. In the active-tilling and transplanting stages, high water content and low redox potential were detected in soil resulting in hypoxic environment, which would promote methanogenesis process. Meanwhile, CH_4 emission from soil surface was only detectable in these two stages. With the exception of the fallowing and transplanting stages, soil pH and TOC were high in CpR, which suggested that much organic carbon was buried into the soil. In the booting stage, when averaged by the cultivation area, the total-biomass respiring rate was lower in CpR than in CvR, but it was 7-fold higher in CpR than in CvR for net primary production on saturated light. In the ripening stage, pore-space CO_2 was lower in CpR soil than in CvR. These results suggested that CpR might be a better carbon sink than CvR since it produced less CH_4 and CO_2, and stored more TOC in soil, as well as consumed more CO_2 from soil surface.

<u>Contact Information</u>: Hwey-Lian Hsieh, Biodiversity Research Center, Academia Sinica, No. 128 Academia Rd., Sec. 2, Nankang, Taipei 115, Taiwan, Phone: 886 2 27899546, Fax: 886 2 27858059, Email: zohl@gate.sinica.edu.tw

BLUE CARBON IN WETLANDS: CONSIDERATION OF LATERAL AND VERTICAL GREENHOUSE GAS FLUXES

Kevin D. Kroeger[1]*, Neil Ganju*[1]*, John W. Pohlman*[1]*, Serena Moseman-Valtierra*[2]*, Jianwu Tang*[3] and *Christopher Weidman*[4]

[1]USGS, Woods Hole, MA, USA
[2]University of Rhode Island, Kingston, RI, USA
[3]The Ecosystems Center, Woods Hole, MA, USA
[4]Waquoit Bay National Estuarine Research Reserve, Falmouth, MA, USA

Efforts to ameliorate rising levels of 3 major greenhouse gases (GHG; CO_2, CH_4, N_2O) include protection and restoration of ecosystems that constitute major carbon C sinks and minor sources of CH_4 and N_2O. In recognition of the need for financial incentives to support climate change mitigation, both voluntary and mandatory C markets have been developed. Coastal wetlands are prime candidates for GHG emission offsets as they display the highest C sequestration rate of any ecosystem. However, lack of scientific data about rates of and controls on C sequestration in tidal wetlands has inhibited development of methodologies or protocols for use by C registries in assigning C offsets to projects. Among likely important environmental controls, nitrogen (N) availability is a key factor that can affect C sequestration in coastal wetlands, because anthropogenic N loading may enhance decomposition and respiration rates. Further, recent experiments show that increased N availability can stimulate production of N_2O. Climate change and SLR are also likely to have critical impacts. Here we present an overview of a new project with a goal to understand the climatic role of coastal wetlands, quantify potential for GHG emission offsets through their restoration or preservation, and understand the impacts of eutrophication, climate change and SLR on those functions. Primary work will be conducted at the NOAA NERR site at Waquoit Bay, and will include measurements of C storage, and vertical GHG exchanges between marsh and atmosphere. The presentation will particularly focus on approaches to measure lateral fluxes or outwelling of fixed C and GHG from coastal wetlands to estuaries due to tidal water exchanges. Lateral fluxes can be large relative to other terms in tidal wetland biogeochemical budgets, and are integral to calculations of carbon sequestration in the marsh sites. Lateral fluxes will be estimated by measuring tidal water fluxes and velocity-weighted concentrations of GHG and dissolved and particulate C and N in the wetland channels. Tidal water fluxes will be measured using the index velocity method: an autonomous acoustic velocity meter provides continuous point velocity and water depth over the time period of interest. Total water flux measurements with downward-looking acoustic Doppler current meters are then used to relate the point velocity measurements to a channel-average velocity measurement and water depth measurements to channel area. Velocity-weighted concentrations of GHG in marsh creeks will be measured with using an off-axis ICOS N_2O analyzer (Los Gatos, Inc.) and a CRDS CO_2/CH_4 analyzer (Picarro, Inc.), coupled to an air/water equilibrator.

<u>Contact Information</u>: Kevin D. Kroeger, USGS Woods Hole Coastal & Marine Science Center, Woods Hole, MA 02543 USA, Phone: 508-457-2270, Fax: 508-457-2310, Email: kkroeger@usgs.gov

VARIABLE EFFECTS OF NUTRIENT ENRICHMENT ON SOIL RESPIRATION IN MANGROVE FORESTS

Catherine E. Lovelock[1]*, Ilka C. Feller*[2] and *Roger W. Ruess*[3]
[1]School of Biological Sciences, University of Queensland, St Lucia, Australia
[2]Smithsonian Environmental Research Center, Edgewater, MD, USA
[3]Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, Alaska, USA

CO_2 efflux from soils (soil respiration) is an important component of the carbon budget of forested ecosystems and of the atmospheric global carbon balance. Mangrove forests are important sites of carbon exchange on tropical and subtropical coasts. Their exposure to nutrient pollution as well as variation in salinity of soils affects their productivity and allocation to roots and thus potentially affects rates of soil CO_2 efflux. Using a network of fertilization experiments over a wide range of mangrove forests we assessed how aboveground growth responses to experimental nutrient enrichment influenced mangrove soil respiration. Proportional increases in aboveground growth in response to fertilization were only loosely correlated with proportional enhancements in soil respiration. While growth was enhanced 6.4 fold due to fertilization, soil respiration increased only 1.3 fold. Soil respiration increased with increasing soil salinity and then declined at salinity over 45 PSU, but this relationship was not altered by fertilization. Proportional enhancements in soil respiration were correlated with proportional enhancements in the specific leaf area (area per mass) of leaves. These results indicate that enhancements in root respiration rate or heterotrophic respiration are likely to be offsetting declines in allocation to roots in response to fertilization. Nutrient enrichment of mangrove forests enhanced soil CO_2 efflux and results in decreased carbon sequestered belowground.

<u>Contact Information</u>: Prof Catherine Lovelock, School of Biological Science, The University of Queensland, St Lucia QLD 4072, Australia. Email c.lovelock@uq.edu.au

THE REGULATION OF GREENHOUSE GAS FLUXES BY WETLANDS AT LANDSCAPE LEVEL

Ülo Mander*, Martin Maddison, Kaido Soosaar, Jüri-Ott Salm, Järvi Järveoja* and *Raili Hansen*
Department of Geography, University of Tartu, Estonia

The world's wetlands, despite being only about 5% of the terrestrial landscape, are currently significant net sinks of more than 1 Pg yr^{-1} of carbon (Mitsch et al 2012). At landscape level wetlands and riparian zones are important regulators of nutrient transport (Zedler 2003; Hefting et al., 2004), however, they can be also significant hot spots of greenhouse gas (GHG) emission (Teiter & Mander 2005; McNamara et al 2006). Swedish experience shows that the nationally planned wetland creation (12,000 ha) could make a significant contribution to the targeted reduction of N fluxes (up to 27% of the Swedish environmental objective), at an environmental risk equalling 0.04% of the national anthropogenic GHG emission (Thiere et al 2011). Only few studies consider the potential GHG emission throughout both natural and created wetlands. The main objective of this study was to clarify the potential of various wetland ecosystem and riparian zones of northern rural landscapes in regulation of GHG emissions.

Monthly-based measurements of CO_2, CH_4 and N_2O emission using closed chamber method were performed from October 2007 to October 2011 in 47 study sites in Estonia. The study sites cover various wetlands and riparian forests as well as reference areas on automorphic soils.

In general wetlands' drainage was the most significant disturbance factor influencing GHG fluxes, causing significant increase in soil CO_2 efflux and N_2O emission as welll as decreasing CH_4 emissions. However, we observed also significantly high CH_4 flux from drained peatlands. The soil CO_2 efflux correlated strongly with soil temperature. In most of soils with ground/soil water levels deeper than 30 cm from the surface a significant decrease in CH_4 fluxes was detected. The highest CH_4 emissions (up to 5060 CH_4-C ha^{-1} yr^{-1}) were detected from drained fen grasslands. In the case of N_2O, no clear differences were found between colder and warmer periods. Relatively higher N_2O fluxes were measured from the drained fen grassland, fertilized arable land, the riparian forest on automorphic soil, and the drained transition fen forest: median values 4.2, 1.4, 1.1, and 0.9 kg N_2O-N ha^{-1} y^{-1} respectively. In peatlands, median values of soil CO_2 efflux were 1,5, 1,9, 2,8 and 1,7 kg CO_2-C ha^{-1} yr^{-1} from natural, drained, abandoned and active mining areas, respectively. Emission of CH_4-C (median values) was 85.2, 23.7, 0.07 and 0.12 kg ha^{-1} yr^{-1}, and N_2O-N -0.05, -0.01, 0.18 and 0.19 kg ha^{-1} yr^{-1}, respectively. There were significantly higher emissions of CO_2 and N_2O from abandoned and active peat mining areas, whereas CH_4 emissions were significantly higher in natural and drained areas. The cultivation of reed canary grass (RCG; *Phalaris arundinacea*) on abandoned peat extraction areas transformed them from a net source of C into a net sink of C: the global warming potential (GWP) for the fertilized and non-fertilized *Phalaris* sites was -5980 and -3890 kg CO_2 eq ha^{-1} yr^{-1}, respectively, whereas the bare soil site had a total GWP of 2540 kg CO_2 eq ha^{-1} yr^{-1}. We also found that the buffering capacity of long-term loaded riparian alder forests in agricultural landscapes will decrease over time, which calls for the careful management of these riparian forests.

Contact Information: Ülo Mander, Department of Geography, Institute of Ecology and Earth Sciences, University of Tartu, Vanemuise St. 46, 51014 Tartu, Estonia, Phone: +372 5087373, Fax: +372 7 375825, Email: ulo.mander@ut.ee

QUANTIFYING THE EFFECTS OF SALINITY AND WATER LEVEL ON GREENHOUSE GAS EMISSIONS USING TWO DIFFERENT APPROACHES: LABORATORY INCUBATIONS VERSUS IN SITU MEASUREMENTS

John M. Marton[1], *Ken W. Krauss*[2], *Ellen R. Herbert*[1] and *Christopher B. Craft*[1]
[1]Indiana University, Bloomington, IN
[2]U.S. Geological Survey, Lafayette, LA

Wetlands provide a suite of valuable ecosystem services such as water quality improvement, water storage and flood abatement, and carbon (C) storage and sequestration. However, they are also a significant source of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Human-induced climate change has accelerated sea-level rise (SLR) which in turn has altered the hydrology and salinity of many tidal freshwater wetlands and has the potential to alter biogeochemical processes.

We present two different approaches to quantifying the effects of water level and salinity on greenhouse gas emissions from tidal freshwater forested (TFF) wetland soils in Southeastern Georgia. In-situ gas flux chambers were used to quantify CO_2, CH_4, and N_2O emissions in tidal forests with varying degrees of degradation through salt water intrusion along the Savannah River. In a separate study, soil cores were collected from TFFs along the Altamaha, Ogeechee, and Satilla Rivers to quantify the effects salinity on CO_2, CH_4, and N_2O production using soil slurries incubated in the laboratory. Although both studies measured greenhouse gas production, there are different considerations and approaches to sample collection and measurement, interpretation of results, and extrapolation to larger spatial and temporal scales.

Flux chambers are useful in measuring greenhouse gas emissions which result from the combined interaction of factors such as soil and air temperature, water depth, salinity, microbial communities, redox status, and soil nutrient pools. Chamber bases extend about 5 cm into the soil surface, thereby allowing both vertical and lateral movement of water through the soil profile during tidal exchange. This results in measurements being taken with minimal disturbance to the soil and vegetation but also requires a strategic experimental design to capture natural variations in both water level and salinity. Using gas flux chambers along the Savannah River, CO_2 emissions were found to be correlated to water depth and soil temperature with higher emissions coming from the drier sites. Conversely, no correlation was found between salinity and CO_2, CH_4, and N_2O emissions, which suggests that there are other factors controlling gaseous efflux.

Laboratory incubations offer greater potential for manipulating individual variables, such as water level and salinity, but are unable to completely mimic in-situ conditions. Soil slurries in particular homogenize the soil, alter the hydrologic regime, and create “closed systems” preventing water and nutrient exchange with the surrounding landscape. Using salinity-amended soil slurries from tidal forest soils along the Altamaha, Ogeechee, and Satilla Rivers, CO_2, CH_4, and N_2O production was measured over a period of 5 days. Increasing salinity significantly reduced CH_4 production from all rivers, while CO_2 and N_2O exhibited mixed responses. Results from the incubations must be interpreted with caution because many of the factors controlling greenhouse gas production were modified. However, these incubations were useful in identifying short-term responses to increasing salinity. Both incubations and in-situ approaches are useful in determining the response of greenhouse gas production to water level and salinity, though both approaches require separate interpretations of results and have different degrees of ecological applicability.

Contact Information: John M. Marton, School of Public and Environmental Affairs, Indiana University, Room 408, 702 North Walnut Grove Ave, Bloomington, IN 47405, Phone: 812-856-7491, Email: jmarton@indiana.edu

QUANTIFYING METHANE CYCLING DYNAMICS IN ALASKAN ARCTIC LAKES

***G.E. McGowan**, K. Bretz, D. Lofton* and *S. C. Whalen*
Department of Environmental Sciences and Engineering, University of North Carolina, Chapel Hill, NC, USA

Atmospheric CH_4 exerts a radiative forcing about 21 times that of CO_2, and accounts for about 20% of the greenhouse effect. Bottom-up and inverse modeling efforts indicate that high latitude regions are the largest natural source of atmospheric CH_4. However, field campaigns have focused on quantifying methane production and oxidation in, and emission from, Arctic tundra soils, but have largely ignored shallow lakes and ponds that occupy roughly 20% of the arctic tundra surface. Lentic environments integrate watershed processes by accruing organic matter inputs. These inputs are expected to increase with climate change due to a lengthened growing season, and organic matter release from thawing permafrost.

Controls on CH_4 emission from arctic lakes may differ fundamentally from those in terrestrial tundra. While methanogenesis in lake sediments may be greater in magnitude than in moist tundra soils due to more intense organic matter loading, CH_4 emission from tundra is modulated only by oxidation in the oxic surficial sediment layer. In contrast, CH_4 diffusing from anoxic lake sediments is subject to oxidation in both oxic surficial sediments and an extensive overlying water column prior to emission to the atmosphere.

We measured rates of sediment-water exchange of CH_4 and water column CH_4 oxidation in six lakes in the Arctic Foothills region in the summers of 2010 and 2011. The study lakes represent a range of lakes in terms of productivity (0.5-35 µg/L chl a), mean depth (2.1-7m) and surface area (0.7-149 ha). Fluxes of CH_4 from lake sediments to the water column were measured using benthic chambers. Oxidation rates of CH_4 in the water columns of the study lakes were assessed using $^{14}C\text{-}CH_4$. Lake surface CH_4 effluxes were estimated using both a mass-balance framework applied to these data, and solubility equilibrium calculations based on measured lake surface CH_4 concentrations.

Benthic CH_4 flux rates varied by three orders of magnitude along a productivity gradient, ranging from 0.0034 to 3.84 mmol CH_4 m^{-2} d^{-1}. Water column CH_4 oxidation rates were always highest near the sediment-water interface. Depth-integrated oxidation rates varied from 0.29 to 49 mmol CH_4 m^{-2} d^{-1} and increased with overall lake productivity. Maximum estimated rates of CH4 emission to the atmosphere were ~ 1 mmol CH_4 m^{-2} d^{-1}. This is comparable to the lower range of many thaw-season CH4 emission estimates for Arctic tundra, which typically range from about 1-10 mmol CH_4 m^{-2} d^{-1}, indicating the extensive oxygenated water column in arctic lakes is highly efficient at oxidizing CH_4 produced in underlying anoxic sediments.

Contact Information: Gabriel E. McGowan, Rosenau Hall Room 148,135 Dauer Drive, Chapel Hill, NC 27599, USA, Phone: 828-329-9282, Email: gabemcg@live.unc.edu

EVALUATION OF DIRECT AND INDIRECT PHOSPHORUS LIMITATION OF METHANOGENIC PATHWAYS IN CALCAREOUS SUBTROPICAL WETLAND SOILS

C.A. Medvedeff, *K.S. Inglett* and *P.W. Inglett*
Department of Soil and Water Science, University of Florida, Gainesville, FL, USA

In oligotrophic ecosystems, phosphorus (P) inputs can result in long lasting consequences affecting both microbial processing and soil biogeochemistry. In the current study we amended low P wetland soils with acetate to stimulate the acetoclastic pathway, butyrate to stimulate syntrophic associations, formate to fuel hydrogenotrophic processing and glucose to stimulate higher trophic level microbes (increase substrate supply). Simultaneously, we amended a second set of microcosms with each carbon (C) substrate listed above and P to determine if an interaction or co-limitation between the two elements affected anaerobic microbial processing. In this study we found formate and glucose (to a much lesser extent) to stimulate methanogenesis although no significant response to acetate or butyrate was observed. In contrast glucose was the only C amendment which stimulated anaerobic respiration (CO2).

Addition of P resulted in a four fold increase in CH4 production. In contrast, production of CO2 in P amended soils was only slightly stimulated relative to control CO2 produced. Accumulation of CH4 from soils amended with both C and P was statistically similar to production observed from P amended soils (no carbon added) suggesting P is the driving factor in CH4 production. However, addition of formate and P combined and independently resulted in similar stimulation of CH4 production relative to the control, although, production was slightly higher in the combined C and P treatment. Concurrent P and C additions resulted in CO2 accumulation similar to control soils except for the glucose treatment which was not affected by P addition. Decreasing ratios of CO2-C:CH4-C with P addition suggests preferential stimulation of methanogenic activity in response to P addition. A similar decreasing trend in CO2-C:CH4-C ratio was also observed in the formate treatment. This study suggests (i) methanogens may be limited by formate, (ii) P directly limits methanogenesis and (iii) P limits methanogenesis indirectly by stimulation of higher trophic level processing (increased substrate availability).

Contact Information: C.A. Medvedeff, Department of Soil and Water Science,University of Florida, 106 Newell Hall, Gainesville, FL, 32511, USA, Email:medvedeff22@ufl.edu

APPROACHES AND LIMITATIONS TO QUANTIFYING PLANT REGULATION OF METHANE EMISSIONS

J. Patrick Megonigal
Smithsonian Environmental Research Center, Edgewater, MD, USA

The presence of emergent plants accounts for the fact that wetland ecosystems are hotspots of methane emissions. Plants are sources of substrates to soils that can enhance or inhibit methanogenesis; they affect the oxidation of methane to carbon dioxide by regulating the pathways through which methane is emitted to the atmosphere; and they indirectly influence on methane emissions through physiochemical features of the ecosystem such as water table depth. I will review the approaches used to investigate the mechanisms by which plants regulate methane emissions.

Plants are the primary source of organic compounds that microbial consortia metabolize to produce the electron donor compounds used by methanogens. The dependence of methane production on photosynthetic activity has been investigated through correlative techniques, experimental manipulation of photosynthetic activity, and isotopic tracer techniques. Tracer studies show that a portion of the carbon dioxide fixed by photosynthesis is metabolized into methane within hours.

Plants regulate methane production and oxidation by conveying atmospheric oxygen to the rhizosphere, where it supports a variety of process that work counter to methane emissions. One class of processes is the production of alternative electron accepting compounds, such as ferrous iron, that support organisms in competition with methanogens. The methods available to study such processes are quite limited. Direct measurement of process rates is typically done by destructive soil sampling and anaerobic incubation, which separates microorganisms from important plant processes. Non-destructive samples of pore water chemistry are informative, but they do not provide rate Information. A second type of process supported by oxygen transport through plants is methane oxidation, which can consume 70% or more of the methane produced in wetland soils. Unlike electron acceptor-generating processes, methane oxidation can be studied in situ and non-destructively by applying gaseous specific inhibitors to a headspace surrounding the plants.

Plants indirectly regulate methane production and oxidation by acting as conduits for gas exchange between the atmosphere and soils. The fact that methane vents from soils through plants presents methodological challenges for the application of static chamber techniques, such as the need to regulate the light environment for species with pressurized ventilation. Plant ventilation is particularly problematic for interpreting plant removal experiments because a change in flux can be caused either by the loss of the plant ventilation pathway, or a change in the supply of organic carbon. To test the hypothesis that plant removal decreases methane production, one must either measure a second major pathway of methane export – bubble ebullition – or in situ rates of methanogenesis itself.

Collectively, research suggests that the net effect of plant activity is generally to stimulate methane emissions at scales ranging from individual plants to continents. However, plant effects are highly species specific, with some species favoring methane suppression through terminal electron acceptor regeneration over methane production via carbon input. This field could advance more rapidly with methods to quantify oxygen flux into wetland ecosystems.

Contact Information: J. Patrick Megonigal, Smithsonian Environmental Research Center, PO Box 28, Edgewater, MD, 21037-0028 USA, Phone: 443-482-2346; Fax: 443-482-2380, Email: megonigalp@si.edu

QUANTIFYING SOIL GREENHOUSE GAS FLUXES IN RELATION TO INUNDATION, SALT-WATER INTRUSION AND MICROBIAL RESPIRATION IN TIDAL WETLANDS

Justin Meschter and *Nathaniel Weston*
Villanova University, Villanova, PA, USA

Tidal marshes are highly productive ecosystems with the potential to sequester large amounts of carbon. Much of the carbon in marshes, however, is released as carbon dioxide (CO2) through plant and microbial respiration. Further, tidal wetlands may be sources of the powerful greenhouse gases (GHGs) methane (CH4) and nitrous oxide (N2O), which are produced via microbial respiration. As global climate changes it is increasingly important to understand the processes that control ecosystem productivity, GHG fluxes, and potential feedbacks between global change factors (such as sea-level rise and salt-water intrusion) and GHG fluxes. Here we describe our research aimed at quantifying rates of GHG (CO2, CH4 and N2O) exchange along with plant biomass and microbial processes in tidal freshwater marshes (TFMs) and salt-marshes of the Delaware River Estuary.

To evaluate the response of the microbial community in TFMs to salt-water intrusion, a laboratory experiment was conducted in which multiple soil cores were subjected to simulated tidal inundation of either freshwater or dilute salt-water. CO2 was measured on each soil core during simulated low-tide at least weekly for one year using an infra-red gas analyzer (IRGA), and CH4 was measured on a subset of cores on each sampling date by flame ionization gas chromatography. As part of this experiment, we also quantified CO2 and CH4 fluxes during periods of high-tide (soil inundation). CO2 fluxes during inundation were determined by measuring changes in dissolved inorganic carbon over time. Rates of CO2 exchange remained relatively constant during exposure and inundation. However, CH4 fluxes decreased significantly during inundation ($p=0.02$), indicating the need to evaluate GHG exchange at various stages of inundation in tidal systems. To evaluate how rates of microbial processes changed in response to salt-water intrusion, we measured depth-specific rates of methanogenesis and sulfate reduction using radiotracer assays. This allowed us to estimate the amount of CO2 produced by these anaerobic microbial processes over the one year experiment (17 mol/m2) versus the amount of CO2 emitted from the soil (14.2 mol/m2), indicating agreement between these two methods. In contrast, the amount of CH4 produced by methanogenesis (20.9 mol/m2) was far greater than the CH4 flux (3.9 mol/m2) suggesting methanotrophy is important in regulating CH4 flux in TFM systems.

In the field, we used static flux chambers to evaluate fluxes of CO2, CH4 and N2O from TFMs and salt-marshes. We have utilized large diameter (0.37 m2) and smaller diameter (0.07 m2) chambers that connect to permanent collars placed in the marsh to measure GHG fluxes, both of which have advantages and drawbacks. These field measurements, together with soil biogeochemical and microbial rate measurements, yield Information on the environmental controls on GHG fluxes. To further elucidate how climate change will influence GHG fluxes and overall tidal marsh functioning, we initiated a field experiment utilizing marsh ‘organs’ that manipulated the elevation of marsh mesocosms to simulate flooding. Measurements of CH4 and N2O gas exchange from marsh organs yield insight into changes in GHG flux in response to changing inundation associated with sea-level rise.

Contact Information: Justin Meschter, Department of Geography and the Environment, Villanova University, Villanova, PA 19085 USA; Phone 610-518-3336; Fax 610-519-3338; Email: justin.meschter@villanova.edu

GREENHOUSE GAS EMISSIONS FROM NATURAL, RESTORED, AND PRIOR-CONVERTED WETLANDS OF THE MID-ATLANTIC

***J.O. Miller**, P.G. Hunt* and *T.F. Ducey*
USDA-ARS, Florence, SC

The hydrologic restoration of drained agricultural wetlands may impact greenhouse gases particularly, N_2O emissions. Assessment of this impact was part of the USDA-NRCS Mid-Atlantic Regional Conservation Effects Assessment Program (MIAR-CEAP), with sample sites in DE, MD, VA, and NC. For this study, twelve MIAR-CEAP sites (four natural, four restored, and four prior-converted wetlands) were selected. Each site had a four point transect along a topographic gradient and was visited three times. Soil samples were obtained from the upper 6 inches of the soil and taken back to the lab for denitrification enzyme activity (DEA) analysis. A photoacoustic gas analyzer was used to measure in-situ greenhouse gas emissions in the field.

The flux of N_2O from the soils was within the typically range -- below detection to 6 mg N_2O/kg soil/day. The emissions that were below detection were during dry periods of the study. Some hot spots were observed in prior converted wetlands, with N_2O emissions up to 120 mg N_2O/kg soil/day. Initial data indicates that N_2O emissions did not vary greatly between the different land uses, but greater emissions were observed in the wetter landscape positions.

Contact Information: Jarrod O. Miller, USDA-ARS Coastal Plains Research Center, 2611 W. Lucas St., Florence, SC 29501 USA, Phone: 843-669-5203 x 106, Email: Jarrod. Miller@ars.usda.gov

DYNAMIC HOTSPOTS OF NITROUS OXIDE AND METHANE IN COASTAL MARSHES: RESPONSES TO TWO LONG-TERM FERTILIZATION EXPERIMENTS

Serena Moseman-Valtierra[1] and *Kevin D. Kroeger*[2]

[1]University of Rhode Island, Department of Biological Sciences, Kingston RI, USA
[2]USGS Coastal and Marine Science Center, Falmouth MA, USA

Greenhouse gas emissions from coastal marshes may be significantly influenced by anthropogenic nutrients. Nitrogen may stimulate microbial processes that produce nitrous oxide (N2O), such as denitrification and nitrification, and they may also enhance emissions of methane (CH4) by inhibiting biological methane oxidation. N2O and CH4, respectively, have 300 and 25 times the global warming potential per molecule of CO2, and thus nutrient loading can significantly affect the climatic roles of wetlands. Our prior experiments have shown that short-term nitrate additions in a Spartina patens marsh significantly increased average fluxes of N2O (42 mol N2O m-2 day-1) relative to control plots (0 mol N2O m-2 day-1). With methane fluxes, maximal fluxes were comparable to about 1/2 of typical daily C sequestration rates of marshes. In two long-term experiments within coastal marshes, fertilized plots showed greatest variability in N2O and CH4 fluxes, although there was not a statistically significant relationship between the gas fluxes and N loads. In a S. patens marsh with 7 years of fertilization (at 15X background nitrate concentrations), N2O fluxes ranged from -10 to 51 mol N2O m-2 day-1. Highest methane fluxes were 176 mol CH4 m-2 day-1. In contrast, N2O and CH4 fluxes were largely insignificant (0-5 mol N2O m-2 day-1 and 0- 44mol CH4 m-2 day-1) in the adjacent unfertilized marsh. When fertilization ceased the following year, N2O and CH4 fluxes became insignificant, except for one large negative flux (-448 mol N2O m-2 d-1), indicating that greenhouse gas emissions can change substantially with shifts in N loading but that responses are spatially heterogeneous. In a S. alterniflora marsh with 31-32 years of fertilization, greatest emissions of N2O (154 mol N2O m-2 day-1) were observed in plots with the highest fertilization rates (7.56 g N m-2 wk-1), while plots with low fertilization (0.86 g N m-2 wk-1) had the highest consumption rates (-460 mol N2O m-2 day-1). Similarly, notable methane fluxes (up to 2623 mol CH4 m-2 d-1) were observed only in plots with high fertilization. N2O and CH4 fluxes at each fertilization level changed significantly between two summers however, highlighting the magnitude of temporal dynamics of greenhouse gas emissions. Recent technological advances, enabling rapid in situ analyses of N2O and CH4 fluxes, will help to better constrain the magnitude and controls on greenhouse gases in these heterogeneous ecosystems, and this work will improve predictions regarding potential feedbacks of coastal wetlands on global climate.

Contact Information: S. Moseman-Valtierra, Biological Sciences Department, University of Rhode Island, 9 East Alumni Avenue, Kingston, RI 0288, Phone: 401-874-7474, Email: smoseman@mail.uri.edu

METHANE EMISSIONS THROUGH TREES IN TROPICAL AND TEMPERATE FORESTED WETLANDS

Sunitha R. Pangala[1], *Vincent Gauci*[1], *Edward R.C. Hornibrook*[2] and *David J. Gowing*[1]
[1]The Open University, Milton Keynes, UK
[2]University of Bristol, Bristol, UK

Wetlands are the single largest natural source of methane (CH4) emissions to the atmosphere. CH4 dynamics in wetlands are generally well understood but recent reports of CH4 flux through trees suggests a need to revisit CH4 transport processes. Wetland trees possess morphological adaptations, such as hypertrophied lenticels, aerenchyma and adventitious roots, which develop in response to soil anoxia. Such adaptations facilitate gas transport, providing a means to aerate the rhizosphere and a conduit for escape of soil CH4 to the atmosphere. Approximately 60% of global wetlands are forested and many tropical forests are permanently or seasonally flooded. Hence tree-mediated CH4 release could be an important factor in the global CH4 budget. CH4 emission from the trunks of temperate tree species has been confirmed; however, CH4 emissions from tropical trees and processes that control tree-mediated CH4 emissions remain unclear.

This study investigated the role of trees in transporting soil-produced CH4 to the atmosphere and the principal mechanisms of tree-mediated CH4 emissions. CH4 fluxes from eight tropical tree species and two temperate tree species were measured in situ. The mechanisms and controls on tree-mediated CH4 emissions were studied using three-year-old common alder (Alnus glutinosa; 50 trees) grown under two artificially controlled water-table positions. The rates of CH4 emission from whole mesocosms, the soil surface and tree stems were measured using static closed chambers.

Both temperate and tropical tree species emitted significant quantities of CH4 and notably, trees dominated ecosystem level CH4 fluxes in a tropical forest peat swamp. In a temperate riparian wetland, CH4 transport mechanism and the quantity of CH4 emitted was dependent on tree species. In Alnus glutinosa, no correlation was observed between stomatal behaviour and tree-mediated CH4 emissions, although stem CH4 emissions were positively correlated with stem lenticel density and the concentration of dissolved CH4 in soil. CH4 was not emitted from leaf surfaces in Alnus glutinosa. These findings indicate that tree-mediated CH4 emissions should be included in flux measurement campaigns in forested wetlands to avoid underestimation of total CH4 emissions from such ecosystems.

Contact Information: Sunitha R. Pangala, Centre for Earth, Planetary, Space and Astronomical Research (CEPSAR), Department of Environment, Earth and Ecosystems, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK, Phone: 00441908653083, Fax: 00441908655151, Email: s.pangala@open.ac.uk

GREENHOUSE GAS FLUXES FROM NATURAL AND RESTORED WETLANDS IN THE AGRICULTURAL MIDWEST

Brianna L. Richards and *Christopher B. Craft*
Indiana University, Bloomington, IN, USA

We measured potential CH_4, CO_2, and N_2O production from soils of four 10-12 year old depressional wetlands restored by the US Department of Agriculture Wetland Reserve Program and four natural depressional wetlands in the Corn Belt of northwestern Indiana using anaerobic laboratory incubations. We also measured in situ net fluxes of CH_4, CO_2, and N_2O during the growing season at two of the restored and two of the natural wetlands using an ecosystem static flux chamber.

Restored wetlands emit lower amounts of greenhouse gases (GHGs) than natural wetlands. Mean net fluxes of methane range from 8.29 to 18.54 mg CH_4 m^{-2} hr^{-1} in restored wetlands and 29.18 to 30.29 mg CH_4 m^{-2} hr^{-1} in natural wetlands. Mean net fluxes of CO_2 range from -93.17 to 211.30 mg CO_2 m^{-2} hr^{-1} in restored wetlands and 457.20 to 787.38 mg CO_2 m^{-2} hr^{-1} in natural wetlands. Mean net fluxes of N_2O ranged from 4.28 to 4.71 µg N_2O m^{-2} hr^{-1} in restored wetlands and 5.64 to 17.23 µg N_2O m^{-2} hr^{-1} in natural wetlands. Greenhouse gas production from anaerobic laboratory incubations also was lower in restored versus natural wetlands. Differences in organic carbon and soil moisture likely explain the difference in emissions between natural and restored wetlands as percent organic C content was 4 times greater in natural than in restored wetlands (6.73% and 1.49%), and soil moisture was 2 times greater in natural than in restored wetlands (47.33% and 27.49%). Data on GHG emissions from restored wetlands will enable more comprehensive land management evaluations of WRP wetlands and also will assist in refining carbon models for freshwater mineral soil wetlands.

Contact Information: Brianna L. Richards, Indiana University, School of Public and Environmental Affairs, 702 North Walnut Grove, MSB II Room 408, Bloomington, Indiana, 47405 USA, Phone: 571-330-9582, Email: briarich@indiana.edu

SOIL PHYSICAL PROPERTIES OF ORGANIC SOILS IN GERMANY AND THEIR RELEVANCE FOR THE CLIMATE REPORTING

***Niko Rosskopf**, Holger Fell* and *Jutta Zeitz*
Humboldt-Universität zu Berlin, Faculty of Agriculture and Horticulture, Division of Soil Science and Site Science, Berlin, Germany

Organic Soils (definition according to IPCC Guidelines 2006) are becoming increasingly important in the context of climate change. In their natural state, they sequester and store organic carbon, after drainage they turn from a carbon sink to a source. In Germany many Organic Soils, especially those formed in mires and peatlands, have been intensively drained and used for more than 200 years. This has led to changes in soil properties and emissions of Greenhouse gases.
In the frame of the research project "Organic Soils", funded by the Federal Ministry of Food, Agriculture and Consumer Protection, we are working on the characterization of relevant properties of Organic Soils in Germany. In this presentation, we focus on physical properties as they are important input data for Greenhouse gas modeling and carbon storage calculations.

More than 40 typical Organic Soil profiles in different study areas around Germany were analyzed and classified according to the World Reference Base for Soil Resources (WRB) and the German soil classification system (KA5). Additionally, we evaluated legacy data in soil databases. A set of nine typical soil profiles could be derived. Each profile consists of a characteristic combination of dominant soil horizons and substrates. These Horizon- Substrate combinations (HSC) could then be parameterized with soil physical properties.

A strongly earthified topsoil horizon is typical for drained peatlands under intensive use. If we compare it with a topsoil of an undrained peatland, it has an up to five times higher bulk density, lower water conductivity and a smaller pore space. This has a direct impact on the water and gas dynamics in the soil. Due to low water infiltration capability this may lead to longer lasting accumulated water on the surface and to higher methane emissions.
The subsoil of a drained peatland is segregated and consists mostly of sedge peat in a higher degree of decomposition. It has a total pore space of 55 %. This is about 20 % lower than a subsoil horizon without segregation.

By taking the pedogenesis into account and with the knowledge of the stratigraphy of the main physical properties in Organic Soils we could optimize modeling approaches and produce more precise input data for carbon budget calculations.

Contact Information: Niko Rosskopf, Humboldt-Universität zu Berlin, Faculty of Agriculture and Horticulture, Division of Soil Science and Site Science, Albrecht-Thaer-Weg 2, 14195 Berlin, Germany, Phone: 0049 30 31471861, Fax: 0049 30 209346403, Email: niko.rosskopf@agrar.hu-berlin.de

ESTIMATING ANNUAL SOIL CARBON RELEASE FROM EVERGLADES TREE ISLANDS

Robert Schroeder[1,2], *Leonard Scinto*[1,2], *Alexandra Serna*[1,2], *Eric Cline*[3], *Thomas Dreschel*[3] and *Fred Sklar*[3]

[1]Southeast Environmental Research Center, Florida International University, Miami, FL, USA

[2]Department of Earth and the Environment, Florida International University, Miami, FL, USA

[3]South Florida Water Management District, Everglades Systems Assessment Section, West Palm Beach, FL, USA

The Everglades ecosystem is under threat from anthropogenic alteration. This system stores a large quantity of soil carbon (C) that could potentially be released into the atmosphere by many factors, including altered hydrology. Water level, or water saturation, is one of the main drivers of respiration in tropical, sub tropical and temperate peatlands and wetlands. Due to the anthropogenic alteration of Everglades hydrology beginning 100 years ago, more than 50% of Everglades' tree island acreage has been lost. High water levels reduce oxygen availability, reducing rates of decomposition due to the lowering of the oxidation-reduction potential which increases the use of methanogenic respiration pathways. This study investigates Everglades' soil respiration rates by means of tree island in situ gas chambers techniques and core incubation experiments. Experiments have been conducted at Loxahatchee Impoundment Landscape Assessment (LILA) at the Arthur R. Marshall Loxahatchee National Wildlife Refuge, Florida. LILA was created to mimic the ridges, sloughs and tree islands landscape characteristic of the Everglades in a semi-controlled system. Carbon release as soil CO_2 efflux was measured via a LICOR LI-8100 infrared gas analyzer while CH_4 efflux was measured in subsamples on a gas chromatograph. In situ efflux measurements were taken from two tree island elevations, on two LILA tree islands quarterly between May 2010 and March 2011, coinciding with major water level changes. Relative water depth (RWD) had an influence on soil CO_2 efflux which varied from 0.13 to 18.49 $\mu mol\ CO_2\ m^{-2}\ s^{-1}$ with low efflux rates during the peak wet season and high efflux rates during peak dry season. In situ measurements were supplemented by soil core experiments using triplicate 20 cm soil cores, to more precisely define the influence of water level on gaseous efflux and the relationship between CO_2 and CH_4. Initially flooded soil cores were drained and then re-flooded over an extended period with frequently measured CO_2 and CH_4 efflux. Rates of C efflux based on water levels were extrapolated and summed annually. Gaseous soil efflux is an important part of the C-budget estimation in the Everglades ecosystem. This Information can be used for better environmental management and climate change models.

Contact Information: Leonard J. Scinto, Southeast Environmental Research Center, OE148, Florida International University, 11200 SW 8th Street, Miami FL 33199, Phone: 305-348-1965, Fax: 305-348-4096, Email: scintol@fiu.edu

CARBON BUDGET ESTIMATION FROM EVERGLADES TREE ISLANDS: BALANCING SOIL ACCRETION AND CO_2 EFFLUX

Leonard J. Scinto[1,2], *Robert Schroeder*[1,2], *Alexandra Serna*[1,2], *Eric Cline*[3], *Thomas Dreschel*[3] and *Fred Sklar*[3]

[1]Southeast Environmental Research Center, Florida International University, Miami, FL, USA

[2]Department of Earth and the Environment, Florida International University, Miami, FL, USA

[3]South Florida Water Management District, Everglades Systems Assessment Section, West Palm Beach, FL, USA

The Everglades has been subjected to extensive anthropogenic alteration, mostly effecting ecosystem hydrology, over the past century. The original peat-accreting system stored large quantities of soil carbon (C) and was undoubtedly a sink for atmospheric CO_2. Additionally, soil accretion rates relative to decomposition have led to variation in the ridge-slough-tree island topography. Developing a conceptual empirically-based model for tree island soil CO_2 sequestration/release based on relative water depth fluctuations can contribute to a better understanding of how ecosystem hydrology, whether natural or managed, may potentially alter the system C-cycle. Water level, or water saturation, is one of the main drivers of soil respiration in tropical, sub tropical and temperate peatlands and wetlands. Understanding how Everglades tree island soil respiration responds to water level fluctuations coupled with plant biomass estimation and soil accretion (C sequestration) can be used by managers to slow, or reverse, tree island loss. This project summarizes some of the on-going experiments being conducted in the Loxahatchee Impoundment Landscape Assessment (LILA) at the Arthur R. Marshall Loxahatchee National Wildlife Refuge, Florida, US. LILA was created to mimic the ridge-slough-tree island characteristics of the Everglades in a semi-controlled system. Soil CO_2 efflux measurements were conducted using a LICOR LI-8100 infrared gas analyzer and chamber system. Efflux measurements were taken across an elevation gradient (corresponding to relative inundation length) on two LILA tree islands quarterly between May 2010 and March 2011. Relative water depth influenced soil CO_2 efflux which varied from 0.13 to 18.49 µmol CO_2 m^{-2} s^{-1} with low efflux rates during the peak wet season and high efflux rates during peak dry season. The balance between loss of organic matter to the atmosphere as CO_2 and the accretion of soil is largely dependent on the rates of addition and decomposition of litter fall. Soil building C input was partially estimated from triplicate litter traps which were collected bimonthly from August 2010-2011 and indicate variations in litter production with time, elevation, and tree island. Organic matter (litter) decomposition showed faster mass losses at lower (wet) elevations. Efflux of CO_2 was much greater than litter trap input while litter trap input was greater than litter bag mass loss. The balance between litter fall and decomposition was determined in conjunction with SET and feldspar measurements, which indicate soil accretion and elevational decrease in the tree islands. A large difference was found between CO_2 efflux and litter trap input indicating a substantial portion of the C balance remains unaccounted in this experiment. This study will help to balance present-day C inputs/outputs in the altered Everglades ecosystem and can be applied to environmental management and climate change models.

Contact Information: Leonard J. Scinto, Southeast Environmental Research Center, OE148, Florida International University, 11200 SW 8th Street, Miami FL 33199, Phone: 305-348-1965, Fax: 305-348-4096, Email: scintol@fiu.edu

LATTICE BOLTZMANN SIMULATION OF GAS BUBBLE DYNAMICS IN PEAT

Michael C. Sukop[1], *Seckin Gokaltun*[1], *Andrew J. Pearson*[1], *Xavier Comas*[2] and *Nicholas Kettridge*[3]
[1]Florida International University, Miami, FL, USA
[2]Florida Atlantic University, Boca Raton, FL, USA
[3]University of Birmingham, Birmingham, UK

Despite the fact that peatlands may account for 5 to 10% of methane flux to the atmosphere, little is known about the role of peat structure on gas flux dynamics and how free-phase gases in peat soils are generated, accumulate, move within the peat matrix, and are eventually released.

Lattice Boltzmann methods offer a promising approach for the simulation of gas bubble dynamics in peat. The key advantages of these methods are 1) their ability to directly simulate multiphase fluids and their dynamic interactions and 2) their ability to readily incorporate complex peat pore space geometry now available from Computed Tomography (CT) scans.

The low density peat structure is difficult to measure with CT techniques and the final structure approximations are highly sensitive to image thresholding procedures. We select reasonable and/or end-member structures for our preliminary simulations.

Simulations are conducted using planar basal and uniformly distributed random bubble sources to simulate 1) gas generation in layers underlying a gas transmission layer and 2) distributed biogenic gas generation throughout a layer, respectively. Different Contact angles and their effect on bubble ebullition rates and ebullition event sizes are considered.

Although the peat structure is highly deformable and that is likely to affect the dynamics of rising bubbles, we do not consider fluid-structure interaction in these initial simulations.

Contact Information: Michael C. Sukop, Earth and Environment Department, Florida International University, University Park, 11200 SW 8th Street, Miami, FL 33199 USA, Phone: 305-348-3117; Fax: 305-348-3877, Email: sukopm@fiu.edu

CARBON FLUXES AT A SUB-TROPICAL PEAT MARSH IN FLORIDA

David M. Sumner[1]*, C. Ross Hinkle*[2]*, Jiahong Li*[3] and *Angelique Bochnak*[4]
[1]U.S. Geological Survey, Orlando, FL, USA
[2]University of Central Florida, Orlando, FL, USA
[3]Licor Corporation, Lincoln, NE, USA
[4]St. Johns River Water Management District, Palatka, FL, USA

Peat marshes in sub-tropical areas represent a substantial carbon reservoir. Transfers of carbon to and from this reservoir are potentially important to atmospheric concentrations of the greenhouse gases of carbon dioxide and methane. However, compared to boreal peatlands, relatively few measurements of carbon sequestration and release have been made in sub-tropical peatlands. Additionally, water managers in Florida are particularly interested in how water-level controls can be directed to avoid excessive oxidative losses of peat soil and, therefore, maintain the existing peatland topography. At Blue Cypress Conservation Area in central Florida, a dense sawgrass marsh has peat accumulations to depths of over three meters. Eddy covariance measurements of atmospheric/peatland carbon fluxes have been ongoing since July 2009 to better define the carbon dynamics of this seasonally inundated, highly productive marsh. Measured carbon dioxide fluxes will be evaluated at water levels ranging from a meter above to a meter below land surface. Gross primary productivity, respiration, and net ecosystem exchange will be defined on diurnal through annual time scales. The relative importance of methane emissions to the carbon budget will be defined using short-term eddy covariance measurements of methane fluxes. Measured carbon fluxes will be related to water level variations to provide guidance on prudent water level management of this marsh.

Contact Information: David M. Sumner, United States Geological Survey, Florida Water Science Center,12703 Research Parkway Orlando, FL 32826 USA, Phone: 407-803-5518; Fax: 407-803-5501, Email: dmsumner@usgs.gov

RAPID ASSESSMENT OF CARBON STORAGE AND SEQUESTRATION CAPACITY IN U.S. WETLANDS

Eric T. Sundquist[1], *Sara Greenberg*[1], *Norman Bliss*[2], *Kate Ackerman*[1] and *Alicia Perez*[3]
[1]U.S. Geological Survey, Woods Hole, MA, USA
[2]ASRC Research and Technology Solutions, Contractor to the U.S. Geological Survey EROS Center, Sioux Falls, SD, USA
[3]Partnership in Education Program, Woods Hole, MA, USA

The U.S. Geological Survey (USGS) is conducting a rapid assessment of biological carbon stocks and sequestration capacity in the United States. For the initial phase of the assessment (USGS Open-File Report 2009-1283), maps available from the U.S. Department of Agriculture (USDA) were used to estimate current organic carbon storage in soils and forest biomass in the conterminous United States. Hypothetical forest biomass carbon sequestration capacities were estimated using maps of potential vegetation, defined as the stable vegetation ecosystems that would occur as a result of ecological succession under specified historical and (or) biophysical conditions. Conducting this initial assessment required an analysis of all ecosystems across the conterminous U.S, providing a valuable basis for extending the assessment to include wetlands.

Wetlands are an important assessment objective because they store large amounts of carbon in relatively small areas. The value of an ecosystem-based analysis is readily apparent in comparisons of geospatial datasets that depict distributions of wetlands and wetland-associated soils. Detailed comparisons were conducted for four regions (Connecticut-Massachusetts-Rhode Island, Louisiana-Mississippi, North Dakota-South Dakota-Minnesota, and California) to examine differences and commonalities among four maps of wetland distribution (Coastal Change Analysis Program, available from the U.S. National Oceanic and Atmospheric Administration; National Land Cover Database, available from the USGS; National Wetlands Inventory, available from the U.S. Fish and Wildlife Service; and Gap Analysis Program, available from the USGS). Although these maps are all based on a single system of wetland classification (Cowardin et al., 1979) significant uncertainties in wetland spatial area and distribution can be attributed to differences in data integration and methodologies. Further uncertainties are apparent in comparisons of wetland distributions to soil map units that contain wetland-associated soils (Soil Survey Geographic Database, available from the USDA). Despite these uncertainties, total areas of wetlands and wetland-associated soils show significant convergence among the datasets when they are aggregated to the level of ecosystems defined by maps of existing and potential vegetation from the Landscape Fire and Resource Management Planning Tools Project (LANDFIRE, available from the USGS and the USDA).

In our initial assessment of biomass carbon, hypothetical amounts of potential biomass carbon sequestration were taken to be the differences between estimates of carbon stored in existing vegetation and in potential vegetation. An analogous approach can be applied to estimate hypothetical amounts of potential organic carbon sequestration in wetland soils. However, because wetlands are particularly vulnerable to changes in hydrologic and landscape settings caused by human activities, maps of potential vegetation may be poor indicators of potential or historical wetland distributions. An alternative assessment approach is to use the distribution of existing hydric soils to estimate hypothetical additional wetland sequestration capacity in ecosystems where the current area of hydric soils exceeds the area of wetlands. Although assessments based on distributions of both potential vegetation and hydric soils are hypothetical and very uncertain, they help to frame policy and management discussion by providing estimates that can be compared to amounts necessary to reduce predicted future atmospheric carbon dioxide levels.

Contact Information: Eric T. Sundquist, U.S. Geological Survey, 384 Woods Hole Road, Woods Hole, MA 02543, USA, Phone: 508-457-2397, Fax: 508-457-2310, Email: esundqui@usgs.gov

CO_2 AND N_2O FLUXES FROM COASTAL WETLANDS: IS THERE ANY DIFFERENCE BETWEEN WETLANDS AND UPLANDS?

Jianwu Tang[1], *Kevin Kroeger*[2], *Serena Moseman-Valtierra*[3]

[1]Marine Biological Laboratory, Woods Hole, MA, USA
[2]USGS Woods Hole Center, Woods Hole, MA, USA
[3]University of Rhode Island, RI, USA

Anthropogenic greenhouse gas emissions cause climate change. Meanwhile, climate change and other anthropogenic activities, such as nitrogen deposition from the atmosphere and nitrogen loading from human activities, significantly influence ecosystem carbon and nitrogen cycles and greenhouse gas emissions. Coastal wetlands could sequester a large amount of carbon into ecosystems, as so called "blue carbon," in ways analogous to terrestrial carbon sequestration in forests. On the other hand, coastal wetlands could emit a substantial amount of nitrous oxide (N_2O) given the increasing nitrogen loading via human activities such as fertilization and wastewater production, and thus partially offset CO_2 uptake. Equivalent to CO_2 as a greenhouse gas, N_2O is more potent with roughly 300 times the radiative forcing (global warming potential per molecule) of CO_2 over a 100 year time period.

To advance our understanding of CO_2 fluxes, N_2O fluxes and their coupling in response to N loading and climatic conditions such as temperature and soil water content, we developed an integrated system to measure in situ CO_2 and N_2O fluxes in a coastal salt marsh in Cape Cod, Massachusetts. This system consists of recently developed laser-based gas analyzers with the new cavity ringdown spectroscopy technique to measure CO_2 and N_2O. These analyzers will be connected to a closed chamber system that enables flux measurement within a five-minute cycle.

The response of CO_2 and N_2O fluxes to N in the salt marsh site was compared with an upland agricultural site in western Massachusetts, where we measured soil N contents, soil temperature and water contents. We further conducted a soil incubation experiment in the laboratory that includes soils from the salt marsh, the agricultural land, and a forest land. Soil samples were incubated at the combination of temperatures of 10°C, 20°C and 30°C and water contents of 10%, 20%, and 30%. We will then develop a model to simulate CO_2 and N_2O fluxes as a function of C stock, N stock, soil temperature, and soil water content.

Contact Information: Jianwu Tang, Marine Biological Laboratory, 7 MBL St. Woods Hole, MA 02543, USA, Phone: 508-289-7162, Fax: 508-457-1548, Email: jtang@mbl.edu.

SOIL, WATER AND COURSE WOODY DEBRIS RESPIRATION FLUXES AND DISSOLVED AQUEOUS CO_2 IN A TIDAL MANGROVE FOREST IN THE EVERGLADES

Tiffany Troxler[1]*, Jose Fuentes*[2]*, Vic Engel*[3]*, Jordan Barr*[3]*, Victor Rivera-Monroy*[4]*, Robert Twilley*[4] and *Thomas Smith*[5]

[1]Southeastern Environmental Research Center, Florida International University, Miami, FL, USA
2Department of Meteorology, Pennsylvania State University, University Park, PA, USA
[3]Everglades National Park, Homestead, FL, USA
[4]Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, LA, USA
[5]Center for Coastal and Watershed Studies, US Geological Survey, St. Petersburg, FL, USA

Soil respiration in mangrove forests can represent a large carbon (C) loss from soils. Soil respiration can be a function of numerous factors including temperature, root growth, benthic microalgae, invertebrates, duration and frequency of hydrologic inundation, salinity and nutrient availability. In riverine mangroves, the soil compartment is comprised of respiration fluxes from soil, roots (i.e. pneumatophores), course woody debris (CWD), and when inundated, surface water (SW). Carbon dioxide dissolved in surface water with tidal inundation can also be an important and often unaccounted export of C from the mangrove system. Eddy flux measurements provide important Information about whole system respiration, but cannot account for those CO2 fluxes attributed to soil respiration or partition parameters that contribute to the largest sources of sub-canopy CO2 flux. Accounting for variability in CO2 flux rates as a function of inter- and intra-site variability helps to elucidate important factors controlling soil respiration fluxes and mangrove forest C cycling. We are measuring soil carbon efflux rates at the Florida Coastal Everglades LTER sites SRS 4, 5 and 6 to complement ongoing vegetation and eddy covariance monitoring at SRS 6. These sites vary in canopy density and tree size, but also in the extent and frequency of tidal inundation and salinity.

CO2 efflux from soils in riverine mangroves of the Shark River Slough estuary was in the mid-upper range of flux rates for fringe mangroves (~0.5-2.75 µmol m-2 s-1; Lovelock 2008). CO2 flux is subject to between-site variation along a freshwater-saline gradient with sites contrasted by vegetation structure, soil properties and frequency/duration of tidal inundation. Longer tidal duration may have the largest influence over site differences, but salinity may also have an influence on the low soil flux rates at SRS 6.

Within the SRS 6 site, intra-site variability is complex. We were able to determine several sources of variation that influenced CO2 fluxes from the soil compartment (i.e. soil, CWD and SW). CO2 fluxes varied with: 1) component measured within the soil compartment, 2) pneumatophore density and presence, 3) level of inundation, 4) soil temperature, and 5) soil salinity. Concentrations of dissolved CO2 of surface water that inundated the forest soil were comparable to values determined for some peatland catchments (e.g. Billet and Moore 2008; 2-8 mg L-1) but for the short measurement intervals, generally lower.

Contact Information: Tiffany Troxler, Florida International University, 11200 SW 8th St, Miami, FL 33133, United States, Phone: 305-348-1453, Email: troxlert@fiu.edu

NET ECOSYSTEM CARBON EXCHANGE OF MANGROVES: COMPLEXITIES IN DEVELOPING GLOBAL BUDGETS

Robert Twilley
Univ of Louisiana at Lafayette, Lafayette, LA, USA

Mangrove ecosystems are considered a major component of global carbon budgets, with complex exchanges with upland, atmosphere, and coastal subsystems along coastal margins. Updated estimates of carbon flux from sediments and waters of mangroves have implications to the debate on how coastal ecosystems influence the global carbon budget. Several studies have re-assessed global mangrove carbon budgets estimates, using a variety of new techniques in carbon exchange. Based on these assessments, more than 50% of the carbon fixed by mangrove vegetation, estimated at ~217 ± 72 Tg C yr^{-1}, appears to be unaccounted for based on estimates of various carbon sinks (organic carbon export, sediment burial, and mineralization). This missing carbon sink is conservatively estimated at ~112 ± 85 Tg C yr^{-1}, equivalent in magnitude to ~30-40 % of the global riverine organic carbon input to the coastal zone. Some assessments conclude that inorganic carbon flux from sediments and mangrove waters is severely underestimated, and that the majority of carbon export from mangroves to adjacent waters occurs as DIC. The magnitude of this process could be similar to that of the missing carbon sink, and may vary in range among different mangrove systems from muddy coasts to carbonate settings. But several of these studies rely on scaling up 'microcosm' fluxes of carbon at the sediment water interface, and have to account for complex hydrology of both wet and dry periods of that sediment interface. A review will be presented on the complexities of estimating net ecosystem carbon exchange across the multiple boundaries of mangrove ecosystems, with emphasis on how the scaling of techniques to global estimates is critical consideration to conclusions about carbon sinks.

Contact Information: Robert Twilley, Univ of Louisiana at Lafayette, Martin Hall, Lafayette, LA 70504, United States, Phone: 225-279-0353, Email: rtwilley@louisiana.edu

METHANE EMISSION FROM ESTUARINE WETLANDS AND THE EFFECT OF WETLAND PLANT

Dongqi Wang[1, 2], *Zhenlou Chen*[1], *John R. White*[2] and *Ronald D. Delaune*[2]
[1]East China Normal University, Shanghai, China
[2]Luoisiana State University, LA, USA

Methane (CH_4) emission fluxes were measured at the Yangtze estuarine wetland by static closed chamber technique, a subtropical monsoon region of China and characterized by a unique environmental setting. The results showed that CD is the source of atmospheric CH_4, and emission fluxes had significant diurnal and seasonal variation. Annual average CH_4 emission flux at the Yangtze estuarine marsh was about 2.06mg·m^{-2}·h^{-1}, with summer being the main CH_4 emission period. At the bare tidal flat (non-vegetated), annual average CH_4 emission flux was low, about 0.04 mg·m^{-2}·h^{-1}. Compared with the other researches, CH_4 emission from Yangtze estuarine wetland is one of solid natural source of CH_4 budget of China.

At semitropical monsoon estuary, temperature and vegetation growth has rhythm change, which crucially influences CH_4 emission. At Yangtze estuarine tidal flat, 10cmGT and SGT were the strongest predictors for CH_4 fluxes at marsh and bare tidal flat respectively. And Vegetation was the other primary factor that controlled the CH_4 flux during its growing stage. The results of the light and dark chamber comparison and plant shoot-clipping experiment suggest that molecular diffusion and convective gas flow methods were the two main mechanisms of CH_4 transported via *S. mariqueter* plants in July. However, molecular diffusion was believed to be the primary transport mechanism from August to October, with leaf resistance as one of the factors regulating CH_4 diffusion. There was significant correlation between CH_4 fluxes and temperature, especially the 10 cm depth ground temperature (R^2=0.7784). Although sediment organic carbon (OC) content did not determine CH_4 fluxes, net ecosystem production (NEP) was significantly correlated with CH_4 fluxes, suggesting that the photosynthates of *S. mariqueter* effectively provided the substrate for methanogenic bacteria.

Contact Information: Dongqi Wang, Department of Geography, East China Normal University, 3663 Zhongshan Road (N), Shanghai 200062, China, Email: dqwang@geo.ecnu.edu.cn

Now 3165 Energy, Coast and Environment Building, Wetland and Aquatic Biogeochemistry Laboratory (WABL), Department of Oceanography and Coastal Sciences, School of the Coast & Environment, Louisiana State University, Baton Rouge, LA 70803 USA, Phone: 225-578-6430, Fax: 225-578-6423, Email: dongqiw@lsu.edu

NUTRIENT REMOVAL EFFICIENCY AND BIOMASS PRODUCTION OF DIFFERENT BIOENERGY PLANTS IN HYPEREUTROPHIC WATER

*Fengliang Zhao[1], **Wencheng Wang**[2], Xiaoe Yang[1], Hong Li[1], Hongyun Peng [1], Zhenli He[3], Binhe Gu[4], Hong Jiang[1]*

[1]MOE Key Lab of Environmental Remediation and Ecosystem Health, College of Environmental and Resource Science, Zhejiang University, Hangzhou, PR China
[2]Ningbo Drinking Water Source Group Ltd., Ningbo, China
[3]University of Florida, IFAS, Indian River Research and Education Center, FL, USA
[4]Southern Florida Water Management District, West Palm Beach, FL, USA

A recent estimate shows that up to 66% and 22% of all lakes/reservoirs in China have become eutrophic and hypereutrophic, respectively. To prevent water eutrophication and aquatic ecosystem deterioration, cost-effective and sustainable remediation technologies are urgently needed. The development of renewable energy and reduction of greenhouse gas emissions have become priorities in research. Advanced approaches with multiple benefits including the remediation of eutrophic water and the development of bioenergy need to be explored. The aims of this study were: 1) to examine the efficiency of nitrogen and phosphorus removal by different bioenergy plant species growing on floating beds; 2) to evaluate the potential environmental benefits for mitigating CO_2 and SO_2, 3) to assess the potential value of the plant biomass as bioenergy feedstuffs.

The results showed that six energy plant species could grow well in the eutrophic water under floating bed conditions. The annual above-ground biomass yield decreased among the plants in the order: *M. Sinensis Anderss*＞*V. Zizanioides*＞*T. Dealbata*＞*A. Calamus* ＞*Z. Caduciflora*＞*T. Lutarioriparia.* The average removal rates of total nitrogen (TN), ammonium, nitrate, nitrite and total phosphorus (TP) were 48%, 61%, 82%, 92% and 86%, respectively, with *M. Sinensis Anderss and V. Zizanioides* having the highest efficiency in removing TP, ammonium and nitrate. In field experiment, *M. Sinensis Anderss and V. Zizanioides* produced much greater accumulated fresh and dry biomass than other species, with annual biomass production of 3210 g m^{-2} and 2336 g m^{-2}, nitrogen removal of 47.0 g m^{-2} and 19.7 g m^{-2}, phosphorus removal of 25.5 g m^{-2} and 20.0 g m^{-2}, carbon sequestration of 1461 g m^{-2} and 1053 g m^{-2}, sulfur sequestration of 5.8 g sulfur m^{-2} and 5.3 g m^{-2}, respectively. Significant differences were noted among the species in neutral-detergent fiber, acid-detergent fiber, acid-detergent lignin, cellulose, hemicellulose concentrations. *M. Sinensis Anderss* and *V. Zizanioides* have higher cellulose, hemicellulose contents, and therefore can be considered as the best energy plant species for biomass production and nutrient removal from eutrophic water.

Contact Information: Wen-Cheng Wang, Ningbo Drinking Water Source Group Ltd., Ningbo 315195, China, Phone/Fax: 0086-571-88982907, Email xyang571@Yahoo.com

WHY DO RESTORED TEMPERATE PEATLANDS SEQUESTER SO MUCH CARBON? INSIGHTS FROM COMPARING CO_2 FLUXES USING EDDY COVARIANCE, STATIC CHAMBER, AND LEAF EXCHANGE APPROACHES

[1]***Lisamarie Windham-Myers***, [2]*Frank Anderson*, [2]*Brian Bergamaschi*
[1]U.S.Geological Survey, National Research Program, Menlo Park, CA, USA
[2]U.S.Geological Survey, California Water Science Center, Sacramento, CA, USA

Peat-accreting wetlands have the potential to keep elevational pace with sea-level rise, thus providing both adaptation and mitigation for expected rises in atmospheric concentrations of greenhouse gases (GHGs). An experimental restoration of emergent marsh on subsided peat soil of the Sacramento-San Joaquin Delta has generated new "proto-peat" at average rates of 4 cm y^{-1}, nearly 40-times mean sea level rise, storing an average of 1 kg C m^{-2} yr^{-1} since 1997, and over 2.5 kg C m^{-2} yr^{-1} in some locations. Using a nested approach of flux measurements, we sought to establish spatial and temporal patterns of GHG fluxes from which to infer the relative drivers of atmospheric exchange and carbon sequestration. Focusing only on the shallower, most promising 3-ha wetland cell, carbon dioxide (CO_2) fluxes were assessed at three scales during the 2011 growing season. **Leaf-scale** CO_2 and water (H_2O) vapor exchanges were measured with a customized LiCor6400XT system on both tule (*Schoenoplectus acutus*) and cattail (*Typha* hybrid spp.) from May-October 2011. Whole-plant, **plot-scale** ($0.5m^2$) fluxes of CO_2, CH_4, and N_2O were measured for 96 hours in late August 2011 by static chamber methods at three sites along a hydrologic gradient. **Wetland-scale** fluxes of CO_2, H_2O vapor and CH_4 were measured by eddy-covariance techniques from mid-April – December 2011. Intensive monthly measurements of aboveground biomass and leaf area were coupled with remotely sensed data and these time-series maps are currently being used to improve our comparison of GHG fluxes at the leaf, plot and wetland scales. For the 2011 dataset analyzed to date, ambient leaf-level CO_2 exchange was found to be fairly constant and similar between plant species and among sites. Plot-level gross primary productivity (GPP) was primarily a function of photosynthetically active radiation (PAR) and leaf area. Plant-scale estimates of GPP and NPP (net primary productivity, both above and below ground) indicate 1) a high carbon use efficiency for both tule and cattail (NPP/GPP, up to 0.7) and 2) the likely recycling of respired CO_2 back into plant biomass. Initial comparisons of plot-level CO_2 exchange based on both leaf estimates and chamber methods, indicate that microbial respiration represents less than half of the CO_2 efflux, and that night respiration is further limited by low temperatures associated with the "delta breeze". Despite interannual variability from 2000-2011, eddy covariance estimates of CO_2 flux have shown similar patterns to the leaf- and plot-scale data sets, in that 1) the wetland is a net annual sink for CO_2, 2) net ecosystem exchange of CO_2 (NEE) is strongly influenced by aboveground biomass, across site, season, and year, and 3) night-time respiration is a small fraction of daily CO_2 efflux. We will present quantitative tests of these patterns, and discuss the methodological benefits and limitations of these approaches to better understand the processes underlying carbon sequestration and GHG fluxes.

Contact Information: Lisamarie Windham-Myers, National Research Program, U.S. Geological Survey, MS480, Menlo Park, CA 94025 USA, Phone: 650-329-4447, Fax: 650-329-4463, Email: lwindham@usgs.gov

GREENHOUSE GAS EMISSIONS DYNAMICS IN RESPONSE TO ORGANIC MATTER AMENDMENT IN A CREATED WETLAND IN SOUTHEASTERN VIRGINIA, USA

R. Scott Winton and *Curtis J. Richardson*
Duke University Wetland Center, Durham, NC, USA

Addition of organic matter (OM) to created wetlands has been shown to increase soil C, N, P, microbial biomass and denitrification enzyme activity. But few studies have measured its impact on greenhouse gas fluxes. Our objective was to determine how emissions of CO_2, CH_4 and N_2O vary with respect to different loading rates (0, 56, 112, 224 or 336 Mg ha^{-1}) of soil OM amendment. Gas samples were collected from static chambers and analyzed using gas chromatography. Our study site is a created freshwater wetland in southeastern Virginia, USA. Preliminary results suggest that CO_2emission rate is positively correlated with OM loading rate while the opposite trend was observed for CH_4 emission rate. Emissions of N_2O were below detection threshold for approximately 80 percent of gas incubations. High variability of emission rates among plots with the same OM treatment may be attributable to other covariates. For example, lower CO_2 emissions are associated with lower soil temperatures and CH_4 emission rates increased ten-fold following heavy precipitation. We quantify the potential climate forcing exerted by mitigation wetlands that have received organic matter amendments to meet jurisdictional wetland requirements and discuss the implications for wetland restoration/creation practitioners who may be concerned with carbon footprinting.

Contact Information: R. Scott Winton, Duke University Wetland Center, Duke University Nicholas School of the Environment, Box 90333, Durham, NC 27708 USA, Phone: 919-613-8009; Fax: 919-613-8101, Email: scott.winton@duke.edu

AUTONOMOUS GROUND PENETRATING RADAR (GPR) MEASUREMENTS FOR EXPLORING TEMPORAL DYNAMICS IN BIOGENIC GAS RELEASES FROM PEAT SOILS IN THE FLORIDA EVERGLADES

William Wright, *Xavier Comas* and *Gerhard Heij*
Florida Atlantic University Department of Geosciences, Boca Raton, Florida, USA

It has been widely accepted that northern peat soils alone are responsible for up to 10% of methane flux to the atmosphere and act as a net sink for as much as 75% of the global mass of atmospheric carbon. As it has recently been suggested that tropical and subtropical peatlands may have even higher rates of gas production, a better understanding of the processes by which lower latitude peat soils store and release carbon products must be gained in order to more accurately model global atmospheric carbon budgets. Rapid ebullition events of biogenic methane and carbon dioxide gases from peat soils are currently not well understood, particularly since the timing of the releases are poorly constrained. Ground penetrating radar (GPR) is a geophysical tool that has successfully been used in the past to non-invasively investigate the release of biogenic gasses from peat soils with sub-daily frequencies. In the work presented here we expand measurement frequency by collecting autonomous GPR measurements at higher temporal resolutions to investigate biogenic gas dynamics during times of variable atmospheric pressures in peat samples collected from various locations in the Florida Everglades. Geophysical data were supported by both surface deformation and direct gas flux measurements using time-lapse photography. The work presented here has implications for global greenhouse gas budgets by better understanding the temporal variability in greenhouse gas emissions from lower latitude peat soils.

Contact Information: William Wright, Florida Atlantic University, 777 Glades Road, Boca Raton, FL 33431, United States, Phone: 561-297-3256, Email: wwrigh19@gmail.com

CLIMATE CHANGE - HYDROLOGIC PROCESSES AND VARIABILITY

CLIMATE AND VEGETATION HISTORY OF CURRENT AND FORMER CAPE SABLE SEASIDE SPARROW WETLAND HABITAT, FLORIDA EVERGLADES

Christopher E. Bernhardt and *Debra A. Willard*
U.S. Geological Survey, 926A National Center, Reston, VA

Regional climate variability and 20th century land use change have structured the distribution of Everglades wetland vegetation, and also are likely to have influenced faunal habitat and distribution. This study compares the climate and vegetation history of current and former Cape Sable Seaside Sparrow (CSSS) wetland habitat within the Florida Everglades. The CSSS, listed as an endangered species, currently occupies marl prairies on both sides of Shark River Slough. Marl prairies, among the driest of the Everglades wetland types, are short hydroperiods (3-7 months) dominated by sparsely distributed grasses. CSSS currently nest in these dry habitats. However, early 20th century bird censuses document the CSSS in sites other than the current marl prairies, including salt prairie marshes on Cape Sable and wet prairies in Big Cypress.

To reconstruct the vegetation associated with CSSS populations over the last few centuries and millennia, we collected sediment cores in the current and historical CSSS habitat. These cores were described lithologically, and samples were analyzed for geochronology, pollen, and charcoal. Our results indicate that the timing of initial marl accumulation varied, ranging from 2700 to 100 years ago at current marl prairie sites. Vegetation changes and increased charcoal concentrations are coincident with marl initiation, indicating the onset of drier conditions. The most significant vegetation changes occurred during the 20th century where grass and sedge pollen, as well as other indicators of drier conditions, increase. We compare vegetation patterns in current marl prairie sites to those in previous CSSS habitats on Cape Sable and inland of mangrove forests to assess the similarities between historic and modern CSSS vegetation. These data should provide insights into the range of habitats occupied by CSSS both prior to and after significant alteration of Everglades hydrology and guide resource managers in selection of sustainable targets for CSSS populations.

<u>Contact Information</u>: Christopher Bernhardt, Eastern Geology and Paleoclimate Science Center, U.S. Geological Survey, MS926A, National Center, Reston, VA 20192 USA, Phone: 703-648-6071, Fax: 703-648-6953, Email: cbernhardt@usgs.gov

CLIMATE CHANGE AND WESTERN AUSTRALIAN AQUATIC ECOSYSTEMS: IMPACTS AND ADAPTATION

Jane Chambers[1,4], *Frances D'Souza*[2], *Romeny Lynch*[2,3], *Michael Coote*[3] and *Kirsi Kauhanen*[1,4]
[1]Environmental Science, Murdoch University, WA, Australia
[2]Western Australian Department of Water, Australia
[3]Western Australian Department of Environment and Conservation, Australia
[4]National Climate Change Adaptation Research Facility (WA node of Water Resources & Freshwater Biodiversity), Australia

Southwest Western Australia is a global biodiversity hotspot and is recognised as one of the most vulnerable regions to the effects of climate change. The trend of reduced rainfall (50mm/10 years,10-15% decline) and increasing temperature (0.4-0.8º C) in the southwest over the last 30 years provides a "natural experiment" where we can learn about the effects of climate change through analysis of direct, quantified evidence in addition to modeled predictions. This warming and drying climate has many freshwater species and ecological communities already at the limits of survival. Utilising a risk assessment framework, the environmental impact of five stressors: change in rainfall, temperature, sea level rise, change in seasonality (mainly later onset of winter in the south-west) and increase in extreme events (cyclones, storms, floods, drought, bushfire, heatwaves) were considered in four ecosystem types: rivers, estuaries, wetlands and groundwater dependent ecosystems (caves and subterranean habitats). The study utilised contributed research and Information from over 150 aquatic scientists, managers and stakeholders across the state.

Climate change predictions were obtained from the outputs of 15 global climate change models over three scenarios of low, medium and high greenhouse gas emissions. For each ecosystem type, the impacts, vulnerabilities and coping capacity were considered for each stressor and, through risk assessment, the stressors and their primary impacts were rated and prioritised. Current and potential adaptation strategies and policies were identified and recommendations were made for priority management and research projects to address impacts or fill knowledge gaps. This Information was encapsulated in a report card to inform future decision-making by government, science and the community.

Key findings, discussed in this paper, indicate that declining rainfall and runoff have reduced flow in south-west rivers, impacting biodiversity and connectivity. This has been exacerbated by increased temperature. Declining groundwater levels, critical to groundwater dependent ecosystems, have caused the terrestrialisation of wetlands and loss of unique cave fauna. Reduced flows have reduced freshwater flushing, while rising sea levels have resulted in greater marine influence in south-west rivers and estuaries, changing habitat distribution and quality. Saline intrusion, resulting from sea level rise, has the potential for irreversible consequences in northwest coastal freshwater wetlands. Adaptation options seek to increase the resilience of aquatic ecosystems, through reducing adverse impacts of human activities and managing the risks from climate change. Current research seeks to identify hydrological thresholds for functional groups of biota, to be incorporated into a risk assessment tool. The tool will assess the risk of declining water levels to the viability of groundwater dependent ecosystems and inform appropriate adaptation strategies.

Contact Information: Jane Chambers, Environmental Science, Murdoch University, Murdoch, WA 6150, Australia. Phone: +61 89360 2739, Email: J.Chambers@murdoch.edu.au

SHIFTS IN EVAPOTRANSPIRATION DUE TO HISTORICAL WET MEADOWLAND CONVERSION TO AGRICULTURE IN SWEDEN

Fernando Jaramillo[1,2] and *Georgia Destouni*[1,2]
[1]Department of Physical Geography and Quaternary Geology, Stockholm University, Sweden
[2]Bert Bolin Centre for Climate Research, Stockholm University, Sweden

Human induced vegetation changes can modify the hydrological cycle of the regions where they occur. Until recently, the relationship between for instance, agricultural development and major hydrological changes has been difficult to assess. The emergence of new technologies like Moderate-Resolution Imaging Spectroradiometer MODIS helps to give insight into this relationship, but only for recent events. Therefore, historic land use changes happening over larger time scales need to be addressed differently.

In Central Sweden, specifically in the central Norrström basin, agricultural development involved draining wet meadowlands in large scale during the early 20th century, to increase the agricultural acreage. Here we show, by using historic hydrological data series and agricultural Information, how during the period 1900-1930 this large scale land use change and its subsequent agriculture development shifted regional hydrology to a higher evapotranspiration level. As a consequence, freshwater runoff decreased while precipitation increased over the same time period. We confirmed, by water budget accounting in comparison with different empirical evapotranspiration equations, that this change was neither driven by climate - precipitation and temperature - change, nor by any major water storage change in the basin. An inter-basin analysis also supports the hypothesis of agricultural development through wet meadowland drainage affecting hydrology in the way found for the Norrström basin. This implies that regional anthropogenic change drivers, such as agricultural development and intensification, can considerably modify evapotranspiration and thereby also control local-regional hydro-climatic conditions. This further means that interpretations of hydrological responses to the global climate change driver, and in particular distinctions between natural and anthropogenic drivers of observed hydro-climatic change, can be misleading without explicitly resolving also the changes in local-regional anthropogenic land and water use drivers. This paper presents a methodology for such resolution, which can be applied and tested in other parts of the world, to assess the effects of historic land-water use changes on hydrological flow partitioning at the regional scale.

Contact Information: Fernando Jaramillo, Department of Physical Geography and Quaternary Geology, Stockholm University, SE-106 91 Stockholm, Sweden. Phone: +46 8 16 4665, Email: Fernando.jaramillo@natgeo.su.se

EFFECTS OF PEATLAND DRAINAGE ON DISSOLVED ORGANIC CARBON QUALITY AND QUANTITY

Evan S. Kane[1], *John A. Hribljan, Merritt R. Turetsky* and *Rodney A. Chimner*
[1]Michigan Tech. University, 1400 Townsend, Houghton, MI, USA

The concentration of dissolved organic carbon (DOC) in streams generally increases with increasing proportion of peatlands in a catchment. Studies conducted across northern Europe and North America have shown increases in dissolved organic carbon (DOC) in lake and stream water in recent decades. While there is little consensus as to the exact mechanisms for the increases in DOC, hypotheses include increased precipitation variability (increased duration of both drought and flooding), changes in atmospheric deposition, and warming as key drivers. Here, we examine changes in DOC and porewater composition with short term (4 years of experimental drainage in Alaska) and longer term (~70 year old ditching/levee project) drainage in fens. In the short-term water table drawdown experiment, both DOC and total dissolved nitrogen (TDN) concentrations increased with water table variation and a declining water table; DOC concentrations were unaffected in the raised water table treatment. In the long-term drainage study, we observed increased DOC in systems that were exposed to site drainage as expected, but surprisingly we also observed higher DOC concentrations in the impounded (flooded) sites (relative to control reference areas). Flooding appeared to be associated with DOC that was more labile in character (lower $SUVA_{254}$, E4:E6, and DOC:TDN), possibly related to increased algal production, while DOC concentrations in the drained sites more likely increased owing to increased water residence time. We will rely on these two study designs to discuss peat physical properties and water table variation as interactive controls on DOC production and turnover.

Contact Information: Evan Kane, Michigan Tech. University, 1400 Townsend, Houghton, MI 49931, United States, Phone: 906-482-6303, Email: eskane@mtu.edu

PREDICTING EVERGLADES NUTRIENT DISTRIBUTIONS IN RESPONSE TO CLIMATE CHANGE PROJECTIONS

Rajendra Paudel[1,2], *H. Carl Fitz*[1,2], *R.K. Shrestha*[3]
[1]Ft. Lauderdale Research & Education Center, University of Florida, Davie, FL, USA
[2]Soil and Water Science Department, University of Florida, Gainesville, FL, USA
[3]Center for Ocean-Land-Atmosphere Studies, Calverton, MD, USA

Climate change has the potential to greatly alter existing hydrologic and nutrient regimes in the south Florida Everglades because of its low topographic relief, and unique hydrologic conditions. This vast ecosystem, which has been subject to considerable human-induced shifts for more than a century, is now becoming vulnerable to climate change. It is critical to assess the impacts of climate-induced variability on nutrient (particularly phosphorus (P)) movement and distribution in the Everglades ecosystem for its effective restoration. In this study, we investigate sensitivity of total P concentrations in surface waters and soil/sediment in response to the projections of future climate change using Everglades Landscape Model (ELM). ELM integrates processes of hydrology, water quality, soils, periphyton, and vegetation over a decadal time scales, and has been validated against spatio-temporal observations of variables including water levels, chloride, and TP concentrations from many sites in the Everglades region using long-period historical data (1981 to 2000). First, global circulation model (GCM) data are downscaled for the Everglades region in a high resolution grid (i.e. 1 km x 1 km) for approximately 50 years – to 2060, and projected changes in daily precipitation and evapotranspiration are compiled and used as inputs for ELM simulations. Then, we evaluate how changes in these climate forcing translate into changes in hydrological and total P regimes. This analysis is expected to provide useful insights for the effective management of Comprehensive Everglades Restoration Plan (CERP) projects.

<u>Contact Information</u>: Rajendra Paudel, Soil and Water Science Department, 2169 McCarty Hall, University of Florida, Gainesville, FL 32611 USA, Phone: 352-392-1951 ext. 218, Fax: 352-392-3902, Email: rpaudel@ufl.edu

WATER AND PLANTS REGULATE TEMPERATURES AND LOCAL CLIMATE – A CASE STUDY FROM TŘEBOŇ BIOSPHERE RESERVE

Jan Pokorný[1] and *Petra Hesslerová* [1,2]
[1]ENKI, o.p.s. Třeboň, Czech Republic
[2]Czech University of Life Sciences, Faculty of Environmental Sciences, Prague, Czech Republic

Distribution of solar energy in different types of ecosystems of flat and diverse Třeboň Biosphere Reserve was studied during several years in order to quantify energy fluxes and temperature differences caused by vegetation cover and amount of available water.

Earth is an open thermodynamic system receiving solar energy which comes to its surface in daily and seasonal pulses. On dry surface, solar energy is transformed mostly to sensible heat whereas in ecosystems supplied with water most of the solar energy is used for evapotranspiration.

Energy fluxes (net radiation, evapotranspiration, sensible heat, ground heat flux) were calculated from data continuously monitored by meteorological stations located in a wet meadow, meadow, drained field, concrete surface etc. Dry concrete surface showed the highest temperature and highest reflection (albedo), wet meadow and fishpond showed lowest temperature and lowest reflection. The highest rate of evapotranspiration was measured in wet meadow. Our results show that evapotranspiration (i.e. presence of plants and water) is the most important process controlling temperature in landscape. Rate of evapotranspiration reaches value of several hundreds watts per square meter.

A remote sensing method for measurement of surface temperature of land cover was developed using a thermovision camera carried by steerable airship. Daily dynamics of surface temperature in an alder growth, harvested and wet meadow, field, water body, forest and concrete are shown. The difference in surface temperature between dry land and wetland reach value of 20 ^{o}C in midday, whereas the standard measurements of air temperature were similar (differences lower than 1 ^{o}C). Our results show how drainage, surface sealing etc. are linked with a marked increase of surface temperature which is not recorded by the standard measurement of thermodynamic temperature.

Climate change is evaluated on basis of long term temperature data measured as an air temperature. Air temperature differs significantly from the surface (radiative) temperature which is heterogeneous and dynamic and reflects energy fluxes between land surface and atmosphere. That is just a surface temperature which organisms and plants compensate for and influence energy, matter and water flows within ecosystems.

Role of evapotranspiration in regional and continental climate is discussed and compared with the radiative forcing, attributed mainly to an increase of green house gases. Evapotranspiraton has a double climating effect: firstly, it cools environment by intensity up to several hundreds $W.m^{-2}$ when water evaporates and secondly, it warms cool places when water vapour condensates and latent heat is released. Living systems are able to dissipate solar energy and damp heat potentials in order of magnitudes several hundreds $W.m^{-2}$ and regulate fluxes of water between land and atmosphere. There is a difference between water cycle in simple short plant stands and in stands of high biomass and vertical structure. Functioning of forests in water cycling is discussed. An effect of large scale deforestation of Mau Forest in Kenya is described: deforestation resulted in dramatic increase of temperature, decrease of precipitation and less water both in rivers and famous lakes Nakuru, Naivasha.

Contact Information: Jan Pokorny, ENKI, o.p.s. Dukelska 145, Trebon, CZ 37901, Czech Republic, Phone: 420602465099, Email: pokorny@enki.cz

FUTURECASTING EFFECTS OF SEA LEVEL RISE, CLIMATE CHANGE, AND RESTORATION ON INDIVIDUAL SPECIES

Brad Stith[1], *Zuzanna Zajac*[2], *Catherine A. Langtimm*[3], *Eric D. Swain*[4], *Don DeAngelis*[5] and *Melinda Lohmann*[4]

[1]Jacobs Technology, U.S. Geological Survey, Southeast Ecological Science Center, Gainesville, FL, USA
[2]Department of Agricultural and Biological Engineering, University of Florida, Gainesville, FL, USA
[3]U.S. Geological Survey, Southeast Ecological Science Center, Gainesville, FL, USA
[4]U.S. Geological Survey, Florida Water Science Center, Ft. Lauderdale, FL, USA
[5]U.S. Geological Survey, Southeast Ecological Science Center, Coral Gables, FL, USA

Futurecasts of sea level rise (SLR), climate change, and restoration or management scenarios, are becoming available from regional hydrology and downscaled climate models at unprecedented spatial and temporal resolution. These models can generate daunting volumes of forecast data for dozens of environmental parameters, many of which are important determinants of habitat suitability for individual species. There is a growing need to incorporate these forecast data into biological and ecological models, thus providing new tools and additional Information for resource managers and decision makers grappling with uncertainties about future changes to the environment.

As part of a USGS integrated modeling effort focused on the Everglades region, we are developing biological models for several coastal species, incorporating futurecast data from the BISECT hydrology model (see Swain et al.), which models different scenarios of projected SLR, regionally downscaled climate parameters, CERP restoration alternatives, and hurricanes (see Krohn et al.). We used a spatially explicit species index (SESI) approach, developed previously to model a suite of non-coastal Everglades species for the Across Trophic Levels System Simulations project (ATLSS). The SESI models are relatively simple extensions of habitat suitability index (HSI) models, but are spatially explicit and incorporate temporal variation. The SESI approach allows rapid development of biological models without requiring extensive biological datasets, yet can fully incorporate detailed environmental forecast data. The output from SESI models shows changes in potential habitat quality and allows relative comparisons of impacts of different scenarios (sea level rise, restoration, etc.) on modeled species. Quantitative comparisons can be made using difference maps, which are generated by subtracting alternative scenarios from a base scenario.

The usefulness of these scenario comparisons may depend significantly on the levels of uncertainty associated with input model parameters and functions. To better understand these uncertainties, we performed an uncertainty analysis (UA) to assess the propagation of uncertainty within several SESI models. We also conducted a global sensitivity analysis (GSA) to determine the relative importance of model inputs to the overall output uncertainties. We illustrate the GSA/UA approach using SESI models for two species of submerged aquatic vegetation with different habitat requirements. The GSA/UA approach showed which variables were most important to each species, and produced maps of model uncertainty. Maps showing different levels of model uncertainty provide useful Information when comparing scenarios and interpreting results, and help address the growing need for managers and decision makers to consider model uncertainty.

Contact Information: B. Stith, Southeast Ecological Science Center, U.S. Geological Survey, Gainesville, FL 33124 USA, Phone 352-264-3529, Email: bstith@usgs.gov

THE ROLE OF WETLAND IN REGULATING THE HYDROLOGY AND BIOGEOCHEMICAL CYCLING IN HEADWATER WATERSHEDS, SOUTHEASTERN UNITED STATES

Ge Sun[1], *Zhaohua Dai*[2] and *Devendra M. Amatya*[3]

[1]U.S. Forest Service, Raleigh, NC, USA
[2]University of New Hampshire, Durham, NH, USA
[3]U.S. Forest Service, Cordeville, SC, USA

Understanding the hydrologic and biogeochemical processes at a landscape scale requires a close look at the dynamics of the wetland component, a critical zone in watersheds in the southeastern US. Quantifying wetlands' unique role is important in making sound watershed management decisions including designing the Best Management Practices (BMPs) for non-point source pollution control. The role of wetlands in regulating watershed hydrology has long been conceived in the Variable Source Area Concept (VSAC) proposed in the early 1960s: wet areas are the sources of storm flow generation in forested watersheds in the Appalachians. VSAC offers a solid framework that explains the mechanisms of streamflow generation at the watershed scale of headwaters, and provides a basis for developing practices that minimize negative impacts on water resources at the landscape scale. Unfortunately, due to the dynamic nature of the variable source area, a zone that varies across space and time, it is rarely measured and quantified at the watershed scale. This paper reviews the advances of VSAC, and presents findings from watershed hydrology and biogeochemical cycling studies at the Coweeta Hydrologic Laboratory site, Forest Service Piedmont Forest BMPs study sites, and Santee Experimental Forest site that span a physiographic gradient from mountain to the sea in the southeastern US. Our studies suggest that the extent of wet areas is controlled by topography, climate-driven water balances, and soils. Simulation studies show that wetland location in a watershed influences water and nutrient export at the watershed outlet. Wetland temporal dynamics affect the overall carbon fluxes at the landscape scale, and thus ignoring wetlands can cause large errors in estimating the water and nutrient balance and transport, and greenhouse gas fluxes, even for relative a flat landscape.

Contact Information: Ge Su, Eastern Forest Environmental Threat Assessment Center, Southern Research Station, USDA Forest Service, 920 Main Campus Dr., Venture 2, Suite 300, Raleigh, NC 27606, Phone (919)5159498; Fax (919)5132978, Email: Ge_Sun@ncsu.edu

INVESTIGATING HYDROLOGIC SCENARIOS WITH CLIMATE CHANGE AND ECOSYSTEM PROCESS FEEDBACK USING HINDCAST AND FUTURECAST MODELING

Eric Swain[1], *Melinda Lohmann*[1], *Dennis Krohn*[2], *Thomas Smith*[2], *Catherine Langtimm*[3], *Don DeAngelis*[1], *Brad Stith*[3], *Jiang Jiang*[4] and *Ann Foster*[3]

[1]U.S. Geological Survey, Ft. Lauderdale, FL USA
[2]U.S. Geological Survey, St. Petersburg, FL, USA
[3]U.S. Geological Survey, Gainesville, FL, USA
[4]University of Miami, Coral Gables, FL, USA

The intricacies of Everglades hydrology and the strong coupling of ecosystems and changing landscape types have complicated water-management planning efforts. Proper management of natural resources and population concerns requires quantification of the effects of climate change on vegetation dynamics, landscape evolution, hydroperiod, and saltwater intrusion. In addition, historic conditions are important when relating past changes and trends in the Everglades to climate change. Computational tools are needed to create accurate hindcast and futurecast simulations which can be used to make informed water-control management decisions.

The USGS developed the BIscayne SouthEastern Coastal Transport (BISECT) model to simulate Everglades hydrology. BISECT was constructed using the Flow and Transport in a Linked Overland/Aquifer Density-Dependent System (FTLOADDS) simulator, which couples a two-dimensional hydrodynamic surface-water simulator with a three-dimensional groundwater simulator. FTLOADDS accounts for density-dependent salinity transport, and the effects of coastal tides and wind.

Both hindcast and futurecast simulations are run with BISECT to determine the effects of climate and management changes on inundation, salinity, and other important hydrologic factors. The Hindcast models detail the 1926-1932 and 1934-1940 periods, simulating historic storms, precipitation, and sea level. Using automated parameter estimation techniques, model parameters are adjusted to generate model output that matches hydroperiods, which are based on aerial photos that show historic landscapes and vegetation. This yields historic land-surface elevation changes and insight into the water depth and salinity factors controlling coastal mangrove-hammock dynamics. Futurecast simulations are used to predict long-term effects of storm surges on remnant salinity, the results of which are incorporated into dynamic modeling of the shifts in vegetation community populations.

Futurecast simulations with BISECT incorporate downscaled precipitation data from the Community Climate System Model (CCSM), which simulates global-scale climate patterns. Data for the 2038-2041 period was downscaled to a 10 km grid and then averaged over BISECT rainfall zones. Sea-level rise is estimated as 30 cm higher than existing tide. This yields predictions of increased hydroperiods and urban flooding, as well as changes in groundwater and surface-water salinity distributions. The effects of major storm events aggravated by changing climatic conditions may be predicted by incorporating historic storm Information in the futurecast simulations.

Similar futurecast simulations have been constructed with another FTLOADDS application to the Ten-Thousand Islands area. A range of sea-level rise estimates are simulated to determine water-level and salinity value variations. As this area contains several species and habitats of interest, the model results provide input to manatee and oyster models to determine changes in habitat suitability and populations.

Contact Information: Eric Swain, U.S. Geological Survey Florida Water Science Center, 7500 SW 36th Street, Davie FL 33314 USA, Phone: 954-377-5925, Fax: 954-377-5901, Email: edswain@usgs.gov

EFFECTS OF PERMAFROST THAW ON NORTHERN PEATLAND METHANE EMISSIONS

M.R. Turetsky
Department of Integrative Biology, University of Guelph

There has been a renewed interest in northern, high latitude methane emissions because of 1) the recent unexpected increase in atmospheric methane concentrations after a period of stability, 2) large releases of methane in bubbles from arctic thermokarst lakes, and 3) the recent discovery that high latitude soil carbon stocks are much larger than previously recognized. Global inverse modeling shows that Arctic methane emissions increased by 30% from 2003-2007, and that high latitude emissions were more sensitive to warming than water table fluctuations. Arctic wetlands and lakes likely have contributed at least partly to recent increases in atmospheric methane concentrations. Across the circumpolar region, thermokarst associated with permafrost thaw is creating lakes and wetlands that tend to have elevated methane emissions. Here, I will present data on contributions of molecular diffusion, plant-mediated release, and ebullition to ecosystem methane fluxes in a thermokarst bog complex in interior Alaska (the Alaska Peatland Experiment or APEX, http://www.uoguelph.ca/Apex). Interestingly, incubation of peat mesocosms from this site showed that ebullition had a higher Q10 than expected. I also will evaluate the sensitivity of northern wetland methane fluxes to soil temperature and water table based on recent meta-analyses of data from more than 300 sites.

Contact Information: M.R. Turetsky, Department of Integrative Biology, University of Guelph, Guelph, ON N1G 1G2 Canada; Phone: 519-824-4120 ext 56166; Email: mrt@uoguelph.ca

HISTORY AND IMPLICATIONS OF THE NOVEL ECOSYSTEM CONCEPT

Arnold G. van der Valk
Iowa State University, Ames, IA, USA

One of the major emerging issues facing wetlands ecologists and managers is the transformation of wetland ecosystems into configurations that never existed historically. These novel wetlands are the result primarily of the establishment of exotic species, changes in environmental conditions, or both. Novel ecosystems range from hybrid ecosystems that retain many of species found in historic ecosystems to new ecosystems whose species composition has no historic precedent. As novel wetland ecosystems increasingly become the norm, it is becoming more and more necessary to re-evaluate the criteria and standards used for the conservation, management, and restoration/creation of wetlands.

Our current reliance on historic species assemblages as the target for ecosystem conservation, management, and restoration is becoming increasingly unrealistic and impractical. This presentation will review (1) the history of the novel ecosystem concept; (2) lessons learned from studies of novel ecosystems presented during this symposium; and (3) the implications of the novel ecosystem concept for wetland conservation, management. These include changes in wetlands caused by invasive species, eutrophication, altered hydrology, and global climate change. Should we embrace novel ecosystems as those best adapted to current of future conditions or try to eradicate them?

Contact Information: Arnold G. van der Valk, Ecology, Evolution and Organismal Biology, 141 Bessey Hall, Iowa State University, Ames, IA 50011-1020 USA, Phone: 515-294-4374, Fax: 515-294-1337, Email: valk@iastate.edu

COMMUNICATION EDUCATION & OUTREACH - EXTENSION AND OUTREACH

MODERNIZING U.S. NATIONAL STANDARDS FOR THE CLASSIFICATION AND MAPPING OF WETLANDS

Jane Awl[1]*, Bill O. Wilen*[2]*, Lawrence R. Handley*[3] and *John M. Galbraith*[4]

[1]Conservation Management Institute (CMI) and Association of State Wetland Managers (ASWM), Knoxville, TN, USA
[2]U.S. Fish and Wildlife Service, National Wetlands Inventory, Arlington, VA, USA
[3]U.S.Geological Survey, National Wetlands Research Center, Lafayette, LA, USA
[4]Virginia Tech, Blacksburg, VA, USA

This presentation will explore the status of the U.S. Federal Geographic Data Committee (FGDC) 1996 National Wetlands Classification Standard, and 2009 National Wetlands Mapping Standard. The Wetland Mapping Consortium, formed in 2009 in partnership with the Association of State Wetland Managers (ASWM) and Virginia Tech, is assisting in the maintenance and implementation of the national wetlands standards through the development of discussion groups, webinars, training, collaborative tools, and other online resources concerning the technical issues related to wetlands inventory mapping and remote sensing.

The Wetlands Classification Standard is based on "Classification of Wetlands and Deepwater Habitats of the United States" by L.M. Cowardin, V. Carter, F.C. Golet, and E.T. LaRoe, which was published by the U.S. Fish and Wildlife Service in 1979 (FWS/OBS-79/31, 131pp.). A maintenance review of the Wetlands Classification Standard was initiated in 2010 by the FGDC Wetlands Subcommittee. The wetlands classification standard has been newly re-formatted and updated to be consistent with more recent FGDC standards. How these changes may affect the users of the wetlands standards will be discussed.

A key issue identified in the implementation planning for the Wetlands Mapping Standard was the lack of nationally-accepted conventions for creating wetland site names and other stable unique identifiers (such as numbers and codes) to allow individual wetland sites to be more effectively tracked, monitored and reported on over time. Such conventions are needed to enhance system interoperability between federal agencies, states, tribes, and contracted partners, in order to facilitate data sharing at a national scale. Additionally, capabilities for associating wetland geographic data with other data sets (such as water quality and monitoring data) may be enhanced, expanding the possibilities for analysis. The affected wetland science community may benefit from the increased availability of wetland Information for analyzing and identifying solutions to management, conservation and protection issues for wetlands and other water resources. This technical challenge is being investigated in coordination with the maintenance review of the Wetlands Classification Standard and prior to the next maintenance review cycle for the Wetlands Mapping Standard (so more Information may be available when the Mapping Standard is updated). The development of technical guidance on this issue will be discussed.

Contact Information: Jane Awl, Conservation Management Institute (CMI) and Association of State Wetland Managers (ASWM), 422 East Oak Hill Avenue, Knoxville, TN 37917, USA, Phone: 865-607-3149, Fax: 865-637-5713, Email: jane.awl@earthlink.net

URBAN, A CITIZEN-SCIENCE PROGRAM BASED IN HAMILTON, ONTARIO

Patricia Chow-Fraser*, Lyndsay Cartwright* and *Maja Cvetkovic*
McMaster University, Hamilton, Ontario, Canada

Due to increasing urbanization, wetlands and streams within city limits are being altered, filled in and degraded by development. The habitat that remains is critical for providing urban areas with ecosystem services and maintaining biodiversity, yet is often insufficiently monitored. To fill this void, citizen-scientists can contribute valuable ecological monitoring data allowing conservation organizations to track long-term trends, while simultaneously learning more about valuable ecosystems. Urban-Rural-Biomonitoring and Assessment-Network (URBAN) is a citizen-science education and outreach program, founded in 2010 at McMaster University, in Hamilton, Ontario. URBAN has three primary goals. The first is to increase public awareness of aquatic habitats in settled areas of Ontario; the second is to work with existing environmental agencies to develop a long-term monitoring program for urban and rural ecosystems, and lastly, to recruit citizens and students (from high schools and universities) into the volunteer monitoring program. We have created an interactive website, where visitors can learn about the program, the importance of wetland and stream habitat, and train themselves in identifying the species that live in these systems. Volunteers are recruited through a spring workshop every year, where they are informed about the program and how they can get involved. In order to be effective, URBAN works closely with local agencies, to determine which sites should be sampled. Our program incorporates methods from existing successful monitoring programs such as the Marsh Monitoring Program (birds and amphibians), Volunteer Aquatic Plant Survey (McMaster Coastal Wetland Group), and the Ontario Benthos Biomonitoring Network (stream invertebrates). At the end of each season, all data are checked, collated, sent to partners and then posted on the URBAN website. For educational outreach, we visit 2-3 university-level Biology and Ecology classes annually, and in future we will incorporate more elementary and secondary school visits. Thus far, URBAN has presented to 4 high schools, and developed a spring and fall monitoring program with a high school environmental club that is keen in sampling their local stream. Interest in the program is high, and the volunteer database currently consists of 180 citizens. Over the past two years, volunteers surveyed birds at 6 wetlands, amphibians at 15 sites, macrophytes at 4 sites, and invertebrates at 7 streams. At the end of each year, we have an Annual Year-End Reception, where we thank all the volunteers and agencies and host a guest speaker. We continue to evaluate this program based on volunteer retention, overall effectiveness of our educational program, and accuracy of data and their potential usefulness for tracking spatial and temporal changes in aquatic habitats within southern Ontario.

Contact Information: Dr. Patricia Chow-Fraser, Professor, Department of Biology, Director, Life Sciences Program, McMaster University, 1280 Main St. West, Rm LSB 224, Hamilton, ON, L8S 4K1 Canada, Phone: 905-525-9140 ext 27338, FAX: 905-522-6066, Email: chowfras@mcmaster.ca

SCHOOLYARD WETLANDS: CREATING AQUATIC SPACES FOR LEARNING

Charles Andrew Cole
Penn State University, University Park, PA, USA

Schoolyard wetlands are becoming more common in K-12 settings as schools try to increase hands-on learning opportunities for their young students. Such wetlands can vary from natural wetlands nearby or adjacent to a school to wetlands that are created on school property for educational purposes. These wetlands, whatever their type, provide students with an opportunity to study wetland ecology, as well as other disciplines, such as wildlife biology and meteorology, as well as math and writing. Equally important is the opportunity for young students to begin to understand the process of science and learn what it means to be a scientist. In State College, Park Forest Elementary (PFE) developed their first schoolyard wetland in the State College Area School District (SCASD) in late spring 2009. The site – affectionately named "The Penguin Puddle" after the schools' mascot - has proven to be extremely popular with the students, especially as many had helped to plant the wetland. The wetland is being used in classroom exercises as well as part of the school's nature journal writing. The success of the wetland has encouraged other elementary schools within the district to develop their own sites. This project has focused upon instrumenting each of these three schoolyard wetlands with weather stations and soil moisture probes. These systems are then connected, live, to the internet and immediately available to school children in the district and beyond. I will discuss the logistics involved with getting these sites developed, how the schools are using them in their curriculum, and give examples of the types of data provided by this unique set of created wetlands.

Contact Information: Charles Andrew Cole, Department of Landscape Architecture, Penn State University, University Park, PA 16802 USA. Phone: 814-865-5735, FAX: 814-863-8137, email:cac13@psu.edu

MARSH MADNESS: A SCIENCE EDUCATION ADVENTURE FOCUSED ON WETLAND ENVIRONMENTS

***Robert D. Doyle*[1]**, *Melissa Mullins*[1], *Nora Shell*[2], *& Tom Conry*[2]
[1]Baylor University, CRASR, Waco, Texas, USA
[2]City of Waco Water Utilities, Waco, Texas, USA

Baylor University and the City of Waco partnered to develop the Marsh Madness environmental education program at the Lake Waco Wetland (LWW) through our joint Center for Reservoir and Aquatic Systems Research (CRASR). This program started in 2006 and is now in its final year of funding provided through a US DoE GEAR UP grant.

The program utilizes the LWW, a 174-acre constructed wetland that also has a Research and Education Center with classrooms, labs, and an interpretive visitor's center. Our guiding objectives have been to promote a land ethic, to provide rigorous science content to grade-appropriate targets, and to stimulate interest in careers in the environmental sciences. The program included a) Marsh Madness Days [half-day experiential learning experiences for students], b) Saturdays in the Swamp [in-depth teacher training during the school year] and c) Swamp School [intensive teacher training during the summer focused on actual design, execution and interpretation of a research project].

Every semester, a new, field trip exercise was developed and implemented by Marsh Madness staff and volunteers. Exercises focused on biodiversity, water quality, benthic invertebrates and wetland values among many topics. The overall model is that students are **outside** (in the wetland rain or shine) actually **doing science** (not hearing about science) in **small groups** for most of the time. Students learn about careers options during lunchtime talks from area professionals. Each semester, Marsh Madness conducts 20-25 field trips that provide opportunities to approximately one quarter of the eligible cohort within the Waco and La Vega ISDs. The cohort consists of students who were in the 6th and 7th grade in 2006 and are now in the 11th and 12th grades.

The Marsh Madness program has served as a springboard that has allowed us to offer other educational opportunities included Project Webfoot workshops for intermediate school teachers (Ducks Unlimited); Project WET (Water Education for Teachers) workshops; Planning of Wetlands (POW) workshops; Active Strategies for Environmental Education in partnership with the Cameron Park Zoo; Climate Change for Educators in partnership with Baylor's Mayborn Museum; a Leopold Education Project workshop; and Growing Up Wild workshops, among others. The LWW coordinator and volunteers also see students from other schools, colleges and universities, and host scouting and other organizations, from all over the region, nearly every day of the year. Materials developed by the Marsh Madness program are often utilized for these other events.

In 2010, the Lake Waco Wetlands Education Team was proud to be recognized with a Texas Commission on Environmental Quality (TCEQ) Environmental Excellence Award for Education. Additionally, that year the Marsh Madness program received recognition for outstanding service in Environmental Education by the North American Lake Management Society (NALMS).

Contact Information: Robert D. Doyle, Baylor University, One Bear Place #97388, Waco, Texas 76798, USA. Phone: 254-710-2911; Fax 254-710-2969; Email Robert_Doyle@baylor.edu

COMMUNITY-BASED MANAGEMENT OF NON-POINT SOURCES OF POLLUTION

BJ Jarvis
Pasco Cooperative Extension Service, University of Florida/IFAS, Dade City, Florida, USA

Wetlands are impacted each day by a variety of natural and man-made activities. Since wetlands are experiencing tremendous degradation and loss of wetlands all over the globe, all sources of impacts should be investigated and steps taken to minimize and mitigate to the greatest extent possible. Wetlands suffer different types of threats by human populations due to their vast and varied catchments. Urban human activity is a just one of the many activities that impact wetlands.

Although some states and regulators require buffering during construction activities, day-to-day landscape maintenance practices can threaten the well-being of wetlands large and small. Therefore, efficient and effective protection requires long-term management plans not only for the wetlands but for the entire catchment area.

Management strategies should not overlook the very end-user who may inadvertently employ landscape practices that have a negative and significant impact on wetlands. The state of Florida has begun to educate end users in two categories to try to remedy impacts that may impact wetlands directly and indirectly.

Homeowners, landscape professionals and managers of homeowner associations are responsible for more the management of 10 million acres of landscapes in the state of Florida. Landscape chemicals including fertilizers, insecticides and herbicides are introduced into the urban environment. These chemicals can become pollutant runoff without proper landscape practices. As a result, wetland ecosystems can be negatively impacted by these non-point sources of pollution.

Pasco County government in cooperation with the University of Florida and the Florida Department of Environmental Protection has instituted two new strategies to educate the managers of the 10 million acres of urban landscapes. The first initiative provides environmental education to green industry professionals who apply landscape chemicals. Individuals must attend a best management practices course and pass a test to obtain certification demonstrating proficiency in practices that minimize the potential for pollutant discharge. The second initiative is to educate certified property managers who manage the contracts and contractors that provide landscape maintenance to the thousands of acres of residential properties and common areas in homeowner's associations. Through this voluntary outreach, the threat to wetlands is strengthened by minimizing the potential impacts of large development projects.

By educating the decision-makers and the staff that apply the chemicals, a major source of wetland pollutants can be minimized or eliminated. By showing high quality landscapes associated with proper maintenance practices, those involved in the decision-making process can be assured that wise management can equal an attractive landscape and a healthy wetland ecosystem. Wetlands and eco-tourism

Contact Information: BJ Jarvis, M.A., Pasco Cooperative Extension Service, University of Florida/IFAS, 36702 State Road 52, Dade City, FL 33525 USA, Phone: 352-518-0231; Fax: 352-523-1921, Email: bjjarvis@ufl.edu

COOPERATIVE EXTENSION MASTER WATERSHED STEWARD PROGRAM AND WETLAND EDUCATION OPPORTUNITIES

Christopher K. Jones
University of Arizona Cooperative Extension, Gila County, Globe, AZ, USA

Cooperative Extension's Master Watershed Steward (MWS) Program is an adult education program focused on the education and training of citizens to serve as volunteers in the protection, restoration, monitoring, and conservation of their water and watersheds, including wetlands. It is based on the concept of Integrated Watershed Management, defined as the process of sustainably managing water and natural resources, human activities and community livelihoods on a watershed basis. Led by extension educators through the nation's Land Grant University system, each program is tailored to address specific watershed issues that are important at the state and local level. It provides an ideal educational vehicle to raise awareness about wetlands and their values, as well as to train volunteers to advocate and help address wetland issues.

The author has taught the program in Gila County, Arizona since 2003 and also in Guatemala in 2008. The Arizona Master Watershed Steward Program starts with a 10- to 16-week (40-50 instruction hours) course that educates adult students about local watershed and water resources issues. The classes are typically small and highly interactive. They include hands-on lab exercises, specialist lectures, fieldtrips and volunteer service projects. They meet with local resource managers and professionals. In each of the author's courses, he has included sections on riparian areas and wetlands, as well as discussion on the effects of climate upon watershed resources. To become certified Master Watershed Stewards, the students then must serve at least 50 hours in one calendar year as citizen scientists and community steward volunteers. Arizona has trained over 450 Stewards in 25 communities, and they contribute over 2,000 hours of service annually.

A closer relationship between the International Association of Ecology and Cooperative Extension's Master Watershed Stewardship program would be mutually beneficial and assist the protection and sustainable use of this nation's and the world's wetlands.

Contact Information: Christopher K Jones, University of Arizona Gila County Cooperative Extension, 5515 S. Apache Avenue, Suite 600, Globe, AZ 85501 USA, Phone: 928-402-8586, Fax: 928-425-0265,
Email: ckjones@cals.arizona.edu

COMMUNICATION EDUCATION & OUTREACH - KNOWLEDGE TRANSFER TOOLS

IT IS ALL IN THE QUESTIONS: INCORPORATING ARCHEOLOGICAL DATA IN WETLAND STUDIES

Grady H. Caulk and *Cynthia Thomas*
U.S. Army Corps of Engineers, Jacksonville, FL, USA

People have been using and living in the wetland environment for tens of thousands years. The remains left behind in archeological sites include plant and animal remains that can tell us about the past environments. In general archeologist are most often interested in knowing about what people in the past eat and how they lived, as well as the past environments that help explain earlier cultures. The remains in archeological sites include bones from animals hunted for food which reflect both the availability of the animals and their abundance. In addition the animals hunted and intently brought to the site other animals, like mice and voles, are attracted to the sites and become part of the archeological record. Plant remains can be recovered from archeological sites in the form of charcoal from fires along with carbonized food remains; all coming from the local environment. In some cases pollen and phytoliths (microscopic silica plant remains) can also be recovered from the archeological soils or adhering to artifacts.

When conducting archeological research it is important to identify the questions to be asked of the sites. Because this dictates what Information is gathered and analyzed. Basic subsistence and technological Information can be recovered using standard excavation methods. However, to recover plant and small animal remains additional fine screen samples are needed. Pollen and phytoliths require additional sampling techniques.

The Jacksonville District of the U.S. Army Corps of Engineers has been conducting archeological investigations in wetlands across Florida in support of restoration projects for more than a decade. This poster presents a sample of the types of environmental Information contained in archeological sites. This Information is available for use by other wetland scientists for environmental reconstruction and examination of past climate changes. The presenters would encourage interdisciplinary involvement and use of the archeological record.

Contact Information: Grady Caulk, Planning Division, U.S. Army Corps of Engineers, Jacksonville District, PO Box 4970, Jacksonville, FL 32232-0019 USA, Phone 904-234-9070, Fax 904-232-3442, Email: grady.h.caulk@usace.army.mil

WETLANDS INVENTORY AND MONITORING USING CITIZEN SCIENTISTS THROUGH CROWD SOURCING

Lawrence R. Handley[1] and *Catherine M. Lockwood*[2]

[1]U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, USA

[2]CNL World, Chadron, NE, USA

Two dynamic innovative, interactive, searchable websites, the Wetland Classification Imagery Gallery and Calling All Wetlands, designed for use by professionals, academics, and citizen scientists, are tools for viewing, inventorying, and monitoring wetlands and wetland change. Both sites utilize crowd sourcing as an effective mechanism for collecting wetland images and data.

The Wetland Classification Image Gallery, developed by CNL World with input from multiple government agencies, provides a visual framework for classification of wetland habitats. The Wetland Classification Image Gallery is a compilation of wetland images and corresponding Information for the Federal Geographic Data Committee (FGDC) Wetland Classification System. The Gallery provides an image framework of potential wetlands habitats. The intent is to support, update, and add new images as examples to compliment the classification scheme within the *Classification of Wetlands and Deep Water Habitats of the United States.* The general public, government personnel, wetland scientists, geographers, environmentalists, citizen scientists, and other interested parties can contribute to the Wetland Image Gallery.

Calling All Wetlands is a citizen science initiative developed by WETMAAP, a program of CNL World, to create opportunities for informal and formal educators and the community-at-large to collaborate by sharing Information and photographs of wetlands. Calling all Wetlands is an interactive and searchable collection of wetland images and corresponding Information. The collection provides an image framework of wetlands from across the United States and around the World. The intent is to support, update, and add new images of wetlands provided through crowd sourcing. Civic groups, schools, and college programs and departments are encouraged to organize a group effort or project to collect images and Information for addition to the Calling All Wetlands gallery.

Contact Information: Lawrence R. Handley, U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, 70506, USA, Phone: 337-298-1025, Email: larry_handley@usgs.gov

SIMGLADES: A WEB SITE FOR SHARING EVERGLADES ECOLOGICAL MODELING INFORMATION

***Leonard Pearlstine**, Janice H. Lynch* and *Alicia M. LoGalbo*
Everglades National Park, South Florida Natural Resources Center, National Park Service, Homestead, FL, USA

simGlades.org is a new web site maintained at the South Florida Natural Resources Center, Everglades National Park to facilitate rapid dissemination of Everglades ecological modeling Information, programs and documentation for collaborative modeling, among-group communication, and peer-review. It is intended to increase transparency of methods, aid natural resource management and promote continual improvement through a larger community of users and modelers. From the Applications section, users can find summaries and status of models in-development or download applications, documentation and freely distributed open source code. Other sections provide summaries of model output such as weekly-averaged Everglades Depth Estimation Network water depths, restoration scenario results and modeling tools such as an on-line interactive curve plotting utility. simGlades.org continues to expand and is an expression of the South Florida Natural Resources Center's commitment to collaborative research and development of ecological models from shared data and resources.

Contact Information: Leonard Pearlstine, Everglades National Park, South Florida Natural Resources Center, National Park Service, 950 N. Krome Ave., Homestead, FL 33030 USA, Phone: 305-242-4228, Fax: 305-224-4147, Email: leonard_pearlstine@nps.gov

SCIENCE AND CULTURE ON EDU-COMMUNICATION REINVENTION

Michèle Sato
GPEA, UFMT, CPP, INAU, Mato Grosso, Brazil

Under a large and multidisciplinary project called National Institute for Science and Technology for Wetlands (INAU), we are the laboratory 5, related to cultural practices, socio-economy and education. The Environmental Education, Communication and Art Research Group (GPEA) assumes that science has no audience, and need to innovate in their methods of diffusion to be known by society. We assume that there is a quadrant of interaction between science, education, communication and art, and that we must emphasize the role of society, beyond the traditional protagonists of science. In other words, we understand the science needs the audience in its four pillars of edu-communication (education plus communication), which are the essence of “scientific culture”: (I) Production and publication of science (scientists); (II) Science education at all levels (scientists, teachers and students); (III) Scientific dissemination and journalism (scientists, teachers, students, journalists, curators, centres or laboratories); (Iv) Scientific audience (scientists, teachers, students, journalists, curators, centres or laboratories collectively with society, which is the main protagonist). The innovation of edu-communication brings out the last quadrant, which considerers the society as a part of scientific culture that needs to absorb the Information and give response it their way. In this context, the edu-communication requires an intervention that can disseminate scientific Information, promotes the scientific educational process, encourages participatory intervention and finally tries to help small communities of Pantanal Wetlands to improve the quality of life.

Considering the subjects of other laboratories, we link the scientific Information to the process of edu-communication, mainly via art, mental maps and pedagogical materials made by researchers and members of community. It is important to stress the material is not the traditional booklet made only by the researchers with some alien Information and childish draw, but it is made by researchers and community together, and it is contextualised by the local knowledge, personal feelings, perceptions and values. In this sense, phenomenology is the methodology adopted by the group, since it comprises the essence of human subjectivity to understand the world.

Further the scientific Information of other laboratories, 3 sub-projects are carried out under the themes: scientific education at all levels; territory and identities; socio-environmental conflicts; labour and popular economy; law and environmental perception related to birds; and the cultural dimension of Millennium Ecosystem Assessment connected to festivities, canoe, art and mythology. We understand the importance of scientific Information, but public policy needs to be reviewed with care, taking account communities believes and subjectivity. Environmental education does not emphasise only the "science teaching", but advocates for a "DIALOGUE of knowledge" among nature and culture; traditional knowledge and science; rationality and subjectivity; and other binaries which do not belong to the opposition field, but work dynamically with complementariness.

<u>Contact Information</u>: Michèle Sato, GPEA, Federal University of Mato Grosso (UFMT), Pantanal Research Centre (CPP), INAU, National Council for the Development of Science and Technology (CNPq/ MCT), 78060-900, Cuiabá, Mato Grosso, Brazil, Email: michelesato@gmail.com

COMMUNICATION EDUCATION & OUTREACH
- UNDERGRADUATE AND GRADUATE EDUCATION

THE FLORIDA-UNESCO-IHE HYDROINFORMATICS PROGRAM: USING THE EVERGLADES AS A LABORATORY FOR LEARNING

Stan Bronson[1], *Garth Redfield*[2], *G. Ronnie Best*[3] and *Schalk Jan van Andel*[4]
[1]Florida Earth Foundation, West Palm Beach, FL USA
[2]South Florida Water Management District, West Palm Beach, FL, USA
[3]United States Geological Survey, Fort Lauderdale, FL, USA
[4]UNESCO-IHE Institute for Water Education, Delft, The Netherlands

In 2005 a partnership was developed between Florida Earth Foundation, UNESCO-IHE, South Florida Water Management District and the US Geological Survey to bring graduate students from UNESCO-IHE in Delft to Florida using the work being done modeling the wetlands systems of the Everglades as backdrop for enhancing these students understanding of hydroinformatics. UNESCO-IHE is a Type I Center in the UNESCO system and is the largest graduate school in the world dealing strictly in water related disciplines. Students come from primarily developing countries and finish with a MSc or PhD with most of them obligated to go back to their country of origin to help with water challenges. Admission to UNESCO-IHE is done on a competitive testing basis with 200 new students each year chosen from 2000-5000 applicants.

Since the program's first class in 2005 over 120 students have participated in the Florida program which occurs the last weeks of May and first weeks of June. Bronson and Redfield lecture students in Delft before leaving for the United States so they have a good knowledge of what they will be seeing. Students first land in Tampa and spend two days with the USF's Patel Center, looking at water challenges and solutions in the Tampa Bay Region. The group then goes down to South Florida Water Management District for intensive training at the Interagency Modeling Center while taking field trips to Everglades Nation Park and the Kissimmee River Restoration sites. The last two days of their stay have traditionally been with USGS, NPS and USFWS scientists in Fort Lauderdale. Pending logistics approval, the UNESCO-IHE students will attend the INTECOL International Wetland Conference.

Contact Information: Stan Bronson, Florida Earth Foundation, 515 North Flagler Drive, Suite 1500, West Palm Beach, Florida USA, Phone (561) 686-3688, Fax: (561 640-0820, Email: stan@floridaearth.org

THE IMPORTANCE OF MENTORING FOR STUDENT SUCCESS IN THE SCIENCES

Julia A. Cherry
University of Alabama, Tuscaloosa, AL USA

Personal mentors and the transforming experiences that they create for students can have profound effects on career choice, especially among students pursuing careers in science. Once interested in the sciences, strong mentoring relationships can improve student retention and advancement through college and graduate school. Research suggests that successful student mentoring combines professional and personal interaction tailored to the students' needs as well as the proper balance of guidance and autonomy. Professionally, mentors serve as teachers and sponsors who can facilitate networking with other professionals, thereby helping students establish credibility in their field of study. Personally, mentors serve as role models and counselors, enhancing confidence levels among students. In addition, students receiving constructive feedback, encouragement, and empathy from their mentors are often more satisfied with their educational experience, and may be more likely to pursue life-long careers in the sciences. Mentors also benefit from these relationships by experiencing increased productivity and personal satisfaction in their students' growth and success. Structured mentorship programs that offer training and facilitate the development of these relationships can increase retention and career advancement, especially in environments where other barriers to success might exist.

Contact Information: Julia A. Cherry, University of Alabama, Departments of New College and Biological Sciences, Tuscaloosa, AL 35487 USA, Phone: 205-348-8416, Fax: 205-348-1403, Email: julia.cherry@ua.edu

TAKING YOUR SCIENCE TO THE GENERAL PUBLIC: THE EXTENSION MODEL

Mark W. Clark
University of Florida, Gainesville, FL, USA

At a time when the scientific community is investigating ever smaller subatomic particles, unraveling our genetic make-up and gazing ever further into the reaches of our universe, there also appears to be a widening gap between the knowledge accumulating in the scientific community and that which the General Public either understands or believes of the science produced. Although the internet and other electronic media sources provide an unprecedented capacity to disseminate Information, is this an effective means to communicate your science to the general public or policy makers? What are the liabilities of walking the fine line between providing Information that would be important for decision makers to consider without appearing to advocate for a particular outcome which could result in a perceived bias of your science. And what are the incentives (or disincentives) to scientists for bringing their work to the public at large when many academic institutions do not equitably reward this sort of service activity. Some of the challenges in bringing science to the public include the proper context, ample background of your audience to grasp the subject, having a receptive audience and convincingly answering the "why is it important" question. This talk will offer an Extension Specialist perspective of public outreach in the area of Wetlands and Water Quality. It will outline the model that the Cooperative Extension Service has developed to communicate science to the public and offer some examples based on personal experience both as a graduate student and as a recently tenured university faculty.

Contact Information: Mark W. Clark, Soil and Water Science Department, University of Florida, PO Box 110510, 106 Newell Hall, Gainesville, FL 32611-0510 USA, Phone: (352) 352-1803 ex 319, Fax: (352) 392-3399, Email: clarkmw@ufl.edu

INCORPORATING WETLAND DELINEATION SKILLS INTO AN UNDERGRADUATE WETLAND ECOLOGY COURSE

Melody S. Durrett
Department of Biology and Wildlife, University of Alaska Fairbanks, Fairbanks, Alaska, USA

Scientific teaching provides student-centered learning for undergraduate students, resulting in better comprehension and long-term knowledge retention. Yet Wetland Ecology courses take place primarily in the classroom, by way of instructor lectures with perhaps a field trip or two to boost student engagement. After graduation, the student-come-scientist must receive further training in skills such as GPS use and mapping, plant identification, and soil pit interpretation, building upon their classroom knowledge (which they may or may not retain). Why not combine field-based skills training into a Wetland Ecology course? Instead of using local wetlands as a backdrop, why not make them the stage?

I developed a Wetland Ecology course as a 3-credit upper-division summer course in order to use local wetlands as my primary classroom setting. Promotional materials for the course promised to teach students wetland delineation skills, and our primary text was the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Alaska Region (available free online), supplemented by a local plant field guide and primary scientific literature. The six-week course was structured as 3 evening "lectures" featuring student group activities, such as paper discussions, keying plants, and mapping exercises, as well as an all-day Saturday field trip to a local wetland where students practiced in-field determination of wetland borders. Because wetlands compose over 40% of the state of Alaska, we were able to visit a great variety of wetland types within an hour's driving distance of the university, including natural, man-made, disturbed and restored wetlands. The class even participated in an active wetland restoration project. Assessments included a compendium of wetland determination forms from field trips, a plant collection of species with different wetland indicator statuses, a photographic record of soil pits with interpretation, and two field exams testing wetland delineation skills.

By the end of the course, students were able to encounter a new wetland, determine its wetland status by gathering plant, soil, and hydrologic data according to US Corps of Engineers guidelines, classify the wetland according to Viereck's Alaska vegetation classification system and the Cowardin classification system, propose ecosystem services provided by that wetland and probable effects of disturbance on those services, and suggest ways to restore the wetland in the event of a particular disturbance. The students' implicit skills, from filling out datasheets to interpreting signs of disturbance on the landscape, are applicable not only to wetland studies but to any scientific pursuit. These skills also depend upon implicit knowledge, like an understanding of biogeochemical cycles, which is retained far longer when students can comprehend its immediate application.

Contact Information: M. S. Durrett, Department of Biology and Wildlife, University of Alaska Fairbanks, 902 N. Koyukuk Drive, 211 Irving I, Fairbanks, Alaska 99775, USA, Phone: 907-474-7735; Fax: 907-474-7616, Email: msdurrett@alaska.edu

WETLAND GEMS OF AMERICA

William M. Morgante
RK&K, Baltimore, MD, USA

Wetland Gems of America is a new Education and Outreach Committee initiative, sponsored by SWS, that will be debuted by SWS Mid-Atlantic Chapter in early 2012. It aims to increase public awareness and appreciation for wetlands and motivate community commitment to stewardship of high-quality wetlands with statewide, national, and even international importance. Its formation was motivated by the Wisconsin's Wetland Gems program that features 100 high-quality wetlands representative of the diversity of Wisconsin habitat types. Wetland Gems of America will expand Wisconsin's model by creating a state-by-state national wetland inventory accessible online. One of the programs primary objectives is providing an interactive website featuring a national map, linked to state maps from which, users can access one-page descriptions of each wetland. Descriptions will include Information on wetland ecology, flora and fauna, and other significant factors unique to that wetland.

Wetland Gems of America will appeal to academics carrying out wetland research, students wanting to broaden their wetland knowledge, citizens interested in wetlands and/or natural areas, and outdoor enthusiasts. We envision academics and students posting appropriate research for Wetland Gems of America sites and providing links to their research through interactive mapping. We also hope that interested explorers of natural areas will access online mapping and Information about specific sites. When a groundswell of interest is generated for the these wetlands, we believe that community commitment to protection of these unique resources will result.

Wetland Gems of America will support additions to the 30 current Ramsar wetland sites in America by providing a listing of high-quality wetlands by state and generating the interest, energy, and supportive network of people required to champion sites through the lengthy Ramsar approval process.

Contact Information: William Morgante, RK&K, 81 Mosher Street, Baltimore, MD 21217 USA, Phone: 410-462-9174, Fax: 410-728-2834, Email: wmorgante@rkk.com

UNDERGRADUATES PERFORM PROTEIN EXPRESSION PROFILING TO UNDERSTAND ENVIRONMENTAL INFLUENCES ON ESTUARINE ORGANISMS

Terri J. Seron

Flagler College, Saint Augustine, FL, USA

Non-Science Majors are learning about how environmental fluctuations such as temperature, salinity, and dissolved oxygen affect organisms that reside in the local estuary by performing hands-on molecular biology experiments. The students were involved in every aspect of the experimentation from the collecting of organisms with seine nets to the running of the gel electrophoresis equipment. Since the production of proteins are a direct reflection of the active genes within each individual, the students were able to see for themselves how the central dogma of molecular biology (DNA -> RNA -> Protein) can be studied and compared to different individuals as well as different species. The students involved with this project are part of an Environmental Science Minor program that focuses on the ecological understanding of the local environment while also providing opportunities to gain experience with the molecular biology techniques and practices that are giving new shape to Ecology fundamentals.

Contact Information: Terri J. Seron, Natural Sciences Department, Flagler College, 74 King St, Saint Augustine FL 32084 USA, Phone: 904-826-8517, Email: TSeron@Flagler.edu

TEACHING UNDERGRADUATES HOW TO CONDUCT RESEARCH: FROM CONCEPTS TO PUBLICATION

R.M. Strecker and *L.M. Hooper-Bùi*
Department of Entomology Louisiana State University, Baton Rouge, LA, USA

Undergraduate research experiences are important components of undergraduate degrees in science that are frequently overlooked because they are often unrequired. We developed an undergraduate research program that trains undergraduates in all parts of the research process from grant writing to laboratory or field research to publications. This 1-2 year program begins with literature review and identifying a question by the undergraduate researcher. They participate in grant writing and conduct research under close mentoring by scientists. Our students have been awarded between $1500 -$2200 each in competitive research grants for undergraduates. Students are mentored through the data analysis and writing process by the PI. The PI also teaches workshops for underrepresented undergraduate researchers on scientific writing and presentations. Undergraduates participating in our wetland research program produce 1-3 peer-reviewed scientific papers by graduation. Students are encouraged to attend conferences and present talks or posters and are mentored through each step in the process. Each undergraduate participating in our program attends at least one scientific meeting during their time working with our group. Previously, 2-4 students have participated in this research program every year. Because of a recent grant, the program will increase to 6-10 undergraduate researchers.

Contact Information: Rachel M. Strecker Department of Entomology, 404 Life Science Building, Louisiana State University, Baton Rouge, La 70803 USA, Phone: 225-578-7149, Fax: 225-578-7504, Email: Rstrecker@agcenter.lsu.edu

CONSERVATION AND MANAGEMENT

BUILDING UP RESILIENCE FOR CLIMATE CHANGE IN A COASTAL COMMUNITY OF TAMIL NADU, INDIA

Guilherme M. O. Abuchahla[1], *Wilhelm Windhorst*[2] and *Yara Schaeffer-Novelli*[3]
[1]PROCAM, University of São Paulo, São Paulo, Brazil
[2]Ecology Centre, Christian-Albrechts-Universität zu Kiel, Kiel, Germany
[3]Oceanographic Institute, University of São Paulo, São Paulo, Brazil

In today's world the urge for economic growth overwhelms the need to consider sustainable development. In order to ensure the sustainable use of the coastal resources, it is important to facilitate alignment of interests of the many stakeholders over the issue. Several studies stress the importance of applying traditional knowledge in the implementation of ICZM (Integrated Coastal Zone Management) plans within a region (WILKINSON *et al.*, 2006; LINTON & WARNER, 2003; BARBIER, 2007; PONS & FISELIER, 1991; ARMITAGE, 2002). Resilience is a key concept in order to reach sustainability. Sustainability can only be reached when society start conserving coastal ecosystems' productivity capacity and resilience. Given the current uncertainty about climate change and the growth of weather catastrophes, it is advisable to proceed cautiously (CINTRÓN-MOLERO & SCHAEFFER-NOVELLI, 2005).

The coastal community in question is Keezhathottam ("the garden of east", in Tamil), a village situated in the coastal area of Thanjavur, at the estuary of Agni River, within Palk Bay, central Tamil Nadu state. The first stage for building-up resilience for climate change in Keezhathottam was listening to people's priority issues through a free survey carried on by the OMCAR NGO. The second stage was adding climate change to the equation by gathering Information and questioning the population about changes in extreme weather events and related issues. The third stage was the management proposal itself: a DPSIR (Drivers, Pressure, State, Impact and Responses) table was built, leading to seven major proposed measures, e.g., sustainable small-scale forestry and aquaculture, and training programs. The entire management proposal was translated into a structural model, which facilitated the understanding of the proposal and indicated the hierarchy of the several measures.

Contact Information: Guilherme M. O. Abuchahla, PROCAM-USP (Instituto de Eletrotécnica e Energia da Universidade de São Paulo), Av. Prof. Luciano Gualberto, 1289, Prédio MEP, Divisão de Ensino e Pesquisa, sala 16, Cidade Universitária, 05508-010 São Paulo, SP, Brasil, Phone: +5511-3091-3235 Email: abuchahla@usp.br

USING QUALITATIVE FRAMEWORKS AND QUANTITATIVE TOOLS TO OPTIMIZE SHOREBIRD HABITAT AT CABO ROJO WILDLIFE REFUGE, PUERTO RICO

Louise B. Alexander[1]*, Christina A. Drew*[1] and *Jaime A. Collazo*[2]

[1]North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University, USA

[2]USGS North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University, Raleigh, USA

Salt flats are wetlands that dominate coastal zones in many Caribbean islands and constitute essential habitat for resident and migratory aquatic birds. In Puerto Rico, these systems are prevalent along the southern coast, attaining landscape dominance at the Cabo Rojo Salt Flats National Wildlife Refuge located on the extreme southwestern portion of the island. This ecosystem is considered one of the most important habitats in the Caribbean for birds migrating between North and South America. The salt flats are recognized by Birdlife International as an Important Bird Area and provide valuable habitat for more than 40,000 birds annually. By controlling the hydrology of the site, refuge managers wish to maximize high quality habitat for aggregations of migratory aquatic birds To achieve this goal, managers must provide accessible (depth) habitat at the salinity levels that sustain the prey base for the suite of species it purports to support. We used the Open Standards for the Practice of Conservation, a qualitative framework rooted in adaptive management, to guide the elicitation of expert knowledge during two workshops. This framework allowed for the identification of appropriate management strategies define explicit links between planned conservation activities to outcomes, and develop indicators to measure success. We also used a statistical software program, Elicitator, to capture expert knowledge about expected ecological responses of shorebirds to management strategies within a statistical distribution, encode responses to suit modeling methods, and quantify uncertainties. We found these methods helpful in the development of a consistent and transparent process and in the facilitation of the learning process central to adaptive management. We discuss the advantages of our approach in light of the refuge's goals and share how the decision process is informed by these decision-support tools.

Contact Information: Louise B. Alexander, North Carolina Cooperative Fish and Wildlife Research Unit, Department of Biology, North Carolina State University, Raleigh, NC 27695, USA, Phone: 919-513-7337; Fax: 919-513-4454, Email: louise_alexander@ncsu.edu

VEGETATION RESPONSE TO FERAL HOG (*SUS SCROFA*) DISTURBANCE IN SEEPAGE SLOPE WETLANDS

Megan Brown[1] and *Debbie Miller*[2]
[1]University of Florida, Gainesville, FL, USA
[2]West Florida Research and Education Center-University of Florida, Milton, FL, USA

Florida is home to one of North America's most unique and diverse natural ecosystems, the seepage slope wetland. Unusual hydrology and frequent fires have resulted in a habitat that supports a variety of insectivorous and other helophytic herbaceous plants. Feral hog (*Sus scrofa*) foraging has resulted in widespread soil disturbances in seepage slope wetlands on Eglin Air Force Base, in the Florida Panhandle. Rooting by nonindigenous hogs is a serious threat to this community because rooting can degrade primary processes, set back succession, and cause changes in species composition and plant population structure. The potential changes are particularly important in seepage slopes because these wetlands provide increasingly rare habitat for several threatened and endangered plant species. The USDA APHIS Wildlife Services trap hogs on Eglin Air Force Base in an attempt to reduce hog disturbance in the seepage slopes.

This study investigates how varying intensities of hog disturbance influence species composition, richness and the rate of revegetation in Eglin's seepage slopes. Over a three-year period, percent cover of species and functional guilds were estimated at 20 seepage slope sites. Vegetation cover and composition were compared inside and outside wire fence exclosures erected in areas of low, moderate, and intense hog disturbance. This study quantifies the effects of intensity of hog disturbance on the initial rate and trajectory of vegetation development after disturbance. Research, such as this, that monitors the community response to management can be used to direct future management activities to better protect these rare wetland communities.

Contact Information: Megan Brown, Howard T. Odum Center for Wetlands, University of Florida, 100 Phelps Lab Museum Road, P.O. Box 116350, Gainesville, FL 32611 USA, Phone: 352-392-2424; Fax: 352-392-3624, Email: meganbrown@ufl.edu

INCREASING COASTAL WETLAND FISH HABITAT PROTECTION UNDER THE ONTARIO WETLAND EVALUATION SYSTEM

***Patricia Chow-Fraser**, Daniel Rokitnicki-Wojcik* and *Jonathan D. Midwood*
McMaster University Department of Biology, Hamilton, ON, Canada

Within Ontario, a wetland that is designated as "Provincially Significant" receives maximum protection from human development under the law, and the method used to determine such a designation is the Ontario Wetland Evaluation System (OWES). Coastal wetlands provide critical spawning, nursery, and foraging habitat for a wide variety of fish species; yet they are undervalued in the current OWES. Unlike wetlands in the other Great Lakes, the coastal wetlands of eastern Georgian Bay, Lake Huron are typically small (<2 ha) and relatively pristine. Protection of these wetlands is therefore critical to prevent habitat loss or alteration. Unfortunately, the small size of these marshes precludes them from OWES evaluation and protection. To more accurately reflect the importance of these marshes as fish habitat, we propose a series of modifications to OWES. First, we suggest four additional submerged aquatic vegetation growth forms to better represent the diversity of aquatic flora Next, we recommend that vegetated deep-water habitat be included as part of the low marsh habitat to fully incorporate wetland fish habitat. Finally, we recommend that the distance associated with complexing wetlands be increased from 750 m to a minimum of 1400 m. This better reflects fish utilization of wetlands during the summer months. Complexes of wetlands can be created and evaluated if there is a clear biological rationale, or they are within 750-m of each other. Results from a two-year study show that while the vast majority of small-bodied fishes (sunfishes, minnows) remain in a single wetland throughout the year, large mobile predators use multiple wetlands over relatively large areas during the active season. Overall, our modifications represent minor changes to the current OWES, which would provide better protection for fish habitat, especially in the coastal wetlands of eastern Georgian Bay.

Contact Information: Patricia Chow-Fraser, McMaster University Department of Biology, 1280 Main St. W., Hamilton, ON, Canada, L8S4K1, Phone: 905-525-9140 ext 27461, Fax: 905-522-6066, Email: chowfras@mcmaster.ca

HOW TO USE ECOSYSTEM SERVICES FOR WETLANDS CONSERVATION PLANNING IN REMOTE AREAS?

***Jérôme Cimon-Morin*[1,2.3]**, *Monique Poulin*[1,3,4,5] and *Marcel Darveau*[2,1,6]

[1]Laval University, Plant Science department, Quebec, Qc, Canada
[2]Ducks Unlimited Canada, Quebec, Qc, Canada
[3]Quebec Centre for Biodiversity Science, Montreal, Qc, Canada
[4]EDS institute, Quebec, Qc, Canada
[5]Centre for Northern Studies, Quebec, Qc, Canada
[6]Centre for Forest Research, Montreal, Qc, Canada

Humans have altered ecosystems, causing a loss of biodiversity and a diminution of the supply of ecosystem services (ES) in numerous parts of the world. Although the boreal zone of Canada remains barely untouched by human disturbances, the impending increase in environmental pressure from industrial development may degrade or even convert key natural ecosystems, especially wetlands. Within the boreal zone, wetlands are of prime importance because they deliver multiple ES which directly benefit human well-being while supporting unique and vast biodiversity.

In order to maintain wetlands contribution to human well-being, it has been proposed to incorporate wetlands' ES as a conservation target. Despite the high availability of wetlands for conservation in remote areas, questions could be asked about the relevance of using ES for wetlands conservation in these areas for several reasons. First, hotspots of most ES do not concord spatially with biodiversity hotspots. Second, the conservation value for most ES decreases with increasing distance from human population. Third, for most ES, the localisations where they are produced are the same as or near to the ones where they are used. In remote areas, this could lead to conservation choices based on ES acting at the global (e.g. carbon sequestration) or long distance (e.g. water provisioning) spatial scales.

Given the current context, a study was undertaken in a remote part of the boreal region of the province of Quebec in Eastern Canada. The main objectives of this study were to develop a wetland conservation approach that incorporate ES targets in order to optimize network selection and to compare this approach with a more conventional one based on biodiversity representativeness (coarse filter). Mostly represented by peatlands and shallow waters, thirteen wetland types were identified in the study area according to the best available data. Preliminary results suggest that certain types of wetlands are more significant than others with relation to the production of certain ES. Moreover, this indicates that the conservation network is sensitive according to which ES are considered as conservation target. It also suggests that by increasing the number of ES considered, it would be easier to conserve a wetland networks more representative of the biodiversity globally. This poster will further examine if using ES as targets for wetlands conservation planning of remote areas is compatible with biodiversity conservation.

Contact Information: Jérôme Cimon-Morin, Université Laval, Département de Phytologie, Pavillon Paul-Comtois, 2425 rue de l'Agriculture, Québec, Qc, Canada, G1V 0A6, Phone: 418-623-1650 extension: 27; Email: jerome.cimon-morin.1@ulaval.ca

A NOVEL METHOD FOR CAMERA TRAPPING SMALL MAMMALS IN IRREGULARLY FLOODED MARSH ENVIRONMENTS

Melissa A. DeSa[1], *Christa L. Zweig*[1], *Rodney Hunt*[1], *H. Franklin Percival*[2] and *Wiley M. Kitchens*[2]
[1]University of Florida, Florida Cooperative Fish and Wildlife Research Unit, Gainesville, FL, USA
[2]USGS, Florida Cooperative Fish and Wildlife Research Unit, Gainesville, FL, USA

Small mammalian herbivores play important roles in salt marsh environments, shaping their habitat through foraging and serving as prey for numerous marsh predators, including raptors. Typical capture methods for small mammals include regularly checking box-type live traps or track boards/plates. However, in certain, remote environments, using live traps can be deleterious to the study subjects, as visits have to be planned according to environmental restrictions and may not be what is best for the small mammals inside the trap. In the Big Bend area of Florida, irregularly flooded marshes are only accessible with the tides. Daily tidal fluctuations submerge or flip traps, which can be a significant cause of mortality for trapped animals. Tides and other animals, namely crabs, also render track boards useless. There is also a limited trapping season during the cooler months (November through April) as advised by the U.S. Fish and Wildlife Service due to increased chances of mortality from overheating in the hotter months. To meet these challenges, a camera trapping device was designed that could withstand wild hog damage, nuisance animals such as raccoons, and tidal fluctuations. Cameras were used to reduce mortality and possibly extend the sampling period into the summer months since animals are not captured and held. The improved camera traps were tested along with live box traps and were comparable to live traps for occupancy studies.

<u>Contact Information:</u> Melissa DeSa, Box 110485, Bldg 810, Gainesville, FL 32611-0485, USA. Email: mdesa@ufl.edu. Phone: 352-846-0639. Fax: 352-846-0841, Email: mdesa@ufl.edu

LOCAL INSTITUTIONAL ARRANGEMENTS FOR WETLAND MANAGEMENT IN ETHIOPIA AND MALAWI

Alan B Dixon
University of Worcester, United Kingdom

In both Ethiopia and Malawi, wetlands make a critical contribution to food security for poor people in marginal rural areas. However, as the demand for wetland provisioning services has increased, so has the threat of over-exploitation and wetland degradation. One response to this threat, in both countries, has been the development of local institutional arrangements for managing and co-ordinating wetland use. Locally developed institutional arrangements, which incorporate rules and regulations, common values, and mechanisms of conflict resolution, are increasingly regarded as adaptive grassroots solutions to natural resource management problems in developing countries. Since they are rooted in community social capital, rather than in external, top-down decision making, they are seen as being dynamic, flexible and responsive to societal and environmental change and, as such, they promote sustainability. Within this context, this paper examines the potential of local institutions to contribute to the sustainability of wetland ecosystem services, comparing recent field experiences in Ethiopia and Malawi. In particular, the paper explores the various factors which have precipitated the formation of local institutions, ranging from endogenous development to government directives and NGO interventions; it then goes on to explore the subsequent implications of these diverse origins for the functioning, effectiveness, and sustainability of the local institutions themselves. It is argued that local institutional arrangements can and do play a key role in co-ordinating and regulating the use of wetland ecosystem services at the local community level, yet their long-term capacity to do this appears to be strongly influenced by their relationship with external institutions such as government, who facilitate either an 'enabling' or 'disabling' socio-economic or political environment. The paper goes on to discuss some ways in which local institutions that promote the sustainable use of wetland ecosystem services, can be empowered and facilitated within a wider institutional context. The paper makes a key empirical contribution to ongoing debates on the role of local people, their institutions and adaptive capacity in wetland management, and in the wider context, balancing people's livelihood needs with wetland conservation in the developing world.

Contact Information: Alan B Dixon, Institute of Science and the Environment, University of Worcester, Worcester WR5 3UB, UK, Phone: +44-(0)-1905-541257, Fax: +44-(0)-1905-855132, Email: a.dixon@worc.ac.uk.

RECREATIONAL ANGLER PERSPECTIVES OF NONNATIVE FISH SPECIES AND MERCURY ADVISORIES

***Christopher Edwards**, Jennifer S Rehage, Joel Heinen* and *Mahadev Bhat*
Florida International University, Miami, Florida, USA

The purpose of this research is to assess the awareness and depth of knowledge of recreational anglers, concerning their catch of native and non-native fish species and local mercury advisories, in order to determine if awareness is positively correlated with high values for environmental services. A semi-structured personal survey of 500 Everglades canal anglers will reveal how awareness and knowledge of these topics correlates with attitudes towards water quality improvement and native species conservation. A social assessment of these opinions is lacking and questions that reveal voluntary compliance rates of mercury warnings could be useful in determining success of public outreach and health advisories. Largemouth Bass, a native species, is a highly targeted recreational fish which might influence attitudes towards native species conservation. Largemouth bass is also the main fish species that has consistently shown to exceed contamination levels of 1 part per million of mercury, the recommended consumption limit, by up to seven times fold in the surveyed canal. The warning was recently posted in Everglades National Park in 2006, which instructed male anglers to not consume more than one bass per week (6 ounces) and 'do not eat' advisories for child-bearing women and children.

Billions of dollars are spent on freshwater recreational fishing in the state of Florida every year by residents and tourists. Stakeholder perspectives are important to consider when management decisions can affect the quality of public access resources. Local perceptions of nonnative species are useful in implementing efforts to monitor, assess and manage invasive species; this survey method could be duplicated in other countries where valued native fish species are interacting with high numbers of nonnatives. Mercury advisories have been implemented in Florida for decades and recreational anglers may no longer perceive the warnings as a serious threat. I expect that awareness of nonnative species threats and mercury poisoning is low, but that anglers will prefer native species success and low mercury levels after being briefed on the topics. Mercury levels in fish are also increasing globally and are a health concern for many countries. This survey will provide species catch numbers, gauge awareness of nonnative species and mercury advisories, and assess support for management decisions that benefit native species and human health.

Contact Information: Christopher Edwards, Department of Earth and Environment, Florida International University, 11200 SW 8th St, Miami, Florida 33199, USA, Phone: 305-763-4308, Email:cedwa008@fiu.edu

COMPARATIVE STUDIES IN SUPPORT OF SUSTAINABLE MANAGEMENT OF THE PANTANAL AND THE EVERGLADES

Vic Engel[1] and *Paulo Teixeira de Sousa Jr*[2]

[1]South Florida Natural Resources Center, Everglades National Park, Homestead, FL. USA

[2]Centro de Pesquisas do Pantanal (Pantanal Research Centre); Federal University of Mato Grosso - Cuiabá-MT, Brazil

The Everglades and Pantanal wetlands are both responsible for maintaining a rich biodiversity and ecological services essential to maintaining the integrity and welfare of the people living in the respective regions. Despite their great importance, both regions have been suffering from human impacts, although in different degrees, which threaten their integrities.

The Pantanal, the largest tropical wetland in the world, occupies an area of approximately 160,000 km2, divided between Brazil (85%), Paraguay (5%) and Bolivia (10%). Several major rivers drain into the Pantanal wetlands, which are characterized by savanna-type vegetation and more densely forested areas. It presents a complex paleoclimatic history and a predictable monomodal low amplitude flood pulse, with pronounced dry seasons (flood, drought and fire stress). Although European colonization of Brazil began over 300 years ago, conservation efforts in the region have been relatively successful, including the formation of the Pantanal National Park, three Ramsar sites, and other large public and privately-held reserves. The region has also received the title of Human Heritage (UNESCO). However, the accelerated occupation of the Brazilian central-western region within the last 40 years has led to impacts on the Pantanal region, bringing concerns about the ability to maintain the ecological integrity of this region for years to come.

The Everglades are a large (9000 km^2) subtropical wetland located in the southern portion of the state of Florida, and represent the only wetlands in the USA which are covered by both the UNESCO and the Ramsar conventions. A wide variety of habitats are represented in the Everglades, including large expanses of inland freshwater and coastal oligohaline marshes, mangrove swamps, and the offshore benthic communities. As is the case in the Pantanal, the Everglades are characterized by distinct, and often extreme, wet and dry seasons to which the flora and fauna are uniquely adapted. However, the timing, magnitude and quality of seasonal freshwater pulses to the Everglades have been significantly influenced by extensive changes in surrounding land use and water management features, including over 1500 km of canals. At 565,000 ha, the Everglades National Park (ENP) has protected portions of this ecosystem since 1934. However, ENP is located at the most downstream terminus of the system and is thus affected hydrologically by all upstream development. The decades-long effort to restore major portions of the Everglades, including ENP, will attempt to return hydro-ecological functioning to pre-development conditions. The trajectory of human impacts on the Everglades (development *towards* restoration) can thus be considered as a “reverse” analogue to the situation in the Pantanal (conservation *towards* development).

Given the different stages of development and human impacts observed in the Everglades and the Pantanal, the goal of this lecture is to present the recent efforts made by scientists and managers in both regions to establish an agenda for comparative studies that can facilitate the actions of the Everglades restoration on one hand, and conservation of the Pantanal on the other hand.

Contact Information: Vic Engel, South Florida Natural Resources Center, Everglades National Park, 950 N. Krome Avenue, Homestead, FL. 33030 USA, Phone: 305-224-4237, Fax: 305-224-4147, Email: vic_engel@nps.gov

CONSIDERING CLIMATE CHANGE IN STATE WILDLIFE ACTION PLANNING FOR FLORIDA

***Michael Flaxman*[1]**, *Juan Carlos Vargas Moreno*[2] and *Steve Traxler*[3]
[1]Massachusetts Institute of Technology, Cambridge, MA, USA
[2]GeoAdaptive LLC, Cambridge, MA, USA
[3]U.S. Fish & Wildlife Service, Vero Beach, FL, USA

Adjusting state wildlife action planning mechanisms to account for climate change is important to Florida's state wildlife managers because the state is likely to be among the first in the nation to experience significant impacts. Even though some of these changes are long term, they affect many current management actions, notably including cooperative conservation efforts, land acquisition and monitoring.

We present here a pilot study testing one potential approach, which we call "spatial resilience planning" or SRP. This is an extension of scenario planning which uses spatial impact models not only to assess potential impacts, but also to develop new conservation strategies. By simulating what might occur under a wide range of possibilities, strategies can be developed which are robust in the face of exogenous or difficult to predict shocks. This also allows separating out management actions which are needed only under particular contingencies, and which are "no regrets" – useful across a wide range of scenarios.

We undertook to develop and test an application of this method working directly with two critical audiences: wildlife experts who are familiar with details of species ecology, and managers responsible for conservation lands and waters more generally. In consultation with Florida Wildlife Commission (FWC), we selected six species representing a wide range of habitat associations and life history characteristics. We used a facilitated expert workshop approach with heavy technological support in the form of simulation modeling within Geographic Information Systems (GIS). The motivation for this approach was to rapidly and efficiently test the basic steps required, and to do so across a reasonably diverse set of conditions. We understood at the outset that FWC is ultimately responsible for hundreds to thousands of species, and so any method developed must be scalable in order to be effective. Thus our focus was not on creating optimized methods for the six species selected within this pilot, but rather to use the species selected to test the proposed method across a range of conditions.

We came to several general conclusions. The first is that species responses and management options in Florida appeared to cluster into three common groups based on the intersection of species life history characteristics and management contexts. First were a set of species with narrow habitat ranges whose habitat is under severe threat from sea level rise, urbanization, or the combination of both. Second were a set of species persisting mostly within Florida's extensive large conservation areas, such as Everglades National Park. These species are also potentially impacted by climate change, and particularly by sea level rise, but there is room for active habitat management and upslope migration. Third were a set of species whose remaining habitat is reliant on private lands. Many of these have very large habitat range, and the impacts of climate change on them are less certain that those coming from continued rural residential development. SRP appears to be a viable method for developing climate-sensitive conservation plans across these diverse contexts.

Contact Information: Michael Flaxman, MIT, 77 Mass Ave., Cambridge MA 02138 USA, Phone: 617 710-9087, Email: mflaxman@mit.edu or mflaxman@geoadaptive.com

ECOHYDROLOGICAL BACKGROUND FOR THE CONSERVATION OF PANTANAL AND EVERGLADES NATIONAL PARKS

***Pierre Girard*[1]** and *Vic Engel*[2]

[1]University of Mato Grosso/Pantanal Research Center, Cuiabá-MT, Brazil

[2]South Florida Natural Resources Center, Everglades National Park, Homestead, FL. USA

The Pantanal of central South America and the Everglades of south Florida are two large wetlands recognized for their biodiversity, cultural peculiarities and the ecological services they provide. Both Brazil and the US have established National Parks in these wetlands to conserve wildlife and crucial ecological functions for society. Both Parks face problems linked to the utilization of the wetland resources and services for economical development. Human interventions in the Everglades have substantially modified the original landscape. On the contrary development pressures on the much larger Pantanal did not begin until the 1970s, so this system is still relatively pristine compared to the Everglades. Even though distinct, Pantanal and Everglades do share ecological similarities useful to inform management of both Parks. One of the main differences is the marine component of the Everglades system which is not shared by the Pantanal. The Everglades are thus uniquely susceptible to pressures from sea level rise. However, in both wetlands, seasonal water level fluctuations coupled with small-scale, "*micro*" topographic relief assumes crucial importance, controlling habitat distribution, ecosystem productivity, biodiversity and, consequently, the value of ecological services. The *micro*-topographic relief in soil surface elevations also means the distribution and total extent of aquatic habitat expands or contracts significantly with water level fluctuations of only a few decimeters in both systems. In the Everglades, it is well known that interruptions to the natural flood pulses caused by development negatively affect habitat quality and the value of ecosystem services provided by this system, For example, the density of aquatic organisms available for seasonal consumption by higher trophic organisms is known to decrease with annual hydroperiod and with hydrologic connectivity between sub-regions. Variations in the timing and extent of flooding pulses also determine the value of ecosystem services such as the recharge of near-surface aquifers for human uses and nutrient retention. The relatively undisturbed Pantanal, represents a unique source of Information on wetland hydro-ecological functioning that may assist in the development of hydrologic targets for Everglades restoration. On the other hand, Information about Everglades' habitat responses to human disturbances may provide field-based metrics for assessing the more recent human impacts in the Pantanal – such as the construction of elevated roads. Economic valuation of the ecosystem services derived from seasonal flood pulses is seen as a critical step in the conservation of both systems. Methods and research approaches developed in the Everglades for this purpose are likely to contribute to the elaboration of appropriate research strategies that will yield the needed Information in the Pantanal.

Contact Information: Pierre Girard, Universidade Federal de Mato Grosso, Dept. de Botânica e Ecologia, Instituto de Biociência, Av. Fernando Corrêa da Costa, nº 2367 - Bairro Boa Esperança, Cuiabá - MT - 78060-900, Brazil, Phone ;fax: 55 65 3664-1121, Email: pierregirard1301@gmail.com

MAKING WETLAND SCIENCE WORK FOR WETLANDS: PERSPECTIVES FROM THE CONSERVATION COMMUNITY

Melissa A. Samet *Presented by:* ***Jan Goldman-Carter***
National Wildlife Federation, San Anselmo, CA, USA

It is well recognized that sound decisions regarding wetland conservation and management must be driven by the most up to date science available. The conservation community is in constant search of the most up to date science to evaluate the adverse impacts of federal policies and activities on wetlands and to guide the development of new wetland restoration policies. Encouraging the incorporation of sound wetland science into policy is included as a goal in the Society of Wetland Scientists current strategic plan.

Despite the fundamental importance of science, it often appears to plays only a secondary role in decisions that affect wetlands across the United States. Federal decision makers often lack access to the most up to date science or fail to understand the full import of the science they do have. In addition, relatively few scientific studies appear to directly address the issues and questions that must be answered to determine whether on the ground activities and national programs meaningfully comply with existing wetland laws and policies.

Science oriented advocates for wetland and ecosystem protection have first-hand knowledge of the challenges associated with obtaining and relaying critical scientific Information to policy makers. This experience can provide important insight for scientists to consider as they develop research questions and seek to make the most effective use of their findings.

This session will provide perspectives from the conservation community on improving the policy-science connection, including strategies for: effectively using existing scientific research to guide policy decisions; identifying research critical to the analyses required under existing wetland laws and policies and to developing new policies; making scientific conclusions more accessible to decision makers, and working with the conservation community.

Contact Information: Melissa A. Samet, Senior Water Resources Counsel, National Wildlife Federation, 83 Valley Road, San Anselmo, CA 94960 USA, Phone: 415-762-8264, Email: sametm@nwf.org

MINIMUM FLOWS AND LEVELS: BALANCING HYDROLOGIC REQUIREMENTS OF NATURAL RESOURCES AND HUMAN USES

G.B. "Sonny" Hall and *Jane Mace*
St. Johns River Water Management District, Palatka, Florida, USA

The St. Johns River Water Management District's minimum flows and levels (MFLs) method, developed in Florida, USA, has been applied to rivers, lakes, wetlands, and springs. MFLs define the limits beyond which further withdrawals would be significantly harmful to water resources or ecology of an area (s. 373.042, Florida Statutes). The method is applied in a regulatory water management framework to protect aquatic and wetland systems from ecological harm resulting from anthropogenic surface and/or ground water withdrawals.

MFLs are primarily ecologically based. Multiple MFLs, which define a minimum hydrologic regime, are developed for an aquatic system to ensure ecological structure and functions are protected through maintenance of high, average, and low discharge and/or stage conditions. MFLs are expressed as statistical thresholds composed of magnitude (flow and/or level), duration (days), and return interval (years) components. MFLs are implemented with output from hydrologic water budget models that simulate long-term system hydrology (>30 years). The model simulations, which include existing and proposed water withdrawals, are analyzed to determine whether MFL thresholds are achieved.

The method enables water management decisions to be made in an *a priori* and cumulative manner, evaluating how proposed water management decisions might affect system hydrologic conditions and existing legal water users. Additionally, the method can be used to evaluate management options for systems that may be over-allocated or for ecohydrologic restoration projects. The method's conceptual approach and terminology can be used outside of Florida.

Establishment of MFLs for a reach of the St. Johns River in east-central Florida will be presented, emphasizing the development of ecological protection criteria (thresholds) and MFLs implementation and evaluation procedures.

Contact Information: G. B. "Sonny" Hall, Division of Water Resources, Bureau of Water Supply, St. Johns River Water Management District, 4049 Reid Street, Palatka, Florida 32177 USA, Phone: 386-329-4368, Fax: 386-329-4555, Email: shall@sjrwmd.com

CONSERVATION OF NINE PONDS THROUGH THREE DECADES: CONSEQUENCES FOR MARSH VEGETATION

Marjorie M. Holland[1]*, C. John Burk*[2] and *David McLain*[3]
[1]University of Mississippi, University, MS, USA
[2]Smith College, Northampton, MA, USA
[3]Massachusetts Audubon Society, Easthampton, MA, USA

Ned's Ditch, now a part of Arcadia Wildlife Sanctuary in Northampton and Easthampton, Massachusetts, is part of an oxbow that was cut off from the main stem of the Connecticut River about 800 yr BP. Vegetation of the site, which now includes one of the largest stands of floodplain forest in New England, dense stands of buttonbush (*Cephalanthus occidentalis*) swamp and nine scattered ponds, has been studied from spring 1973 through 2007. Fully developed zonation of the ponds includes concentric bands of high marsh which is transitional to the lower strata of adjacent floodplain forest vegetation; mid marsh, a zone of emergent plant species; and low marsh, which supports a variety of aquatic hydrophytes. However, in 1973, before the area was acquired by the Massachusetts Audubon Society, five of the nine ponds lacked zones of high marsh, two lacked zones of mid marsh, and one lacked a low marsh zone. The four high marsh zones were dominated by either royal fern (*Osmunda regalis*), sensitive fern (*Onoclea sensibilis*), wild grape (*Vitis* spp.) or seedlings of floodplain forest trees. Six of the seven mid marsh zones in 1973 were dominated by emergent buttonbush, the seventh by buttonbush and seedlings of ash (*Fraxinus pennsylvanica*). Seven of the eight low marsh zones were dominated by spatterdock (*Nuphar variegatum*), and one by seedlings of willow (*Salix* spp.). Human activities in 1973 at the site included occasional logging for firewood, disposal of wastes including sediments from road construction, hunting, and trapping of resident muskrats.

When Ned's Ditch was acquired by the Massachusetts Audubon Society in 1974, most of these disturbances were halted. Over the next three decades, despite annual fluctuations resulting from periods of flooding or drought, overall plant species richness increased and zones of high, mid, and low marsh developed where previously lacking. In 2004, six zones of high marsh were dominated by royal fern, two by sensitive fern and ash seedlings, and one by seedlings of silver maple (*Acer saccharinum*). Silver maple seedlings had become well established in high marsh at most ponds. Buttonbush continued to dominate seven zones of mid marsh while common duckweed (*Lemna minor*) had greatest coverage in two. Over the study period, spatterdock in the low marsh had largely been replaced by a variety of floating or submerged aquatics, including common duckweed, *Polygonum* spp., watermeal (*Wolffia columbiana*), and elodea *(Elodea nuttallii*). Observed changes in wildlife populations since 1973 include an increase in muskrat populations, the invasion of beavers, which had built a lodge in high marsh in one pond, and the establishment of a breeding colony of great blue herons in the floodplain forest. These changes in wildlife populations may have contributed to changes within the pond vegetation through trampling, herbivory, and nutrient enrichment from the droppings of the herons and beavers.

Contact Information: Marjorie M. Holland, Department of Biology, P.O. Box 1848, University of Mississippi, University, MS 38677 USA, Phone: 662-915-5874, FAX: 662-9155144, Email: mholland@olemiss.edu

DISSOLVED ORGANIC MATTER IN LARGE, SUBTROPICAL, FRESHWATER WETLANDS: A COMPARATIVE STUDY BETWEEN THE PANTANAL, EVERGLADES AND OKAVANGO DELTA

R. Jaffé[1], *K. Cawley*[1], *N. Hertkorn*[2], *C. Nunes da Cunha*[3], *P. Wolzki*[4] and *D. Calheiros*[5]

[1]Florida International University, Miami, Fl., USA
[2]Helmholtz Center, Munich, Germany
[3]Universidad Federal de Mato Grosso, Cuiaba, Brazil
[4]University of Botswana, Maun, Botswana
[5]EMBRAPA, Curumba, Brazil

This study presents the first comparison of dissolved organic matter characteristics in three of the most notable, subtropical wetland ecosystems in the world, namely the Pantanal (Brazil), the Everglades (Florida) and the Okavango Delta (Botswana). Dissolved organic matter (DOM) is ubiquitous to all natural waters and among others contributes to heterotrophic activity, pH control, metal chelation, light penetration and transport of pollutants. Due to the oligotrophic nature of the Pantanal, Okavango Delta, and Florida Everglades, DOM is a potentially important pool of nutrients such as N and P. The organic source material in a watershed influences DOM concentration, chemical structure, reactivity, and bioavailability. However, due to its complex molecular structure still little is known about DOM characteristics, and in particular, comparative DOM characterizations among large freshwater wetlands remain poorly explored.

In this study three large freshwater wetlands from subtropical climates were studied and surface water DOM collected on spatial scales for characterization. For this comparative study, dissolved organic carbon (DOC) concentrations, fluorescence index (FI), which provides Information about DOM source, and excitation emission matrix fluorescence with parallel factor analysis (EEM-PARAFAC) were determined to characterize DOM composition. In addition, several samples from each wetland were further characterized using proton nuclear magnetic resonance (H-NMR) and ultra-high resolution mass spectrometry (FT-ICR/MS). In this study we used a PARAFAC model developed for the Everglades, and although the Everglades-based PARAFAC model worked well to characterize DOM from the Pantanal and Okavango Delta, suggesting a high degree of similarity in DOM composition, our results show clear differences in DOM fluorescence characteristics in the most agriculturally and hydrologically impacted region of the Everglades compared to the pristine Pantanal and Okavango Delta wetlands and ENP. Similarly, the detailed molecular composition of DOM showed some similarities and variations within and among wetlands. Details on DOM composition variability among these wetlands and within them will be presented and ecological implications discussed.

<u>Contact Information</u>: R. Jaffé, Southeast Environmental Research Center, Florida International University, Marine Sciences Building, Room 250C, 3000 NW 151 Street, North Miami, FL 33181, USA, Phone: 305-348.2456; Fax: 305-348.4096; Email: jaffer@fiu.edu

INVASIVE PLANT MANAGEMENT STRATEGIES: INTEGRATING SCIENCE AND MONITORING

***Lisa A. Jameson**, Rebekah E. Gibble* and *Christen A. Mason*
U.S.Fish & Wildlife Service, Boynton Beach, FL, USA

The Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) is the northernmost remaining portion of the historical Everglades, consisting of primarily ridge and slough habitat. The important habitat supports a variety of native wildlife species, including the migratory birds for which the Refuge was established. Despite extensive, ongoing exotic plant control efforts, invasive species such as Old World climbing fern (*Lygodium microphyllum*) and Melaleuca (*Melaleuca quinquenervia*) pose a significant threat to biodiversity. To date, more than $30 million have been allocated to the Refuge for exotic plant control and resulted in significant progress toward established goals. However, rapid re-colonization that is characteristic of invasive species requires routine monitoring and re-treatment. The Refuge incorporated aerial sketch mapping into standard monitoring and inventory methodology in 2009. The ability to map critical infestations has significantly enhanced monitoring and inventory capabilities and aided in the treatment of over 90 percent of mapped Melaleuca populations on the Refuge since 2009.

Aerial sketch mapping identified over 3,471 acres of Old World climbing fern on the Refuge in 2009. However, this technology typically misses low, sprawling infestations due to dense tree canopy cover. The treatment of over 10,000 acres of Old World climbing fern since 2009 reflects this discrepancy. Unfortunately, regrowth in treated areas is high. The Refuge intends to hold a Lygodium workshop with state, federal, non-profit, and private land managers in a cooperative effort to address Old World climbing fern control issues that impact virtually all South Florida natural areas. These efforts are directed at accomplishing multiple goals, including restoring and preserving habitat, improving wetland function, and protecting endangered species.

To build on current successes and keep treated areas free of future invasive plant infestations, new methods of monitoring regrowth (native and exotic) on treated tree islands and of biocontrol activity in untreated areas are being developed and implemented. Methods include permanent photo plots and frequent vegetation surveys. Additionally, a joint project with Florida Atlantic University will address the causes of an observed 'dead zone' around aerially treated stands of Melaleuca. These 'dead zones' have been observed to have very little recruitment of native or exotic vegetation, even multiple years post-treatment. This type of nontarget impact may reduce the desirability of aerial treatments. This project will allow the Refuge to refine methods of exotic plant removal, minimize non-target damage, and establish strict standards for conducting aerial treatments. Plans for research, monitoring, and treatment in the Refuge will be discussed in the context of meeting established Refuge goals and objectives, as well as addressing exotic species issues in the greater Everglades community.

Contact Information: Lisa A. Jameson, U.S. Fish & Wildlife Service, A.R.M. Loxahatchee N.W.R., 10216 Lee Road, Boynton Beach, FL 33473 USA, Phone: 561-735-6025; Fax: 561-369-7190, Email: Lisa_Jameson@fws.gov

THE ROLE OF SCIENCE IN THE MANAGEMENT OF PANTANAL AND EVERGLADES NATIONAL PARKS: JOSE AUGUSTO FERRAZ DE LIMA, PANTANAL MATTOGROSSENSE NATIONAL PARK-BRAZIL AND ROBERT JOHNSON, EVERGLADES NATIONAL PARK-USA

Robert Johnson
Department of the Interior, Homestead, FL, USA

The governments of Brazil and the USA have each established national systems of protected areas because they recognize that the degeneration of native habitats and species is closely linked to a reduced quality of life and societal well-being. In particular, sustainable wetland ecosystems provide many important economic benefits such as improved water quality, furtile soils, pest and disease control, and water supply and flood attenuation. In the case of Pantanal and Everglades National Parks, these protected areas were set aside to preserve a portion of a much larger wetland ecosystem and they have management goals that focus on conserving native biodiversity and protecting and restoring endangered habitats and species.

The Pantanal and Everglades ecosystems represent two examples of large tropical to semi-tropical wetlands that are known for their unique natural habitats and biodiversity. Both ecosystems are impacted to varying degrees from anthropogenic influences resulting from expanding agricultural and urban development. The Pantanal ecosystem is in an early stage of intensive resource exploitation, while Pantanal National Park is in a remote area far from these alterations, with essentially no nearby human habitation and thus represents nearly intact natural habitats and species. By contrast, the Everglades ecosystem has experienced intensive drainage and development for more than a century, Everglades National Park is adjacent to the densely populated greater Miami region, and the park therefore contains many critically endangered natural habitats and species, as well as a large percentage of invasive exotic species. While these two ecosystems represent very different points along a continuum of anthropogenically impacted watersheds, the geographic areas contained in Pantanal and Everglades National Parks represent world-renowned resource areas that are internationally designated as World Heritage Sites, International Biosphere Reserves, and Ramsar Wetlands of International Significance.

Both Brazil and the USA manage national parks to conserve these areas for scientific, educational, aesthetic, and recreational purposes. National park managers have been directed to conduct scientific studies of the natural flora and fauna, the region's geological and cultural characteristics, as well as evaluating the primary threats that could lead to degradation of their resources. Key natural resource studies include evaluations of the structure and function of all of the major habitats and species including native fish, amphibians, reptiles, and mammals, with a special emphasis on rare, threatened, and endangered species. In the case of Pantanal and Everglades National Parks, their international protection designations were designed to safeguard the outstanding universal values of the natural and cultural resources of these areas. Similarly, landscape-scale studies being conducted to define the physical and biological characteristics of the major biomes and ecosystems of the region, and their natural resource management requirements.

The 1997 Partner Park Agreement between the governments of Brazil and the USA has created an opportunity for comparative studies between the Pantanal and Everglades ecosystems. The results of extensive scientific investigations in the Everglades have shown that the greatest threats to the natural resources of this watershed have been alterations in the volume, distribution, and timing of water flows, nutrient enrichment and water quality degradation, and changes in the duration of flooding and drydowns in the wetlands. These specific hydrologic and water quality changes in the Everglades have led to reduced ecological productivity, losses of habitat and species biodiversity via invasive exotic species and urban encroachment. The key comparative studies that are recommended for the Pantanal and Everglades include (1) biogeochemical cycling, (2) the structure of communities of fish, reptiles, wading birds and other upper trophic level consumers, the impacts of nutrients in oligotrophic wetlands, and (3) the role of seasonal hydrologic changes (water flows and depths) related to sediment/nutrient transport and ecological responses.

Contact Information: Robert Johnson, Department of the Interior, 750 N Krome Avenue, Homestead, FL 33157, United States, Phone: 305-972-3639, Email: robert_johnson@nps.gov

INTEGRATING CURRENT RESEARCH INTO MANAGEMENT DECISIONS AT THE ARTHUR R. MARSHALL LOXAHATCHEE NATIONAL WILDLIFE REFUGE

Marcie A.D. Kapsch and *Rebekah Gibble*
U.S. Fish & Wildlife Service, Boynton Beach, FL, USA

The U.S. Fish and Wildlife Service supports and encourages research that provides scientific findings to guide management decisions. Refuge biologists work cooperatively with a number of scientists in other agencies and universities to generate data and synthesize recommendations to support adaptive management in the Refuge. Mechanisms for conducting research on the Refuge include Cooperative Agreements (CESU) with state and federal agencies and Special Use Permits (SUP) with universities. These mechanisms are in place in order to promote sound, high-quality scientific research, technical assistance, and education that aid resource and environmental managers in achieving stated goals. Research approved to be conducted in the Refuge can be used to directly or indirectly address management questions. An example of research directly addressing Refuge management questions include reassessment of the number of fishing tournaments the Refuge can support based on electrofishing data collected in the L-40 and L-39 canals. An example of research indirectly addressing management questions include a project summarizing vegetation patterns and characterizing the physical landscape patterns occurring around established long-term water quality monitoring sites within the Refuge. Information obtained from this project provides additional knowledge about potential factors that may influence observed spatial and temporal nutrient and mineral patterns in Refuge surface water.

Some research supports the development of Refuge-specific performance measures, which is another current goal of Refuge management. Performance measures include specific ecological targets, and can be used to indicate or predict how the system responds to management activities and/or environmental conditions. There are a variety of performance measures routinely used, or in development for, the greater Everglades. However, these PMs are not necessarily appropriate for the Refuge in their current state. An example includes a performance measure for prey based fish densities, which are good indicators of environmental conditions. A goal of Refuge management is to develop Refuge-specific performance measures that establish specific ecological targets, which are then used to make management decisions.

Performance measures developed for the greater Everglades were recently assessed for applicability in the Refuge during the 2011 science workshop hosted by the Refuge. This annual workshop provides a forum for scientists to deliver their research and technical assistance to Refuge resource managers as well as providing the ability to create and maintain effective partnerships among federal agencies and universities to help the Refuge address key management issues. PMs such as periphyton habitat suitability indices, wading bird nesting/foraging patterns, and aquatic prey indices were identified as priorities for development, or modification of existing PMs to make them Refuge-specific. Project proposals submitted to the Refuge that address questions related to the development of these PMs are considered priority projects and will facilitate application of adaptive management strategies in the Refuge.

Contact Information: Marcie Kapsch, Arthur R. Marshall Loxahatchee NWR, United States Fish and Wildlife Service, 10216 Lee Road, Boynton Beach, FL 33473 USA, Phone: 561-735-6039; Email: Marcie_Kapsch@fws.gov

EFFECTS OF FLOW AND NITROGEN ON FILAMENTOUS ALGAE IN FLORIDA SPRING-FED RIVERS

Sean King
University of Florida, Gainesville, FL USA

Many artesian springs and rivers in Florida are experiencing proliferation of filamentous algae and other changes which have led to degraded ecosystem structure and function. Elevated nitrate concentrations have been observed in many springs and therefore alleviation of N-limitation has been suggested as the main driver of algal proliferation. However, past studies concluded that nutrient limitation was not apparent in springs historically when nitrate concentrations were lower than at present, and more recent studies have not found strong evidence that nitrate enrichment is the primary cause. In flowing aquatic systems, nutrient limitation may only occur at relatively low nutrient concentrations due to the continuous replenishment of nutrients from upstream sources. Currently numeric nutrient criteria are based mostly on concentrations of N and P that would theoretically limit algal growth; however in flowing systems nutrient concentrations alone are often not reliable predictors of algal nutrient limitation. This study tests the hypothesis that the nutrient flux (the product of concentration and flow rate) is a better indicator of nutrient availability than concentration, and examines whether it could be a suitable metric for numeric nutrient criteria. Overall the role of flow as a control on filamentous algal biomass in Florida springs and rivers has yet to be thoroughly studied, although it is likely a major driver of algal dynamics. This research focuses on how flow rate affects the growth of filamentous algae, both directly and due to its contribution to nutrient flux. Field and laboratory experiments were conducted to determine the degree to which flow rate, nitrate concentration, and nitrate flux influence the filamentous alga *Lyngbya*. Results to date indicate that flow significantly affects filamentous algal growth in comparison to nitrate levels.

Contact Information: Sean King, Department of Environmental Engineering Sciences, University of Florida, P.O. Box 116350, Gainesville, FL 32611 USA, Phone: 352-256-6667, Fax: 352-392-3624, Email: sking83@ufl.edu

COASTAL WETLANDS OF THE DELAWARE ESTUARY: PAST, PRESENT AND FUTURE

Danielle Kreeger[1,4], *Angela Padeletti*[1], *Tracy Quirk*[2], *Andrew Homsey*[3] and *Kelly Somers*[4]
[1]Partnership for the Delaware Estuary, Wilmington, DE, USA
[2]Academy of Natural Sciences of Drexel, Philadelphia, PA, USA
[3]University of Delaware, Newark, De, USA
[4]Drexel University, Philadelphia, PA, USA

Tidal wetlands are a hallmark feature of the naturally muddy Delaware Estuary, and hence changes in their extent and condition represent excellent environmental indicators of the health of the watershed. Our 2012 "State of the Estuary" analysis indicates that we have lost >50% of our coastal wetlands and probably >95% of the nationally rare freshwater tidal marshes in the upper estuary due to diverse factors that differ among sub-watershed regions. Despite protection, losses continue with a >2% decline in acreage (>2500 ha) between 1996 and 2006. Rapid health assessments also suggest that most areas are at least moderately degraded. Due to projected sea level rise, salinity increases in tidal freshwater and brackish areas, erosion, continued development, nutrient loadings, subsidence, and possibly sediment deficits, and other local factors, we are projecting a net acreage loss of between 25 and 75% by 2100. If realized, the reduced wetland area will impair system resilience due to reduced flood protection, fisheries and wildlife support, water quality support, and more.

If sustained, a new multilevel Mid-Atlantic Coastal Wetland Assessment (MACWA) will allow us to track continued changes around the estuary, understand their causes, and provide critical Information for coastal managers to help stem continued degradation and losses with implementation of new best management practices and strategic adaptation projects. MACWA consists of fixed monitoring stations (Level 4), scientific studies of cause-effect relationships (Level 3), rapid assessments of condition and stressors (Level 2), and all within a landscape context tracked with remote sensing (Level 1). Baseline physical and biological data from new monitoring stations and selected rapid assessment results will be contrasted among representative watersheds in Delaware, Pennsylvania and New Jersey to highlight some of the most important current stressors in this nationally significant Delaware Estuary.

Contact Information: Danielle Kreeger, Ph.D, Science Director, Partnership for the Delaware Estuary, 110 S. Poplar St, Suite 202, Wilmington, DE 19801 USA, Voice 302-655-4990 / Fax 302-655-4991, email: dkreeger@delawareestuary.org

INSIGHTS INTO THE MANAGEMENT OF WETLANDS UNDER DISTURBANCE FROM EXPERIMENTAL AND THEORETICAL MODELS

Seungjun Lee
University of Florida, Gainesville, FL, USA

Wetlands are among the most productive ecosystems. Like other ecosystems, structures and processes of wetlands are frequently or infrequently altered by natural or anthropogenic disturbances. Since the productivity of a wetland is likely to be influenced by disturbance regimes in the region, understanding productivity patterns under variable disturbance regimes is critical for better restoration and management of wetlands. This study investigated the effects of disturbances on the productivity of systems using aquatic microcosms and simulation models. In the microcosm study, I observed five different disturbance-productivity relationships and these variable relationships were attributed to the different initial states of the microcosms under the same input sequence of test schemes and disturbance regimes. The microcosm study provided insights regarding restoration and management of ecosystems including the insight that initial seeds for restoration of an ecosystem should be carefully selected in consideration of typical disturbance regimes of the region. It was also suggested that consideration or manipulation of disturbance regimes in each successional stage is sometimes needed for maximum productivity or a designated goal of a restoration project because self-organizing patterns that result under disturbances vary depending on a system's maturity. The results of the microcosm study and their mechanisms were explained by simulation models. In the simulation model study based on an energetic perspective, I hypothesized that disturbances differentially alter the intrinsic rates of energy pathways in a system, and that there is a disturbance threshold where response of the intrinsic rates changes abruptly according to the alternative stable state hypothesis. Simulation results showed variable patterns of gross primary productivity under the diverse scenarios of disturbance effects on the intrinsic rates. Simulation results confirmed that the second hypothesis (i.e., disturbance threshold) was essential to obtain the variable disturbance-productivity relationships observed in the microcosms.

Contact Information: Seungjun Lee, University of Florida, 116 Phelps Lab., Museum Rd., Gainesville, FL 32611, USA, Phone: 352-392-2426, Email: slee@ufl.edu

SPECIES DISTRIBUTION MODELS FOR INVESTIGATING POTENTIAL CHANGE IN FLOODPLAIN VEGETATION IN LARGE FLOOD-PULSED TROPICAL WETLANDS

***Michael Murray-Hudson*[1]**, *Piotr Wolski*[1], *Mark T. Brown*[2] and *Thomas Davidson*[3]

[1]Okavango Research Institute, University of Botswana, Maun, Botswana

[2]Howard T. Odum Center for Wetlands, University of Florida, Gainesville, FL, USA

[3]Dept Biosciences, Aarhus University, Copenhagen, Denmark

Spatial ecological models of large wetland systems are important tools for evaluating system response to changes in allogenic variables, in particular hydrological inputs, which can be substantially changed by manipulation for water supply or hydropower, or as a result of climate or land use change. Here we present an approach using multiple probabilistic species distribution models for floodplain macrophytes. These are based on empirical relationships with flood duration, and constructed as cellular modules in a spatial ecological model for a data-poor large wetland system.

A suite of 27 indicator species was identified for floodplain classes in a seasonally pulsed distributary of the tropical Okavango Delta, based on a field survey of 30 floodplains (Murray-Hudson et al, 2011). Spatial hydrological history was constructed from remote sensing. Duration-species frequency relationships from constrained ordination of these data were used to derive species-hydroperiod distributions through general linear modeling (GLM). The GLM model parameters were then used to construct a statistical multi-species model driven by flood duration data from a spatial hydrological model, which generates monthly inundation duration for each 1km^2 cell for given annual inflows. Tests of model performance against an evaluation set of 5 floodplain sites showed an average of 87% correct predictions of species presence, and 69% of species absence. Predictions of frequency of occurrence were almost always lower than observed frequencies. The modeled distribution fits of most species were generally robust (18 GLMs with significance $p < 0.05$).

A limited number of future scenarios of basin development and climate change were simulated, based on modifications of the historic 42-year inflow record. Modeled outputs were aggregated in a rule-based model using average duration optima for 4 seasonal floodplain communities. The results of simulated effects of climate change were greater than any of those resulting from potential anthropogenic development activities in the basin. The simulations are intuitively credible, and test site compositions were predicted well, but further validation based on temporal change will improve confidence in the model. In addition, more data on species distributions at the upper end of the duration range are needed to improve GLM fits.

Contact Information: M. Murray-Hudson, Okavango Research Institute, Private Bag 285, Maun, Botswana Phone: +267 6817232, Fax: +267 6861835 Email: mmurray-hudson@ori.ub.bw

DEFINING WETLAND HEALTH: A FOUNDATION FOR CONSERVATION PLANNING

Erica J. B. Gaddis, J. Hope Hornbeck, ***Brian T. Nicholson*** and *B. Eric McCulley*
SWCA Environmental Consultants, Salt Lake City, UT, USA

Great Salt Lake is one of the most ecologically important and least understood natural resources in Utah. The lake and the wetlands surrounding it are of worldwide importance for migratory bird populations. It is influenced by an array of environmental and human factors resulting in a dynamic and complex web of habitats and human interaction. The complexity of the Great Salt Lake system coupled with hydrologic modifications and the effects of surrounding land use has challenged managers to define what is “good” for the lake and what is meant by “health.” Without clear definition of health and framework for evaluation of current condition and future use of the lake, there remains a gap between conservation initiatives and the type and magnitude of stressors which they seek to counteract. In response to the need to better measure conservation effectiveness and address stresses to the lake, The Great Salt Lake Advisory Council sponsored a project to develop a definition of health for the lake using components of the Conservation Action Planning (CAP) Process, originally developed by The Nature Conservancy. The process relies on facilitated workshops involving a panel of scientists to identify ecological targets at the core of conservation, key ecological attributes that affect those, and measurable indicators of their “health.”

Within the GSL CAP framework the panel established ecological targets, identified threats to these targets, and used Level I-III monitoring data to allocate a health status (poor, fair, good, or very good) to the ecological target. Wetlands surrounding Great Salt Lake are an integral component of Great Salt Lake health that regulate both water quality and quantity in addition to providing habitat for migratory birds species of regional and hemispheric importance. The various types of wetlands around the lake are ecological targets in the GSL CAP framework for which the panel identified species of special concern (e.g. migratory shorebirds) and other key elements of biodiversity. These elements play an important role in trophic interactions and require a broad spectrum of habitat conditions within the ecosystem. The condition of the ecological targets is measured by assessing specific indicators for a set of key ecological attributes. For example two key attributes of the condition of the wetlands are hydrologic regime and macroinvertebrate populations supportive of avian groups. Indicators of these attributes are inundation duration and timing and biomass, respectively, and each are rated poor to very good. The definition of health specific to GSL specific wetland habitats, resulting from the CAP process, will help to conserve the remaining wetlands (approximately 35% have been lost since the 1850s), allow for more targeted monitoring, measure conservation effectiveness, and prioritize restoration opportunities and conservation strategies.

Contact Information: Brian Nicholson, SWCA Environmental Consultants, Salt Lake City, UT 84111 USA, Phone: 801-322-4307, Fax: 801-322-4308, Email: bnicholson@swca.com

LANDSCAPE ECOLOGY APPROACHES FOR THE CONSERVATION OF PANTANAL AND EVERGLADES VEGETATION

C. Nunes da Cunha[1] and *J.Richards*[2]
[1]Universidade Federal de Mato Grosso, Cuiabá, MT, Brazil
[2]Florida International University, Miami, FL, USA

The Everglades and Pantanal are subtropical wetlands of global importance, each shaped by marked seasonal variations in hydrology representing variations on flood pulse systems. Both are relatively young ecosystems, although the Everglades wetlands have been influenced by sea level rise and fall, while the Pantanal wetlands have been more affected by variable climatic regimes. Both are threatened by anthropogenic activities, with the Everglades having undergone major alterations to hydrologic regime as a result of drainage and compartmentalization and the Pantanal being endangered by similar alterations.

Different basin geomorphology and hydrologic inputs have led to contrasting landscape formations in the two systems, although they both are characterized by large-extent, flat, nutrient-poor wetlands. The Everglades are a shallow basin surrounded by the ocean. This geomorphology and flow regime produced a patterned ridge-slough-tree island vegetation oriented parallel to flow but lacking major channels. The Pantanal is an floodplain ecosystems surrounded by uplands, flat basin. Highly seasonal rainfall combined with the flat basin create a downstream region that floods spectacularly and seasonally, with interannual variation in flooding combined with microtopography to produce great heterogeneity in vegetation. Vegetation of both the Everglades and the Pantanal consist of different forest types, scrublands, floating-leaved, emergent, free-floating and submerged aquatic macrophyte communities, and natural and, in the Pantanal, man-made savannas.

Water depth, hydroperiod and water quality are major drivers of plant community type and composition in both of these wetlands. Thus, human activities that alter hydrologic regime and change nutrient input are conservation threats in both ecosystems. Nutrient inputs from surrounding agriculture are problems in both the Everglades and Pantanal, while upstream deforestation and the resulting increased sediment loading threatens downstream habitats in the Pantanal. Fire has a natural role in shaping plant communities in both ecosystems, but the role of this driver is not fully understood in either. Increased drainage, however, increases fire frequency in both and may account for and increased spread of woody species such as willow in the Everglades and cambará in the Pantanal. In both ecosystems, increased human activity and environmental disturbance have led to exotic plant invasions, e.g., *Melaleuca quinquefolia* (Everglades) and *Brachiaria subquadripara* (Pantanal).

Wetland plant communities are dynamic habitats that respond to intra-annual and interannual hydrologic variation. Understanding the interdependence of wetland plant communities is essential to support wetland biodiversity conservation. Although the Pantanal and Everglades have different plant communities, they share many plant community types that will be similarly affected by environmental changes. Shared knowledge about trajectories of plant community change in response to environmental change in both the Everglades and the Pantanal can guide management, land use and conservation strategies. The Everglades-Pantanal Initiative is a collaboration between Brasilian and US researchers that seeks to provide this dialogue.

Contact Information: C. Nunes da Cunha, Depto Botânica e Ecologia, UFMT, INCT-Wetlands, Cuiabá, MT Brazil, 78060-090, Phone: 0055-65-36158896, Fax 0055-65-36158878: Email: catianc@ufmt.br

RETHINKING ADAPTIVE MANAGEMENT AS A SCIENCE-POLICY BRIDGE: HOW DO WE ENGINEER THE BRIDGE?

Rachel Pawlitz
University of Florida, School of Natural Resources and Environment, Gainesville, FL, USA

Conventional wisdom among ecologists is that adaptive management (AM) is a novel resource management approach because it embraces uncertainty and promotes learning by doing through an iterative cycle of analysis and reflection. From a theoretical perspective, little differentiates this philosophy from other theories of science in the policy process, which have been critiqued for failing to address the role of problem framing, promote transparent expert involvement, and link research directly to policy problems.

This study examined two decades of attempts to craft adaptive solutions to an ongoing water conflict in the Apalachicola-Chattahoochee-Flint river basin, tracking solutions that were based on adaptive management and comparing them to alternatives that existed to those adaptive approaches. The findings suggest the importance of adequate forums for engaging the right combination of stakeholder or scientific investigations that balance specific issues affecting those stakeholders with sound theory and interpretation by experts. This suggests if AM is to bridge science and policy, initiatives must be designed to engage the right types of actors, provide adequate forums for these actors to discuss science needs, and use research strategically to bridge gaps between ecological theory and practical problems.

Contact Information: Rachel Pawlitz, USGS Southeast Ecological Science Center, 7920 NW 71st Street, Gainesville, FL, USA, 32653, Phone: 352-264-3554; Fax: 352-378-4956, Email: rpawlitz@ufl.edu

CONCEPTUAL MODEL OF HUMAN AND NATURAL SYSTEMS INTERACTIONS IN THE AGRICULTURAL AND RANCHING AREAS IN THE EVERGLADES AND PANTANAL

Elise V. Pearlstine[1] *Rena R. Borkhataria*[1] and *Scott Markwith*[2]
[1]University of Florida, IFAS, Belle Glade, FL, USA
[2]Florida Atlantic University, Boca Raton, FL, USA

Conceptual models allow scientists to communicate complex environmental, social and ecological concepts to a variety of audiences for planning, communication and assessment purposes. They identify major drivers and stressors in natural systems, delineate linkages between components of the system, and identify the ecological effects and measurable attributes of the system that can be monitored for change caused by stressors or management and restoration. The Everglades is an impacted wetland in south Florida that is the object of the largest restoration effort in history, detailed in the Comprehensive Everglades Restoration Plan (CERP). Models have been developed for 11 regions in the Everglades and for the total system to assist with this restoration, but none have focused on the ranching and agriculture dominated regions. The existing models have been critical as Everglades restoration progresses for this globally significant wetland. The Pantanal of Brazil is another immense wetland of global importance and is at danger from human impacts including land clearing, hydrological alteration, climate change and agricultural intensification. The Everglades Pantanal Initiative is a group of scientists working collaboratively in Brazil and Florida with the goal of using commonalities between these regions to better understand conservation and management needs for these wetlands. Some common stressors in these wetlands include overgrazing, land conversion, impoundment and water use, erosion, recreational and subsistence fauna harvest, and competition and predation from introduced species. Climate change, present and future, also has high potential for adverse impacts to both areas. The main contrast between the two areas is relative impact of agricultural activities. In Florida, agriculture is fairly intensive, consisting of row crops, sugarcane and cattle operations. In the Pantanal, cattle ranching is a traditional activity that most landowners maintain as a low-density operation. Most land is privately owned with some federal and private reserves. These similarities and differences can both be used to formulate and refine conceptual models for human-influenced landscapes in both ecosystems.

Contact Information: Elise V. Pearlstine, University of Florida, IFAS, Everglades Research and Education Center, 3200 E. Palm Beach Rd., Belle Glade, FL 33430, USA, Phone: 954-608-3611, FAX: 561-993-1582, Email: epearls@ufl.edu

HABITAT USE BY WILDLIFE IN AGRICULTURAL AND RANCHING AREAS IN THE PANTANAL AND EVERGLADES

Julio Souza[1] and ***Elise Pearlstine***[2]

[1]Universidade Federal de Mato Grosso do Sul, Aquidauana, Brazil

[2]University of Florida, IFAS, Belle Glade, FL, USA

The Pantanal contains approximately 140,000 km^2 of wetlands and is located in Brazil in the central portion of South America on the border with Bolivia and Paraguay in the central part of the Upper Paraguay River Basin. Most of the Pantanal wetlands are privately owned and used for cattle ranching, although some are considered reserves, and there are small areas of protected national parklands. The Everglades of south Florida are natural wetlands with national and state protected lands in the southern end and agriculture and cattle ranching mixed with protected lands to the north surrounding Lake Okeechobee. Conversion of natural Everglades habitat to farming and ranching have heavily impacted the remaining protected areas in south Florida and the area is the target of restoration efforts on both state and national levels. In contrast, the Pantanal has a long history of co-existence between ranching and natural wetlands. Ranching in the Pantanal is low intensity with a low density of animals per hectare, and it is also extensive. Many ranchers have achieved a balance between supporting domestic animals, such as cattle, and preservation of wildlife habitat. In Florida, ranching is of higher intensity but increasingly landowners are interested conservation of their lands for ecosystem services and ecotourism. Both areas have characteristic and diverse wildlife that inhabits the natural wetlands/agricultural landscape. Because the agricultural areas are an integral part of both areas, many wildlife species can be found in both natural and altered landscapes and may move freely between. It is important to understand the landscape features and patterns that support wildlife in these habitats and how they connect and interface with nearby important natural areas. Standardized surveys in the south Florida for wildlife including birds and amphibians have illustrated the importance of management and habitat features as they affect wildlife presence. We will discuss how these features can be important in other agricultural and ranching landscapes. Edge habitat has long been recognized as important in high intensity agriculture both for protecting water bodies from runoff but as corridors and habitat for smaller animals and pollinators. In sugarcane fields they provide refuge for birds after sugarcane harvest. In wetlands, areas that are not cleared are important for wildlife conservation, soil retention, and reduced evaporation of water. Trees in the Pantanal on the edges of rivers and water courses are important for conservation of the bed, preventing siltation there. Trees also provide shade for livestock. Wetlands, either as an integral part of the landscape or as features of agriculture such as retention ponds or flooded fields, can also support native fauna either as breeding habitat or as temporary habitat during migration or dispersal.

Contact Information: Júlio Cesar de Souza, Av. Oscar Trindade de Barros, 740, CPAQ-UFMS, Aquidauana, MS-CEP: 79200-000, Bairro Serraria, UFMS - Unidade II- Brazil, Phone 55-67-99725377, Email Julio.souza@ufms.br

MULTI-AGENCY ECOLOGICAL MODELS FOR EVERGLADES RESTORATION

Leonard Pearlstine[1], *Stephanie Romañach*[2], *Doug Donalson*[3], *Laura Brandt*[4], *Alicia M. Lo Galbo*[1] *and Craig Conzelmann*[5]

[1]Everglades National Park; National Park Service, Homestead, FL, USA
[2]Southeast Ecological Science Center; U.S. Geological Survey; Davie, FL USA
[3]U.S. Army Corps of Engineers, Jacksonville, FL USA
[4]U.S. Fish and Wildlife Service, Davie, FL USA
[5] National Wetlands Research Center; U.S. Geological Survey; Lafayette, LA USA

Collaborative efforts to develop ecological models in recent years have resulted in a suite of models to evaluate Everglades restoration strategies. The Joint Ecosystem Modeling (JEM) group has facilitated common standards for data and file sharing and linkages to hydrologic models including the Regional Simulation Model (RSM). Ecological models for Everglades' species and communities such as wood stork, Cape Sable Seaside Sparrow, Everglade snail kite, amphibians, blue crab, oysters, apple snails, freshwater and estuarine fishes, slough vegetation, and freshwater and coastal vegetation succession are presented. Most of the models can be run from a desktop computer and are open-source applications available for download from JEM.gov or simGlades.org. Topical areas being further incorporated into ecological modeling simulations include climate change and sea level rise impacts, wildlife dispersal and connectivity, and linking vegetation succession with wildlife temporal responses.

Contact Information: Leonard Pearlstine, Everglades National Park, South Florida Natural Resources Center, National Park Service, 950 N. Krome Ave., Homestead, FL 33030 USA, Phone: 305-242-4228, Fax: 305-224-4147, Email: leonard_pearlstine@nps.gov

BALANCING ECONOMIC AND ENVIRONMENTAL PRODUCTION: THE ROLE OF WETLANDS IN SUSTAINABLE REGIONS

David A. Pfahler
University of Florida, Gainesville, FL, USA

Economic growth and development is seen as an important goal within Florida, however, economic growth often comes into conflict with the conservation and management of natural systems such as wetlands. Furthermore, in coupled human and natural systems, conversion of natural landscapes to economic land uses can alter and destroy necessary ecosystem services that support the economic subsystem. If a region is over-developed, the coupled system can experience a loss in its ability to sustain current production levels into the future. Management tools are needed that can help regions balance the production of both economic and environmental goods and services in order to achieve long term sustainability.

A method has been developed that couples regional economic models with environmental service models to maximize the sustainable production of the coupled system. The method is based on a linear programming model of regional production using a set of regional land uses, each of which provides a characteristic set of economic and environmental service production. The model optimization is subject to sustainability constraints on water, energy, and carbon flows within the region. These sustainability constraints can be modified to reflect current environmental policy requirements. The result of a regional analysis is a distribution of land uses within the region that maximizes regional production without compromising future productive capability.

The method is applied to the Peace River watershed region in southwest Florida, which has experienced extensive conversion of wetlands into economic land uses since the 1940's. The ecosystem services provided by both forested and marsh wetlands are incorporated into the model of the Peace River region. The impacts of water use and carbon emission policies as sustainability constraints are explored, and the role of wetlands in the resulting optimal land use distributions are compared to demonstrate the capabilities of this approach.

Contact Information: David A. Pfahler, PhD Candidate, Environmental Engineering Sciences, Center for Environmental Policy, University of Florida, P.O. Box 116350, Gainesville, FL 32611-6350, USA, Phone: (352) 392-2425, Email: dpfahler@ufl.edu

WETLANDS OF THE BRAZILIAN AMAZON: EXTENT AND RECENT ISSUES AND CONCERNS ON THEIR PROTECTION

Maria Teresa Fernandez Piedade[1], *Wolfgang J. Junk*[2], *Florian Wittmann*[3] and *Jochen Schöngart*[3]
[1]National Institute for Amazon Research, INPA, Manaus, Amazonas, Brazil
[2]National Institute for Wetlands, INAU, Cuiabá, Mato Grosso, Brazil
[3]Max Planck Institute for Chemistry, Mainz, Germany

In Brazil the wetlands occur in all biomes covering about 20% of the country's territory. Only in the Amazon region, 1,500,000 Km^2 correspond to the category of wetlands with their own flora and fauna, which makes them "hot spots" for the development and maintenance of Amazonian mega-biodiversity. Among the Amazonian wetlands the most conspicuous are the extensive floodplains of the large rivers covering more than 400,000 Km^2, which can be divided in the fertile “várzeas” and the “igapós” of low fertility. Due to high precipitation in the drainage basin, these flooded areas suffer water level fluctuations of more than 10 m, between flood peak and the peak of the drought, being subjected to an aquatic and a terrestrial phase every year.

The floodplains influenced by this annual pulse are colonized by lush flood flooded forests. In "igapós" more than 600 species have been catalogued, while in the “várzeas” there are more than 1000 species of trees, many endemic. The arboreal vegetation of floodplains have productivity higher than that of the terra firme forest and is fundamental in regulating river hydrological systems, regional climate and preserving water quality. In flooded forests vegetation facilitate deposition of sediments of the water, protecting the margins from erosion. Furthermore, the vegetation is habitat and provides food for the aquatic fauna, particularly fish, protein basis to regional populations.

One of the most important aspects of the “várzea” floodplain is that they harbor more than 60% of the rural population of the Amazon which develop in these environments multiple economic activities of low environmental impact. In 1993, Brazil ratified the Ramsar Convention assuming to protect, to inventory, to describe the structure and function, and to ensure the wise use of Brazilian wetlands, including those of the Amazon. Though, Brazil is not in the direction to fulfill these tasks.

The old Brazilian forest code gives protection to the fringing wetland areas according to the high water level. However the new forest code currently in discussion protects only areas according to the medium water level. This apparently small change in words in the document will let most wetlands without legal protection, especially in the Amazon. Furthermore this change will negatively affect the integrity of the remaining wetland areas, severely compromising their benefits for humans and the environment.

Contact Information: Maria Teresa Fernandez Piedade, National Institute for Amazon Research, INPA, Department of Environmental Dynamics, Av. André Araújo, 2936, Aleixo, CEP 69060-001, Manaus – Amazonas, Brazil, Phone: +55-92-36433157, Fax: +55-92-36421503, Email: maitepp@inpa.gov.br

TIME SERIES OF INUNDATION IN FLOOD-PULSED WETLANDS FROM THERMAL AND RADAR IMAGERY

Narcisa Pricope
Southern Oregon University, Ashland, Oregon, USA

Chobe River, a watershed with an unusual flood pulsing regime shared between Botswana and Namibia, lies at the heart of the world's largest transfrontier conservation area. Significant ecological changes and vegetation conversions are occurring along its floodplains. Various scenarios for agricultural and urban water use are currently being proposed by the government of Botswana. However, the understanding of the river's annual flow regime and timing of the relative contributions of water from three different sources is relatively poor. In light of past and future climate change and variability, this means that allocating water between ecological flows and economic and domestic uses will become increasingly challenging. We reconstruct the inundation history in this basin to help ease this challenge. This paper presents an improvement to a spatio-temporal approach to estimate the contribution of water from various sources and the magnitude of changes in the flooding extent in the basin between 1985 and 2010. The previous approach was based on time-series analysis of bimonthly NOAA Advanced Very High Resolution Radiometer (AVHRR) and NASA Moderate Resolution Imaging Spectroradiometer (MODIS) data and climatologic and hydrologic records to determine the flooding timing and extent. We now build on this previous research that showed a consistent decline in the average monthly flooded area in the basin and that between 12% and 62% of different areas in the basin are flooded on an annual basis by incorporating thermal and radar imagery into the analyses. We use MODIS thermal imagery (land surface temperature product) and European Space Agency (ESA) *Advanced Synthetic Aperture Radar* (*ASAR*) soil moisture data to further refine the spatial extent of inundation analysis for this watershed. The results may prove useful not only for surface inundation monitoring in flood-pulsed systems, but also in future water utilization feasibility studies, in determining measures for protecting ecological flows and levels and in ecosystem dynamics studies.

Contact Information: Narcisa Pricope, Southern Oregon University, 1250 Siskiyou Blvd, Ashland, OR 97520, United States, Phone: 541-840-2848, Email: npricope@gmail.com

EFFECTS OF SEASONAL HYDROLOGY ON FISH DYNAMICS IN SUBTROPICAL FRESHWATER WETLANDS: A COMPARATIVE STUDY BETWEEN THE PANTANAL AND THE EVERGLADES

J.A. Ferraz[1] and ***J.S. Rehage***[2]
[1] Pantanal National Park, Cuiaba, Brazil
[2] Florida International University, Miami, FL, USA

The Everglades and the Pantanal are among the largest, tropical/sub-tropical freshwater wetlands in the world. Despite the larger size and more pristine state of the Pantanal, both wetlands face similar conservation challenges. Water demands and management, altered land use/land cover patterns, and development pressures threaten ecosystem structure and function in both systems. Further, these stressors can negatively impact the ability of these systems to provide ecosystem services, posing immediate risks to local communities' subsistence strategies (e.g., collapse of fisheries and deterioration of water supply) and long-term risks for the social and economic resilience of communities living within the wetlands' surrounding watershed.

In both wetlands, seasonal hydrology acts as the main driver of ecological processes, including fish community dynamics. In this study, we compared the response of fish communities to seasonal hydrology. We hypothesized that in both systems, composition and productivity of piscivorous fishes depends on sustained inundation and connectivity
of aquatic habitats that allows for recruitment in the wet season and movement out of drying habitats in the dry season. Seasonal variation in water levels also affects landscape connectivity between central wetlands and adjacent floodplains, which act as sources of nutrients and organic matter that fuel primary production, and heterotrophic microbial communities. At the same time central wetlands act as valuable dry season refugia as shorter hydroperiod habitats dry.

This study presents the first comparison of fish communities in two of the most notable, subtropical wetland ecosystems in the world, namely the Pantanal (Brazil), and the Everglades (Florida).

<u>Contact Information</u>: J.S. Rehage, Southeast Environmental Research Center, Florida International University, 11200 SW 8th Street, Miami, FL 33199, USA, Phone: 305-348.3804; Email: rehagej@fiu.edu

DENDROECOLOGY OF *CALOPHYLLUM BRASILIENSE* IN BRAZILIAN WETLANDS

Sejana A. Rosa[1,2]; *Andressa B. Scabin*[3]; *Patrícia T. de P. Leite*[1,4]; *Catia N. da Cunha*[1,5] and ***Jochen Schöngart***[1,6]

[1]National Institute for Science and Technology in Wetlands (INAU), Cuiabá, Brazil
[2]National Institute for Amazon Research (INPA), Postgraduate Program in Climate and Environment, Manaus, Brazil
[3]National Institute for Amazon Research (INPA), Postgraduate Program in Ecology, Manaus, Brazil
[4]Federal University of Mato Grosso (UFMT), Postgraduate Program in Ecology and Conservation of Biodiversity, Cuiabá, Brazil
[5]Federal University of Mato Grosso (UFMT), Department of Botany and Ecology, Institute of Bioscience, Cuiabá, Brazil
[6]Max Planck Institute for Chemistry, Mainz, Germany

In this study we analyze tree-ring series from populations of the evergreen species *Calophyllum brasiliense* (Calophyllaceae) which occurs in different Neotropical ecosystems from Mexico to North Argentina. Due to special morpho-anatomical and physiological adaptations this tree species has a huge ecological plasticity which allows it to establish in different wetland types often forming monospecific stands. The timber of the species is used for construction and other purposes. Within Brazil the species can be found in wetlands comprising the nutrient-rich (várzea) e nutrient-poor (igapó) floodplains in the Amazon basin, different wetland types of the savannah belt (cerrado) including the Pantanal and swamp forests of the Atlantic coastal rainforests (Mata Atlântica). We sampled a total of 320 trees from 15 different wetlands from the Amazon floodplain, Cerrado and Mata Atlântica with the aim to relate tree growth to environmental factors (hydrology, precipitation, soil conditions). In the field we measured diameter at breast height (DBH) and tree height from 20-25 individuals. From each tree we sampled two cores, one to determine the wood density (ratio of dry mass to fresh volume), the other to estimate tree age and diameter increment rates. In the laboratory the samples were sanded to analyze the wood anatomical structure of the tree rings characterized by marginal parenchyma bands. Ring width was measured to the nearest 0.01 mm with a digital measuring device (LINTAB) supported by the software TSAP-Win. We compare age-diameter relationships and diameter increment rates between the different wetland types and model tree growth in diameter and volume to define site-specific management criteria for this commercial tree species in terms of felling cycles and minimum logging diameters.

Preliminary results indicate maximum tree ages of 408 years observed in oligotrophic floodplain forests of the igapó in the central Amazon region. Diameter increment rates differ considerably between the Amazonian sites from 0.70 ± 0.15 cm/year in the nutrient-rich várzea to 0.19 ± 0.05 cm/year in the nutrient-poor igapó reflecting the contrasting nutrient status between the two systems. First developed growth models indicate felling cycles varying between 29 to 53 years and minimum logging diameters varying between 34 and 55 cm. We therefor recommend a site-specific timber resource management for this species, which might get economically unviable if felling cycles increase. We find significant differences in wood density of C. *brasiliense* between different wetland types varying between 0.53 and 0.66 g/cm^3. We find a significant relationship between flood height of the trees and wood density.

<u>Contact Information</u>: Sejana Artiaga Rosa, INPA/MPIC cooperation, Dendroecological Laboratory. Av. André Araújo, 2936, Aleixo, Manaus, 69060-001, Brazil, Phone: 0055 (0)92 3643-3136, Fax: 0055 (0)92 3643-3136, email: sejansme@hotmail.com

MANAGEMENT CRITERIA ESTIMATED BY TREE-RING ANALYSIS FOR*TABEBUIA SPP.*IN THE BRAZILIAN PANTANAL

Patrícia T. de P. Leite **[1,2]**, *Catia Nunes da Cunha*[1,2] and ***Jochen Schöngart*** [2,3]
[1]Federal University of Mato Grosso (UFMT), Postgraduate Program in Ecology and Conservation of Biodiversity, Brazil
[2]National Institute for Science and Technology in Wetlands (INCT-INAU)
[3]Max Planck Institute for Chemistry, Mainz, Germany

The Pantanalin Central Southern America is one of the largest wetlands in the world, but increases in deforestation for the establishment of cultivated pastures and agriculture lands endanger its ecosystems. Rivers periodically flood the Pantanal as a result of the seasonal precipitation regime in their watersheds.

Wetland forests in the Pantanal establish at elevations up to 3 m above the mean water level and consist of different species compositions depending on the flood and drought tolerance of the tree species and soil conditions. *Tabebuia heptaphylla* and *Tabebuia aurea* (Bignoniaceae) are two deciduous tree species growing in the huge Pantanal wetland in seasonally flooded riparian forests and savannahs often forming monospecific stands. The timber is used by the local populations for construction, fences and other purposes.

We collected stem disks and cores of 27 trees form *T. aurea* and 23 individuals from *T. heptaphylla*. From all trees we measured diameter at breast height (DBH) and tree height. The transversal section of the samples was polished to analyze the wood anatomical features of the tree rings. Afterwards, ring-width was measured to construct individual diameter growth curves. Further, wood samples were collected to determine the wood density (ratio of dry weight to fresh volume).

T. aurea has a wood density of 0.60 g/cm^3, while *T. heptaphylla* has a wood density of 0.75 g/cm^3. The relationship between tree age and DBH is statistically significant for both species allowing the modeling of cumulative diameter growth curves. The period of optimal harvest is the maximum current volume increment rate. The diameter which corresponds to this age is the minimum logging diameter (MLD). Felling cycles were estimated by the mean passage time through 10-cm diameter classes until reaching the MLD. *Tabebuia aurea* achieves the MLD of 50 cm with 156 years, while *T. heptaphylla* reaches the MLD of 40 cm in 122 years. The felling cycle differed only slightly between *T. aurea* (31.2 years) and *T. heptaphylla* (30.5 years).

Our results indicate that under the current forest legislation which suggests a MLD of 50 cm and a felling cycle of 25 yearsis not adequate to manage the timber ofboth *Tabebuia* spp. We recommend species-specific management criteria to increase the sustainability of the timber resource management. Furthermore, Information of population structure and regeneration processes are needed to develop species-specific management plans for these species.

Contact Information: Patricia Tiemi de Paula Leite, Federal University of Mato Grosso, Institute of Biosciences, Av. Fernando Correia s/n,Coxipó, 78.060-900 Cuiabá, Brazil, Phone: +55 65 36158896, Email: paty_zig@yahoo.com.br

TOOLS AND STRATEGIES TO ADDRESS COASTAL WETLAND LOSS

Susan-Marie Stedman[1], *Nancy Laurson*[2], *Jennifer Linn*[2], *Arleen O'Donnell*[3], *Janine Harris*[4], *Martina McPherson*[3], *Emily Sheehan*[5], *Clay Miller*[2] and *Brittany Croll*[6]

[1] National Oceanic and Atmospheric Administration (NOAA), Silver Spring, MD, USA
[2] Environmental Protection Agency (EPA), Washington D.C., USA
[3] Eastern Research Group, Lexington, MA, USA
[4] I.M. Systems Group, contractor to NOAA, Silver Spring, MD, USA
[5] Oak Ridge Institute for Science and Education Fellow at EPA
[6] EPA at the time of the study, now at NOAA, Silver Spring, MD, USA

Wetlands in coastal areas are under pressure from numerous sources, both human (e.g., development, shoreline hardening) and natural (e.g., storms, sea-level rise). A 2008 report on wetlands in the coastal watersheds of the eastern United States concluded that between 1998 and 2004 more than 360,000 acres of wetlands in those watersheds were lost. To develop a better understand of the underlying causes of this loss, the Environmental Protection Agency and the National Oceanic and Atmospheric Administration co-led a series of workshops in specific watersheds around the country, focusing on those where the greatest amount of wetland loss was occurring. Although the locations were as diverse as Cape Cod, Massachusetts and Mississippi Sound, Mississippi, a number of common themes emerged. Population growth and development, sea-level rise, and the limitations of regulatory programs (which can manifest as non-jurisdictional and/or unauthorized wetland losses) were identified as common stressors. In the north Atlantic region, tidal restrictions, dams, and excess nutrients create additional stress on aquatic systems. In the mid-Atlantic region, extensive shoreline armoring alters habitat and creates the need for more shoreline armoring. In the south Atlantic region, agriculture, silviculture, and significant alterations to hydrology compound the effects of development. In the Gulf of Mexico region, substantial losses of estuarine wetlands are accompanied by even greater losses of freshwater wetlands to development and silviculture.

To address these stressors, workshop participants identified tools and strategies that are currently successful and could be applied more widely. These varied regionally but included low-impact development, high-resolution mapping, watershed-based management, living shorelines, interagency collaboration, and public outreach and education. The use of living shorelines (as opposed to hard armoring) was identified as an important strategy and future policy priority for addressing shoreline stabilization at multiple workshops. Educating and empowering local governments was viewed as one way to address the limitations of federal and state wetland regulatory programs and successful examples of this included the local conservation commissions of Massachusetts and adoption of wetland minimum standards by counties in Florida. Unfortunately, although unauthorized and non-jurisdictional wetland loss was identified as a universal problem, very few successful approaches to address it currently exist. Future work through the National Ocean Policy and the Interagency Coastal Wetlands Working Group will strive to fill this need.

Contact Information: Susan-Marie Stedman, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Habitat Conservation, 1315 East-West Highway, Silver Spring, MD 20910 Phone: 301-427-8649 E-mail: susan.stedman@noaa.gov

PREDICTORS OF KNOWLEDGE-SHARING BEHAVIORS AMONG COMMUNITY-BASED NATURAL RESOURCES ORGANIZATIONS IN THE OKAVANGO DELTA, BOTSWANA

Olekae T. Thakadu[1], *Tracy Irani*[2] and *Ricky Telg*[2]
[1]University of Botswana, Okavango Research Institute, Maun, Botswana
[2]University of Florida, Department of Agricultural Education & Communication, Gainesville, Florida, USA

Communication of Information about natural resources conservation and the environment is becoming an essential component in all aspects of sustainable development. Information diffusion interventions have often relied on the use of agents to disseminate Information to their constituents. The approach has the potential to facilitate broad-based impacts in terms of Information dissemination and social change. However, effective communication of Information requires an understanding of the knowledge-sharing behaviors of the agents. Research related to knowledge-sharing behaviors is scarce in environmental/natural resources communication literature, though it abounds in other disciplines, such as organizational management. There is, therefore, a need to explore knowledge-sharing behaviors in the field of environmental communication. This article presents research results conducted to examine the relative contribution of selected predictors of knowledge sharing behaviors in explaining knowledge-sharing among the community-based natural resources management (CBNRM) leaders in the Okavango Delta, Botswana.

The study was guided by theory of reasoned action and responsible environmental behavior model framework. The constructs explored, drawn from the two theories; knowledge, beliefs, attitudes, locus of control and intentions, were used to conceptualize a research model. While the responsible environmental behavior model posits knowledge to be a product of three knowledge domains, the study proposed an additional fourth knowledge domain: traditional ecological knowledge. Traditional ecological knowledge represents a body of socio-ecological knowledge, practices, and beliefs accumulated by communities over time through adaptive process and transmitted culturally across generations. One hundred and twenty subjects, representing 13 CBNRM Boards, took part in the quasi-experimental study. Subjects completed a retrospective-pretest instrument after exposure to an experimental treatment – presentation of an environmental issue. Data was analyzed using multiple regression statistical procedures.

Findings show that the three immediate predictors; knowledge, locus of control, and attitudes accounted for 46.3% of the variance in the knowledge sharing behavioral intention. Knowledge and attitude had an equal relative importance in the prediction of behavioral intention ($\beta = .37$), with locus of control ($\beta = .17$) exerting the least influence. Among the four knowledge domains, skill knowledge has the strongest effect ($\beta = .24$), followed by issue knowledge ($\beta = 17$). The results indicate that attitudes towards knowledge sharing, knowledge of the subject matter, mainly factual and skills, have important effects in the promotion of knowledge sharing behaviors.

Based on the findings, an effective Information-diffusion intervention targeting agents should focus on promoting favorable attitudes and beliefs towards knowledge-sharing among agents, as well as focusing on equipping the agents with both factual and skill knowledge. Interventions that also build from the subjects' traditional-ecological knowledge may help contribute to impacting beliefs. The study gives insights to practitioners in environmental communication and education on predictors of agents' knowledge-sharing behaviors and guidance in the design of interventions that target significant factors influencing agents' decisions to share acquired knowledge. Implications for future research are discussed.

Contact Information: Olekae. T. Thakadu, Okavango Research Institute, University of Botswana, Private Bag 285, Shorobe Road, Sexaxa, Maun, Botswana, Phone: +267-681-7230/+267 716 1 5282; Fax: +267-686-1835, Email: othakadu@orc.ub.bw

DOES THE EVERGLADES STILL EXIST?

Joel Trexler and *Evelyn Gaiser*
Florida International University, Miami, Florida, USA

In the first sentence of her classic work, ‘The Everglades, River of Grass,’ Marjorie Stoneman Douglas wrote, ‘There is no other Everglades in the world.’ Is this true and, if so, what remains of this unique ecosystem? Wetlands of the Everglades have been altered by many types of anthropogenic impacts. The size of the ecosystem has been decreased, the limiting nutrient, phosphorus, has been added, annual cycles of hydrology have been modified and periods of inundation shortened system-wide, peat soil has been lost to oxidation, habitat continuity and water flow has been diminished by canals and levees, apex predators have been depleted and non-native plants and animals added. Should the Everglades be considered extinct, replaced by a ‘novel’ ecosystem or perhaps changed into a large swamp of the southeastern United States of no distinct character? Has human activity made the Everglades less distinct or more ‘novel’ than its historical condition? We will discuss the structural and functional features of the historical Everglades that distinguished it and evaluate their status in the modern ecosystem. By comparing the Everglades to other karstic wetlands found throughout the Caribbean, we propose that it is has many features in common with these widespread, but poorly characterized wetlands. Placing the Everglades in this broader taxonomy of wetlands is helpful in identifying its distinctive nature and unique place in ecosystems of the United States of America. Compared to other Caribbean wetlands, we believe that its unique aspects are derived from its size and system-level properties emerging at the landscape scale and remain intact, though altered by human activity. We propose that key ecosystem features and functions remain in the Everglades and will be preserved and enhanced by the planned Comprehensive Everglades Restoration Plan (CERP). We believe that treating the modern Everglades as a novel ecosystem that is no longer the one praised in Douglas’ seminal work is to overlook the features of the ecosystem that distinguish it, even if its unique qualities are under challenge. Human activities such as eutrophication tend to make the Everglades less unique and novel relative to its historical state, and are targeted by ongoing restoration activities.

Contact Information: Joel Trexler, Department of Biological Science, Florida International University, 3000 NE 151st Street, North Miami, FL 33181, Phone: 305-348-1966 Email: trexlerj@fiu.edu

THE INTEGRATION OF SCIENCE AND FIRE MANAGEMENT AT THE LOXAHATCHEE NATIONAL WILDLIFE REFUGE

Jon Wallace
U.S. Fish & Wildlife Service, Boynton Beach, FL, USA

In 2006, the Loxahatchee National Wildlife Refuge (Refuge) began to utilize fire as a tool for exotic species control, habitat management of sawgrass ecosystems, and hazardous fuels reduction. Implementing the program had multiple challenges including dense urban development adjacent to the Refuge, logistical challenges such as highly variable and unstable environmental conditions, and an inadequate understanding of fire behavior in the northern Everglades under current environmental conditions. Interdisciplinary science and modeling, coupled with interagency relationships with Refuge program staff, US Forest Service, National Park Service, Florida Forest Service, and Palm Beach County Fire Rescue were implemented to overcome many of these challenges.

Modeling tools and ongoing research are used to further refine the prescribed fire program in a way that restores the Refuge fire regime to those consistent with the natural fire regime in the greater Everglades, benefiting both wildlife and the local public. The return of the historical fire regime we will have direct benefit to the public through fuels management and the subsequent reduction in risk of wildfire and smoke impacts. Prescribed fire also benefits wildlife by removing excessively dense vegetation and promoting a wide range of healthy habitat types in a mosaic pattern across the Refuge. Evidence suggests prescribed fire also benefits water quality by promoting less phosphorus sequestration in the peat soils and therefore reducing available phosphorus in the system. These benefits are critical to achieving the goals and objectives outlined in the Refuge Comprehensive Conservation Plan and the integration of science facilitates the ongoing assessment and refinement of the fire management program at the Refuge. This presentation briefly describes some of the scientific techniques and models designed to meet the goal of restoring the Refuge fire regime to that consistent with the historic Everglades fire regime.

Contact Information: Jon Wallace, Arthur R. Marshall Loxahatchee NWR, United States Fish and Wildlife Service, 10216 Lee Road, Boynton Beach, FL 33473 USA, Phone: 561-735-6036; Fax: 561-369-7190, Email: Jon_Wallace@fws.gov

MAKING SCIENCE REAL – USING STATE OF ENVIRONMENT REPORTING TO IMPROVE WETLAND PRACTICE

Damian Walters
Wildlife & Environment Society of South Africa, Pretoria, Gauteng, South Africa

In an effort to strengthen wetland management of a large plantation forestry company managing over 20 000ha of wetlands on 350 000 ha of land in South Africa, a state of the wetlands report was produced by a wetland programme of two South African conservation agencies (Wildlife & Environment Society of South Africa and World Wide Fund for Nature) in partnership with the company. The technical tools and processes used in developing the state of wetlands report in a plantation forestry context will be shared as an example that others could learn from. Importantly, the social learning processes used to support the development of the state of wetlands report to strengthen the wetland sustainability practices will be explained.

The ecological condition and functionality of 14 wetland systems across the land holdings were assessed. The South African developed Wet-Health and Wet-EcoServices assessment tools were used to evaluate wetland health and ecosystem functioning. Analysis revealed five dominant impacts that accounted for most of the degradation of wetland hydrology, geomorphology and vegetation integrity. The type and extent of ecosystem goods and services provided by the wetlands varied considerably across the study site. Some of the wetlands are critical habitats while others are important sources of direct benefit such as grazing and water provision. It was found that even highly impacted wetlands can be functionally important.

While the findings of the research have been critical to improving the management of the corporate's priority wetlands, the project served as a valuable vehicle for enhancing the capacity staff from the corporate as well as the conservation agencies and through a meaningful partnership. Key social learning processes used in the research strengthened relational and technical skills, and allowed for a comprehensive understanding of the socio-ecological issues surrounding wetland management within afforested landscapes to be developed. The social learning orientation taken in this natural science research suggest a different and perhaps better way for conservation agencies (and consultants) to work with corporate and government partners in an effort to ensure wetland science results in improved wetland practices.

Contact Information: Damian Walters, Mondi Wetlands Programme, Wildlife & Environment Society of South Africa, PO Box 338, Irene, Pretoria, South Africa. Phone: +27-83-6848000. Fax: +27-12-6675720. Email: walters@wetland.org.za

NOVEL ECOSYSTEMS: A EUROPEAN PERSPECTIVE

Martin J. Wassen
Copernicus Institute of Sustainable Development, Utrecht University, Heidelberglaan, CS, Utrecht

Novel ecosystems are considered in this presentation as ecosystems containing new combinations of species following human influences, environmental change and species invasions. In Europe numerous examples exist of ecosystems with unconventional species combinations. However, many of them exist already for decades or even centuries, seem to function well and are highly valued from a nature conservation perspective whereas others are considered as pest species and trash ecosystems. So, the question we asked ourselves was why some species are considered pest species whereas others are seen as valuable components of ecosystems, although non-native and if and why some ecosystems are regarded as novel ecosystems. For a number of non-native species we analyzed distribution and abundance, specific traits, role in ecosystem processes, interspecific competition, temporal dynamics and persistence. Further, we interviewed resource managers and conservationists about their appreciation of these species, the ecosystems they are part of and the reasons why. We concluded that a variety of subjective reasons explain the valuation of species. Competition strength, expansion rate, tendency to dominate, nuisance for other functions and beauty are key factors. We also concluded that the concept of novel ecosystems was rather unknown and regarded as quite irrelevant.

Contact Information: Martin J. Wassen, Environmental Sciences, Faculty of Geosciences, Copernicus Institute of Sustainable Development, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, Phone: + 31 (0)30 253 2359, Email: M.J.Wassen@uu.nl

LAND-USE CHANGE AND WATER MANAGEMENT ASSOCIATED WITH SOCIETAL AND ECOLOGICAL DEVELOPMENTS IN THE PANTANAL AND THE EVERGLADES

***Richard Weisskoff*[1]**, *Shimon Wdowinski*[1] and *Peter Zeilhofer*[2]
[1]University of Miami, Miami, FL, USA
[2]Universidade Federal de Mato Grosso, Cuiaba, Brazil

The Brazilian Pantanal and Florida Everglades make an unlikely couple. Both are moving bodies of freshwater with extensive wetlands. The Everglades National Park (ENP) has been matched up with the Pantanal National Park. Both are Wetlands of International Importance and World Biosphere Preserves. The Pantanal, however, is the northern stretch of the vast Paraguay/Parana River system; and the lower Pantanal wetlands themselves -- 135,000 sq. km falling entirely within Brazil-- are the size of the entire state of Florida! Perhaps it is the similarity of the wildlife and richness of its rookeries that encourages the comparison, for the Pantanal today is perhaps reminiscent of what the Everglades was 100 years ago when the flocks of migrating birds blocked the sun and hunters, poachers, and fisherman ravaged its waters and raided its rookeries (See Douglas, 1988).

The comparison of the Everglades to the Pantanal, however instructive, may not be flattering to either party. The Everglades is a remnant of a Pantanal after 100 years of intensive development and dismemberment. Today, its waters barely flow, as they are encased by a series of "water conservation areas" and the water levels are allowed to rise or drain, as flood control policy dictates by means of pumps and flood gates to protect the 6 million people, rather than nature, now living in the region. It is entirely a manipulated and managed system.

Despite the difference in scale, Florida's historical treatment of its Everglades holds some rather remarkable similarities to the events occurring now in the Pantanal. What the US did in a century, the Brazilians are, for better of worse, compressing into a single decade of hyper-development and agricultural expansion.

Economic, agricultural, and census data for Florida's counties allow us to trace land use and societal changes for the Everglades counties from 1900 on. Similar municipality data for the Pantanal region is available for the past 30 years. But since the rapid development of the lower Everglades occurred mainly in the 1950s, prior and during the early stages of the space era, we do have limited imagery, mostly aerial photography, for monitoring the extensive LUC of the Everglades in the 1950s. The extensive development of the Pantanal occurred since the 1980s and is well document by satellite imagery. By using both optical and radar (SAR) satellite imagery we track Land Use Change in the Pantanal and its watershed in order to understand the relations between wetland ecosystems and the major stresses, both anthropogenic and natural, affecting the wetlands. Thus, we are able to connect the economic surveys and census data to land cover changes and socio-economic processes that have affected the developments of both the Everglades and the Pantanal.

Contact Information: Richard Weisskoff, Department of International Studies, University of Miami, 325 Ferre Building, Coral Gables, FL 33124-2231. Phone: (305) 481-3161; Fax: 305-284-4406. Email: rwecon@gate.net

COMMUNICATION, SOCIAL NETWORKS, AND PERCEPTIONS OF WATER AND WILDLIFE IN THE OKAVANGO DELTA, BOTSWANA

Deborah J. Wojcik[1,2] and *Martha C. Monroe*[1]
[1]University of Florida, Gainesville, FL, USA
[2]Stanford University, Stanford, CA, USA

Information is a critical resource for rural community members who must adapt to survive and sustain natural resource-dependent livelihoods in wetland ecosystems. In rural villages of the Okavango Delta of Botswana, climate change is predicted to contribute to changes in natural resource availability, health outcomes, and livelihood strategies (IPCC 2007). Rural people rely upon water resources to sustain themselves, their subsistence crops, and the wildlife populations that provide local livelihood benefits through community-based natural resource management (CBNRM) programs. People need to access, integrate, and act upon Information about these natural resources in order for them to participate in decision-making processes and adapt to changing and uncertain conditions (Kaplan and Kaplan 1982).

This interdisciplinary research is based upon the premise that in order for people to adapt and manage natural resources, it is necessary to investigate what how Information is exchanged (through both formal and informal modalities) and how that Information is integrated into people's perceptions. Authors applied social network analysis, ethnographic field observations, and interviews to investigate how specific social variables affect Information flows and perceptions about water and wildlife in rural villages.

Results revealed that the perceptions people hold about natural resources are affected by the type of resource and several social factors. Mental models (cognitive representations built from experience) are more robust for wildlife than water, reflecting the relative complexity and decision-making importance associated with understanding wildlife in this setting. While there are national government ministries that influence the management of both water and wildlife resources in Botswana, communication around these resources differs. Understanding how social variables affect communication networks, participation, and perceptions about water and wildlife is helpful in designing communication strategies and decision-making processes that actively foster Information exchange and facilitate adaptation among rural community members living in wetland ecosystems.

Contact Information: Deborah J. Wojcik, University of Florida, P.O. Box 116350, Gainesville, FL 32611-6350 USA, Phone: 352-213-7263; Fax: 352-392-3624; Email: deb.wojcik@ufl.edu

CONSTRUCTED WETLANDS - DESIGN CRITERIA AND TREATMENT EFFICIENCY

DROUGHT AND CONSTRUCTION TECHNIQUES INFLUENCE ECOSYSTEM-LEVEL RESTORATION OF A BRACKISH MARSH

***Anna R. Armitage**, Chuan-Kai Ho, Eric N. Madrid, Michael T. Bell, Erin Kinney* and *Antonietta S. Quigg*
Texas A&M University at Galveston, Texas, USA

The development of plant canopy features is often considered to be a sign of successful coastal marsh restoration, but a robust plant canopy may not correspond with the recovery of other ecosystem attributes such as nutrient retention or faunal assemblages. Furthermore, construction designs that incorporate different soil sources and elevation gradients can also influence the ecosystem-level characteristics of a restored marsh. The objectives of our study were to (1) evaluate whether plant canopy development corresponded with the recovery of ecosystem attributes, and (2) compare the influence of construction design on species- and ecosystem-level characteristics between normal and drought years. The study site included a reference brackish marsh and four types of restored marshes constructed in spring 2008 in the Lower Neches Wildlife Management Area in Texas, USA. The restored areas consisted of mounded or terraced formations built from on-site soil or from off-site dredge material. We conducted comprehensive surveys of the biotic and abiotic characteristics of the emergent marshes and aquatic habitats in restored and reference areas in two typical summers (2009, 2010) and in an exceptional drought year (2011).

At the emergent plant level, each construction approach successfully yielded similar percent cover, stem density, and aboveground biomass as the reference area. In 2009 and 2010, Discriminant Function Analyses (DFA) of visible emergent plant characteristics suggested that there was substantial overlap among reference and restored areas and that most plant canopy features were similar among all restored and reference areas. Emergent plant communities were not strongly affected by the 2011 drought. DFA of a more complex suite of plant, soil, and aquatic characteristics in 2009 revealed that the reference area had more sand and higher soil nitrogen and carbon content relative to all restored areas. Classification success was generally greater than 70%, suggesting that at the ecosystem level, each restoration approach was distinct from the others. DFA of plant, soil, and aquatic characteristics in 2010 revealed fewer abiotic differences among areas, and classification success decreased to less than 67%, suggesting that the four restored areas were becoming less distinct from each other over time. However, in the drought year, 2011, the aquatic plant and animal community dramatically shifted from brackish (< 8 ppt) to marine (> 25 ppt) assemblages. Overall, at the ecosystem level, each of the restoration approaches was unique, and none of them resembled the reference area. As the suite of measured variables increased in complexity, so did the dissimilarity between the reference and restored areas. These differences diminished over time as the restored areas developed, and all areas were similarly impacted by drought.

Contact Information: Anna R. Armitage, Department of Marine Biology, Texas A&M University at Galveston, PO Box 1675, Galveston, TX 77553 USA, Phone: 409-740-4842, Fax: 409-740-5001, Email: armitaga@tamug.edu

ADVANCES IN THE USE OF PASSIVE WETLAND SYSTEMS FOR SELENIUM TREATMENT OF MINE-IMPACTED WATER

J. Bays[1], *BT Thomas*[2], *T.Harrison*[3] and *D. Evans*[4]

[1]CH2MHILL, Tampa, Florida, USA
[2]CH2MHILL, Atlanta, Georgia, USA
[3]CH2MHILL, Cincinnati, Ohio, USA
[4]CH2MHILL, Houston, Texas, USA

The need to achieve stringent selenium standards (4.7 ug/L monthly average, 8.2 ug/L daily max) imposed recently has challenged coal mining companies to investigate and implement new technologies to improve mine drainage water quality related to mountain-top mining and related valley fill impoundments. Following a detailed literature review and bench- and field-scale pilot studies, a southern Appalachian mining company has implemented four innovative passive treatment systems designed to treat selenium-contaminated drainage from valley fills.

System A was designed in late 2010 to treat drain water averaging 10 ug/L Se and an annual average flow of 60 gpm. After construction was completed in August 2011, the 0.2-ac system readily passed an EPA-mandated 2-month evaluation test period, reducing selenium concentrations below method detection levels (0.1 ug/L). This facility includes an initial downflow biochemical reactor (BCR) comprised of organic media for selenium reduction, followed by an upflow BCR composed of peat substratefor selenium polishing and particulate trapping, a tidal-flow subsurface flow wetland for organic matter oxidation, and a surface flow marsh for final polishing. These advanced natural treatment processes provide state-of-the-art passive treatment for a challenging pollutant and the by-products emitted from the biochemical reactor.

System B is designed to treat drainwater averaging 23 ug/L Se at an annual flow of 230 gpm. Since construction was completed by October 2011, the 0.5-ac system has been meeting Se water quality standards. This facility includes an initial head tank for flow equalization, an upflow biochemical reactor for selenium reduction, overlaid with a surface layer of peat, followed by a surface flow wetland for final byproduct polishing.

System C is designed to treat drain water averaging of 5.6 ug/L at an annual average flow of 239 gpm. Construction was completed by December 2011. The 0.3-ac facility includes an initial equalization cell that feeds two parallel downflow biochemical reactors, each followed by upflow peat polishing cells. Both trains discharge to a common aerobic pond for byproduct polishing.

System D is designed to treat flows from a large sedimentation pond fed by a valley fill drain with an average concentration of 9.9 ug/L and an annual flow of 1857 gpm. Construction was completed in November 2011. The facility receives up to 1,500 via a siphon, which conveys flow to an 1.8-acre upflow biochemical reactor. Treated flows are designed to be blended back with the untreated flow to yield a final concentration below the monthly standard. Treatment at this site is augmented with carbon supplements upstream in the valley fill, which serves to reduce inflow concentrations further.

Analyses performed by others estimated that conventional treatment systems installed at all four sites would total $119 million in construction, with an annual O&M cost of $5.7 million. The collective cost for all four PTS was estimated to total approximately $2.8 million to build and $60,000 annually to operate, yielding a >40-fold cost savings in construction and almost 100-fold cost savings in operational costs relative to conventional technologies.

The projects have demonstrated that passive treatment is a practical, cost effective and technologically appropriate way to manage selenium from these southern Appalachian outlets. A similarly cost-effective solution is expected for remote, small flows in other regions where siting and sizing constraints can be met.

<u>Contact Information</u>: James Bays, CH2MHILL, 4350 W. Cypress St, Tampa, FL 33607, USA. Phone: 813- 281-7705, Fax: 813-374-3056. Email: jbays@ch2m.com

SOIL CHARACTERISTICS AND TREE GROWTH IN A CREATED WETLAND

S. P. Charles and *J. E. Perry*
Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, Virginia, USA

Forested wetland sites created for mitigation exhibit varying degrees of success. Unsuccessful attempts at mitigation often fail due to a combination of poor tree selection as well as environmental site conditions. This project aims to identify factors affecting mitigation success through a long-term mesocosm study at the New Kent Forestry Center in New Kent, Virginia. One key factor is how primary and secondary successional species (in this case *Betula nigra* and *Quercus palustris*) respond to being transplanted into different environmental conditions. 44 trees of each species were transplanted into three sites bearing distinct hydrologic and soil characteristics (ideal, saturated, and flooded conditions). After 2 years soil was tested for N, P, C, C:N ratio and bulk density. The cells showed significant differences ($p<.0001$) in all soil criteria except for P, in which the saturated and ideal cells were similar. Soil carbon and C:N ratios increased from the flooded cell to the saturated cell and are highest in the ideal cell. Nitrogen content and bulk density showed the opposite trend. Carbon content and C:N ratio showed significant positive correlation with tree height growth, while bulk density showed the expected negative correlation. Interestingly, nitrogen content showed negative correlation with tree growth. Negative nitrogen to growth trends may be explained by an imbalance in the soil. These findings have important implications for site selection and preparation in created wetland sites.

Contact Information: S. P. Charels, P.O. Box 1346 Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, VA, 23062 USA, Email: spchar@vims.edu

INFLUENCES OF INFLOW TOTAL PHOSPHORUS CONCENTRATION AND LOADING AND VEGETATION TYPE ON PHOSPHORUS REMOVAL PERFORMANCE IN THE EVERGLADES STORMWATER TREATMENT AREAS

***Hongjun Chen**, Kathleen Pietro* and *Delia Ivanoff*
South Florida Water Management District, West Palm Beach, Florida, USA

The Everglades Stormwater Treatment Areas (STAs) are constructed wetlands that reduce phosphorus (P) from agricultural runoff and other sources to help reduce the P loading into the Everglades. The STAs vary in terms of operational period, size, configuration, plant types, hydraulic loading, and P loading. An in-depth analysis of historical data was conducted to help better understand the key factors affecting P removal and determine which of those factors could be modified to further improve STA performance. We utilized period-of-record data from all STAs to evaluate the effects of inflow P loading rate (PLR) and total P (TP) concentration on outflow TP concentration on an STA, individual treatment cell, and vegetation type (emergent and submerged aquatic vegetation, EAV and SAV respectively) basis. Outflow TP concentration was positively correlated with increasing inflow TP concentration in both treatment cell and STA levels. Initial analyses suggest that to achieve a low outflow TP concentration in the STAs, the inflow PLR must be maintained at low levels. The correlation between PLR and outflow TP concentration was statistically significant. These findings indicate that STA performance can be improved by reducing inflow TP concentration and loading. Further parsing of the data will be performed to isolate the influence of other environmental and operational factors on STA performance, particularly at the back end of the flow-way.

Contact Information: Hongjun Chen, Water Quality Treatment Technology Section, Applied Science Bureau, Water Resource Division, South Florida Water Management District, 3301 Gun Club Road, West Palm Beach, FL33406, USA. Phone: 561-682-6511, Email: hchen@sfwmd.gov

MEDIA AND PLANTS TO OPTIMISE PHOSPHORUS REMOVAL AND CARBON SEQUESTRATION IN SUB-SURFACE FLOW CONSTRUCTED WETLANDS

Margaret Greenway and *William Lucas*
Griffith University, Brisbane, QLD, Australia

Nutrient removal from municipal wastewater and urban stormwater is essential to safeguard downstream ecosystem health. Membrane Bioreactors are used to polish sewage effluent but have considerable installation, operational and life-cycle costs and high energy usage. Alum dosing to achieve low phosphorus discharge concentrations is also costly. Constructed wetlands (CW) are cheaper to install and operate. CW are highly effective in nitrogen removal but often less effective in phosphorus removal. This paper summarises 7 years of research into the treatment effectiveness of vertical flow CW - bioretention systems by trialing different soil media and plants to remove nutrients, in particular phosphorus, from sewage effluent.

Our experiments used 240L mesocosms. Initially mesocosms were constructed using gravel, sand or loam media. Subsequently, sandy media amended with varying proportions (up to 30%) of Red Mud (byproduct of bauxite), Krasnozem (local weathered volcanic soils) and Water Treatment Residuals ('sludge' byproduct of alum dosing) was trialed. These amendments are known for their phosphorus adsorption properties. Ten different plant species were trialed.
The 'vertical flow' mesocosms were irrigated once a week with 135 L recycled sewage effluent. The entire outflow volume was collected in 150L cylindrical PVC chambers and composite samples analysed. Average annual loads (g/m2) were 1096 g TP, 835 g PO_4, 1105 g TN, 615 g NO_x. Shoots were cropped every 6 months to determine harvestable shoot biomass. Total biomass (above and below ground) was conducted after 2, 3 and 4 years. Sub samples of plant tissue were analysed for N, P and Carbon content.

Total Phosphorus removal was highest (94-99%) in the sand media amended with Water Treatment Residuals, followed by the loam (92%), then the sand amended with Red Mud or Krasnozems (86-89%) and lowest in sand-gravel 44%. Phosphorus concentrations were reduced from 5mg/L to 0.08mg/L in the sand amended media .Total Nitrogen removal was highest in the loam (79%) but relatively poor in all the sandy media types (around 50%). Mean annual mass retention varied between 82-85 g/m2 TP and 32-65 g/m2 TN in the sandy media types and 100g/m2 TP and 87 g/m2 TN in the loam.

The grass *Pennisetum alopecuroides* and the sedge *Carex appressa* had the highest biomass yield. Cropping shoots enhanced shoot growth. Plant growth was similar for all media. In terms of nutrient removal, plant uptake measured over 2 years accounted 12-18gP/m2/y and 51-64gN/m2/y. These high removal rates are attributed to luxury uptake from the effluent and shoot harvesting in *Pennisetum* and *Carex*. Woody species had the highest carbon sequestration

In conclusion the most effective treatment media for our 'biofilter 'was sand (80%) plus water treatment residuals (20%), with up to 99% removal of P and 54% N. The assemblage of plants in our biofilter accounted for the annual removal and incorporation into plant biomass of up to 64gN m^{-2}, 18gP m^{-2} and 1000gC m^{-2}.

Contact Information: Margaret Greenway, School of Environmental Engineering, Griffith University, Nathan Campus, Brisbane, Qld 4111, Australia. Phone 61 7 37355296; Email m.greenway@griffith.edu.au

ENVIRONMENTAL COMPLIANCE AND ECOLOGICAL RESTORATION WITH FLOATING WETLAND ISLANDS

Kevin Hedge and *Ted Gattino*
BlueWing Environmental Solutions & Technologies, LLC, Ellicott City, Maryland, USA

Floating Wetland Islands are man-made replicas of natural peat based systems found around the world. They are an example of Biomimicry, which is the use of nature's models to address anthropocentric problems. In our context, we use nature to improve and restore aquatic habitats and water quality. This presentation is intended to give the attendee a basic understanding of Biomimicry and why it is important. Give a basic understanding of floating wetlands and how they work to process nutrients and provide critical riparian wildlife habitats. Demonstrate how the floating wetlands function and provide numerous ecosystem services, as well as provide a glimpse into where the floating wetlands have been used and potential applications for the future.

The floating wetlands are manufactured using a fibrous recycled material (matrix) and are installed in all types of water. The interstitial spacing of the recycled materials allows naturally occurring microbes to colonize the fibrous surfaces creating a diverse wetland ecosystem where waterborne pollutants and contaminants are bio-processed into and out of the food chain. We will examine the key processes present in the floating wetland system and details of system dynamics that are optimized with the current island design. The massive potential of this habitat and nutrient processing tool will also be examined, along with explanation of existing and proposed projects, as well as the potential for future embodiments that can be utilized to reduce dead zones in all impaired waterways.

There are many applications that have been identified to date and people are thinking up creative ways to use the floating islands all the time. A partial listing includes: sewage treatment, storm water, drinking water reservoirs, polluted rivers and streams, erosion control in urban environments; treating effluent water from aqua and agri-culture operations; treating cleansing water and settling out heavy metals from mining applications; habitat enhancement and wave dampening projects related to climate change adaptation and lake restoration, dead zone mediation.

The floating wetlands can be applied to wet ponds and wetland applications and are a variation of infiltration and filtration practices. They can be used in stream and abandoned mine restoration projects, monitored drinking water projects as well as wastewater landfill leachate treatment projects.

By combining the best of wetland science, ecosystem design and processing, along with proven wastewater treatment technologies, this system has been effectively shown to reduce temperature and oxygen (DO) stratification in deep water ponds. The system is designed to easily allow removal of pollutants from the aquatic environment for proper storage, disposal and processing.

Participants will learn about the Biomimicry, concentrated wetland effect, biofilm, and ecosystem services.

Contact Information: Kevin Hedge, Managing Partner, BlueWing Environmental Solutions & Technologies, LLC, 4309 English Morning Lane, Ellicott City, Maryland 21043; Phone: 410-203-2270; Email: Kevin@bluewing-env.com

TROPICAL STORM IMPACTS TO EVERGLADES STORMWATER TREATMENT AREA SUBMERGED AQUATIC VEGETATION COMMUNITIES

Scott Jackson[1], *Thomas A. DeBusk*[1], *Jaimee Henry*[1] and *Neil Larson*[2]

[1] DB Environmental, Inc., Rockledge, Florida, USA;

[2] South Florida Water Management District, West Palm Beach, Florida, USA

Six separate large-scale (913 to 6695 ha) constructed surface flow wetlands, called Stormwater Treatment Areas (STA), have been deployed to remove phosphorus (P) from Lake Okeechobee surface waters and agricultural drainage waters (ADWs). The STAs typically are configured with front-end cells dominated by emergent vegetation (*Typha* spp.), and back-end "polishing" cells dominated by submerged aquatic vegetation (SAV).

Hurricanes result in large volumes of rainfall runoff, increased total P inflow concentrations, erosion of levee banks, and uprooting of aquatic vegetation. Following three hurricanes, we documented SAV loss and water column P changes in two SAV-dominated cells of separate STAs: STA-2 Cell 3 and STA-1W Cell 5. The former wetland is 919 ha and is equipped with vegetated earthen strips that effectively create six compartments of approximately 150 ha each, while the second is 928 ha in size, with only one rock berm situated perpendicular to flow at the approximate midpoint of the wetland. STA-2 Cell 3 contained *Hydrilla* in the immediate inflow compartment, along with a diverse assemblage of native SAV species in the remainder of the wetland. STA-5 Cell was dominated by *Hydrilla*, with only a slight cover of native SAV species.

Immediately prior to Hurricane Wilma in October 2005, an internal sampling event in STA-2 Cell 3 indicated removal of most of the water column P within the front half of the cell (mean inflow TP concentration of 129 μg/L vs. mid-point and outflow concentrations of 22 and 12 μg/L, respectively). The hurricane destroyed 100% of the dense *Hydrilla* in the immediate inflow region compartment, leaving only trace amounts of biomass. In the next two downstream compartments that comprise the inflow "half" of the wetland, we observed an 18% reduction in dense *Najas* beds, the dominant SAV species in these regions. An internal sampling event immediately following the storm revealed inflow TP concentrations of 161 μg/L, and midpoint and outflow concentrations of 107 and 30 μg/L.

Prior to Hurricanes Jeanne and Francis in September 2004, an internal sampling event in STA-1W Cell 5b also demonstrated removal of most of the water column P within the front half of the cell (mean inflow TP concentration of 144 μg/L vs. mid-point and outflow concentrations of 38 and 27 μg/L, respectively). The hurricanes destroyed 85% of the dense *Hydrilla* in the entire first half of the cell, leaving almost no SAV biomass within this region of the wetland. An internal sampling event immediately following the storm revealed inflow TP concentrations of 332 μg/L, and midpoint and outflow concentrations of 310 and 102 μg/L.

While both STA-2 Cell 3 and STA-1W Cell 5b exhibited adverse hurricane impacts, our observations suggest that the diverse SAV assemblage in the former wetland was more resistant to wave and wind damage than the *Hydrilla*-dominated regions of the STAs. These findings also suggest that compartmentalization of the large shallow (0.25 – 1.0 m) wetlands is a beneficial structural component of the large STA cells. Since 2005, additional compartmentalization, primarily with large bands of *Typha*, has been incorporated into all STA SAV cells, an approach that should help minimize future hurricane impacts to the submerged plant communities.

Contact Information: Scott Jackson, DB Environmental, Inc., 365 Gus Hipp Blvd. Rockledge, FL 32955 USA, Phone: 321-631-0610; Fax: 321-631-3169, Email: scott@dbenv.com

WATER, ION AND PHOSPHORUS BUDGETS OF A PERIPHYTON-BASED STORMWATER TREATMENT AREA

R. Thomas James
South Florida Water Management District, West Palm Beach, Florida, USA

The South Florida Water Management District (District) has investigated various technologies to test Phosphorus (P) removal at low inflow concentrations to achieve the total phosphorus (TP) Class III criterion in the Everglades Protection Area. One technology is the Periphyton-based Stormwater Treatment Area (PSTA). In 2005, the District built a 100 acre PSTA cell in the Everglades Construction Project's STA-3/4. Peat was scraped from the cell to the caprock removing this potential source of TP. Emergent vegetation strips were planted perpendicular to flow to improve the cell's hydraulic efficiency. Water, chloride (CL), calcium (Ca), sulfate and TP budgets were developed from May 2008 to April 2011 using observed data and equations to estimate volumes and seepage. Mass was determined from water quality measurements and daily volume estimates. Net load (inflow load + seepage + rainfall - discharge load) was subtracted from the daily change in mass to provide a residual (error) term.

Surface outflow averaged 18.4 acre-ft/day, resulting in a turnover time of 13 days. Volume error estimates averaged two acre-ft/day or 1% of the average PSTA volume of 237 acre-ft. The standard deviation of these error estimates was ± 55 acre feet or 24%. Two changes were made to reduce this error: 1) the pump flow rate was reduced at the discharge structure to allow for more constant and even outflow and 2) the opening of one inflow structure was closed and the other was restricted to improve velocity measurements.

Chloride and calcium budgets were consistent with water budgets, accounting for major inputs, outputs and associated errors. Only small differences were observed between inflow and discharge loads. Seepage for both ions was slightly more than 25% of the total inflow load. Turnover for each was 14 and 12 days, respectively. Sulfate budgets were similar, with seepage representing 23% of the inflow load and a turnover time of 14 days. However, discharge load and outflow concentrations were 20 and 29% less than inflow load and concentration.

PSTA discharge samples were at or below 10 ppb 70% of the time. The discharge load of 79 kg TP/year was 50% less than the total inflow load of 152 kg TP/year. Seepage and rainfall contributed 29% and 6% respectively to the input load. Per area, the input load was 376 mg P/m^2/year and output was 195 mg P/m^2/year resulting in an average removal rate of 181 mg P/m^2/year.

These results indicate that PSTA is an effective method to remove TP. The sizing of any future PSTA projects will be aided by improved measurements of flow and load provided by the changes made at the in inflow and outflow structures.

Contact Information: R. Thomas James, Water Quality Treatment Technology Section, Applied Sciences Bureau, Water Resources Division, South Florida Water Management District, 3301 Gun Club Road, West Palm Beach, FL 33406 USA, Phone: 561-682-6356; Fax: 561-682-6356, Email: tjames@sfwmd.gov

INTEGRATED SUBSURFACE FLOW CONSTRUCTED WETLAND TREATING DOMESTIC SEWAGE IN BEIJING, CHINA

Bingbing Jiang and *Jian-ming Hong*
College of Life Science, Capital Normal University, Beijing, China

An integrated constructed wetland system with procession of 120m^3 per day is constructed by a chosen piece of wetland on a rural school in Beijing. This paper through the experiments of constructed wetland of the integrated operation parameters on the effect of the pollutant removal, and through the analysis of the water quality monitoring data for COD, ammonia nitrogen and phosphorus, total nitrogen indexes, such as the seasonal variations and the yearly variations. Through various hydraulic loads of nitrogen, phosphorus and pollutants such as the fitting, a dynamic model of the level between them is established, in different orders. Conclusions are as follows:

(1) the COD removal rate, ammonia nitrogen removal rate, and the total nitrogen removal rate are higher when the water level is at 0.5m than those when the water level is at 0.7m; while the total phosphorus removal rate is the opposite, which means that it is higher when the water level of the constructed wetland system is at 0.7m than that when the water level is at 0.5m. (2) the consecutive and the intermittent running mode have the same influence on the COD removal rate, ammonia nitrogen removal rate, total nitrogen removal rate, and the total phosphorus removal rate of the eastern and western constructed wetland systems. In other words, when the constructed wetland system employs the intermittent running mode, the removal rates of all the index above are higher than those when the consecutive runnign mode is employed.

Through the dynamics simulation of the removal procession of the hydraulic loading to the nitrogen and phosphorus of the integrated constructed wetland with the correlation coefficient for 0.8: the dynamics modes of the ammonia nitrogen, total nitrogen, and total phosphorus of the eastern constructed wetland system are: $\ln(C_e/C_0)= -0.6183q_A - 1.4599$; $\ln(C_e/C_0)= -0.8127q_A - 1.2776$; $\ln(C_e/C_0)= -1.1105q_A - 1.2068$; while the dynamics modes of the ammonia nitrogen, total nitrogen, and total phosphorus of the western constructed wetland system are: $\ln(C_e/C_0)= -0.4994q_A - 1.3254$; $\ln(Ce/C_0)= -0.6923q_A - 1.0176$; $\ln(C_e/C_0)= -0.5394q_A - 1.5678$. It can be seen from this model equations that the removal rates of each pollutant areas in the eastern constructed wetland system are all higher than those in the western one, which indicates that the influence of hydraulic loading on the nitrogen and phosphorus removal effect of the system in the eastern constructed wetland is greater than that in the western one.

Keywords: integrated constructed wetland, nitrogen, phosphorus, model

Contact Information: Bingbing Jiang, East China Normal University, Visiting Scholar of Ohio State University from 10/31/2011 to 10/31/2012; 352 W Dodridge St. Columbus, OH 43202-1574, USA, Phone: 614-3307933, Fax: 614-292-9773, Email: j.bingbing@yahoo.com

PHOSPHORUS COMPOSITION AND REACTIVITY IN OUTFLOW WATER FROM CONSTRUCTED WETLANDS

C. Jørgensen[1]*, K. S. Inglett*[2] and *K. R. Reddy*[2]
[1]Centre for Lake Restoration, Institute of Biology, University of Southern Denmark, Denmark
[2]University of Florida, IFAS, Soil and Water Science Department, Florida, USA

In Florida during the last decade several both large scale and smaller scale wetlands have been constructed to reduce pollutant (nutrients) loading rates to adjacent water bodies. Since, many of Florida's natural ecosystems are phosphorus (P) limited there is a considerable interest in optimizing these wetlands for P removal. The P removal efficiency is often evaluated based on soluble reactive P (SRP) and total P (TP) removal by the system. As the water passes through the wetland, several P transformations may occur in the water column resulting in alteration in P forms and change in bioavailability of outflow water. In this study we used ^{31}P NMR spectroscopy to understand the reactivity of P forms in water samples from nine treatment wetlands and one treatment pond located in selected watersheds in Florida. Based on this analysis we were able to distinguish between orthophosphate and several groups of biogenic P (P compounds linked to carbon). In the majority of the wetlands, the relatively amount of biogenic P compared to inorganic P increased significantly from the inflow water to the outflow water rendering it even more important to know the specific composition of biogenic P in the outflow. Two of the biogenic P compounds (pyrophosphate and polyphosphate), which normally considered less refractory than the other biogenic P compounds, seemed to increase from the inflow to the outflow. In two of the systems these compounds combined contributed up to 36% of the TP in the outflow water, as compared to 10% in other sites. The wetland sites chosen in this study differ in source of inflow water, P loading rate, size, hydraulic retention time, soil types, and vegetation. More in depth analysis will be conducted to determine the influence of both external and internal factors regulating the biogenic P composition in the outflow water.

Contact Information: Charlotte Jørgensen, Centre for Lake Restoration, Institute of Biology, University of Southern Denmark, Campusvej 55, DK-5230 Odense M, Denmark, Fax: +4565502785; Phone: +4565502744, E-mail: charlottej@biology.sdu.dk

INTEGRATION OF HABITAT HETEROGENEITY AND COST-EFFECTIVE RESTORATION TECHNIQUES AND STRATEGIES INTO INNOVATIVE LARGE-SCALE WETLANDS RESTORATION EFFORTS IN SOUTH FLORIDA URBAN AREAS

Gary R. Milano
Miami-Dade County, Miami, Florida, USA

Florida's rapid population growth and associated development began after 1945, and resulted in the virtual elimination of wetlands and aquatic vegetation along vast areas of Florida's coastline. Southeast Florida (Miami-Dade County) population grew from approximately 267,000 in 1940 to over 2.5 million people by 2010, an increase of 900%. Historic dredging and filling practices and regional modifications to the distribution, quality, and quantity of freshwater to the coastal areas has resulted in degradation of South Florida coastal habitats. Overall, Florida wetland habitats have been reduced by 50%, which has changed the landscape from expansive wetlands to heavily developed communities. Concentrated and expanding human presence continues to dramatically change the South Florida ecosystem.

Florida wetland communities are important habitats for a wide variety of fish, invertebrates, reptiles, amphibians, birds, and mammals, including endangered and threatened species. The mangrove wetlands stabilize shorelines, especially during hurricanes. These wetlands are being threatened by the effects of urbanization, development, agriculture, and storm water runoff effluent, and the resultant water quality decline. The ecological importance of coastal wetlands as habitat and a vital link in the marine food web has resulted in government regulatory protection and wetlands habitat restoration.

South Florida historical altered wetlands are being restored on publicly owned lands through the cooperative efforts of federal, state, and local governmental agencies. Twenty-five years of coastal urban wetlands restoration, associated with Miami-Dade County's Coastal Habitat Restoration Program, has resulted in the restoration of 220 hectares of coastal wetlands. This has been accomplished within twenty-five projects ranging from one to thirty-five hectares in size using innovative cost-effective restoration techniques and strategies.

Large-scale wetlands restoration efforts are being designed and implemented regionally to maximize habitat heterogeneity for a wide variety of fish, reptiles, amphibians, birds, and mammals. Wetland designs include a network of tidal flushing channels inter-connecting tidal pools and shallow open water areas with specific hydrological criteria. These protected shallow tidally connected pools of water are designed to provide diverse seagrass and mangrove habitats which are critical low energy habitats for wading birds, invertebrates and juvenile fish development.

The restoration process typically consists of clearing of invasive exotic vegetation, elevation adjustments for restored wetland species, creation of tidal creeks and pools, and planting of native wetland species with volunteer participation. Establishing proper planting elevations is a critical factor determining the success or failure of restoration efforts. As a result, post-construction as-built topographic surveys are required prior to final planting, approval, and contract payment.

Success criteria of the projects are based on ongoing planting survivability and Information regarding habitat use by fauna. Planting survivability is determined qualitatively using photo-stations and quantitatively using the line-intercept and fixed-quadrat monitoring methods within the restored wetlands. Faunal assessments at restored sites are conducted by volunteer wildlife experts and students. Long- term monitoring is documenting the value of habitat heterogeneity within the restoration sites in maintaining taxonomic diversity and resultant ecological infrastructure for a wide variety of invertebrates, fish, reptiles, amphibians, birds, and mammals.

Contact Information: Gary Robert Milano, Miami-Dade County, Permitting, Environment and Regulatory Affairs, 701 NW 1st Court, 5th Floor, Miami, Florida, 33136-3912 USA, Phone: 305-372-6851, Fax: 305-372-6659, Email: MilanG@MiamiDade.Gov0

GEORGE W. SHANNON WETLANDS WATER RECYCLING FACILITY – FROM RESEARCH TO REALITY

Loretta E Mokry[1], *Darrel Andrews*[2] and *Mark Ernst*[2]
[1]Alan Plummer Associates, Inc., College Station, Texas, USA
[2]Tarrant Regional Water District, Fort Worth, Texas, USA

Tarrant Regional Water District (TRWD) provides raw water supply for over 1.6 million people in its service area that currently spans across ten counties in North Central Texas. To meet these raw water supply needs, the TRWD has four major surface water reservoirs and pipeline connections have been constructed to link these reservoirs to other existing reservoirs. Based on conservative projections, the population within TRWD's service area will swell to over 3.8 million by the year 2060. One option being pursued to meet future water supply requirements is to supplement the yield of two of the TRWD's downstream reservoirs (Richland-Chambers and Cedar Creek Reservoirs) by diverting return flows from the Trinity River to constructed wetlands for polishing, then pumping the wetland-treated water to the reservoirs. The TRWD's plan, designated the George W. Shannon Wetlands Water Recycling Facility (GWSWWRF), should provide about 115,500 acre-feet/year (103-MGD average) of additional raw water supply from these two reservoirs.

TRWD formulated a staged program to research and examine the financial aspects, operation and maintenance issues, and treatment performance of constructed wetlands. The staged research program involved an initial 2.5-acre Pilot-Scale constructed wetland, operated from 1992 to 2000, then a Field-Scale wetland consisting of one sedimentation basin and four wetland cells totaling 243 acres was constructed as the first train of the Richland-Chambers Wetland. Operation of the Field-Scale wetland began in spring 2003. A second treatment train (Phase I Expansion) consisting of a sedimentation basin and two wetland cells totaling 187 acres was completed in 2009. Phase II Expansion detailed design has been completed and construction initiated in early 2011. Upon completion, the Richland-Chambers Wetland will have a footprint of approximately 2500 acres to treat an average flow of 91 MGD. This project will supplement the yield of Richland-Chambers Reservoir by 63,000 acre-feet per year.

The TRWD's GWSWWRF will eventually also include a project to polish diverted Trinity River flows to supplement the yield of Cedar Creek Reservoir. Although the Cedar Creek Wetland is on a longer time line, the water right permit has been acquired and preliminary assessment and site selection studies have been completed. The Cedar Creek Wetland Project will ultimately supplement the yield of the reservoir by 52,500 acre-feet per year.

Design criteria have been refined at each phase of the wetland system design based on the operational and management data gathered from the preceding phases. Concurrent operation of the Field-Scale Wetland and the Phase I Expansion train provided opportunity for direct comparison of performance following moist soil management draw down activities versus continuous flow-through conditions. The mass balance analyses provide important insights regarding the removal efficiencies achieved under the varying conditions. The Phase I Expansion train exhibited improved nutrient removal efficiency, especially for total phosphorus (TP), over the initial and concurrent Field-Scale Wetland operations. Effective removals of TSS, total nitrogen, and TP were demonstrated, but removal efficiency is influenced by hydraulic and mass loading to wetland treatment area as well as different operational conditions.

KEYWORDS - Water supply, water reuse, constructed wetland, design, construction, operations

SUMMARY - Research data analysis demonstrates effective removals of TSS, TN, and TP, with modified design criteria providing better water level control and improved TP removal efficiency.

Contact Information: Loretta E Mokry, Alan Plummer Associates, Inc., 10060 N. Dowling Rd., College Station, TX 77845, Phone: (979) 694-7619 or (817) 845-3280, Email: lmokry@apaienv.com

SUB-SURFACE FLOW WETLANDS – CONSTRUCTED WASTEWATER TREATMENT SYSTEM

John O'Meara[1], *Robert Wiley*[2], *David Flowers*[3] and *Alice Bailey*[1]
[1]Environmental Consulting & Technology, Inc., Ann Arbor, MI
[2]St. Clair County Drain Commissioner, St. Clair County, MI
[3]Natural Water Solutions, LLC, Cedarburg, WI

The Village of Avoca Wetland Wastewater Treatment Project involved the engineering, construction and operation of a wastewater collection system with a subsurface wetland treatment system. The purpose of the system is to treat the sewage from approximately 77 homes and businesses in the Village of Avoca, Michigan. The project goal was to eliminate the discharge of approximately 17,500gpd raw and/or semi-treated sewage from Avoca to the County Drain, which flows ultimately into Lake St. Clair. The St. Clair County Drain Commissioner believed that this problem may be pervasive across the State of Michigan and may become more obvious as the NPDES Phase II storm water regulations are implemented. It was decided to use an innovative solution in the form of a subsurface wetland wastewater treatment system to eliminate the discharge of raw sewage from Avoca.

The project consisted of a conventional gravity collection system with a subsurface wetland wastewater treatment system. The treatment system consists of two trains of septic tanks in series to provide pretreatment/ preliminary treatment prior to discharge to a two-stage wetland treatment/ polishing system. The wetland system consists of lined cells that provide additional treatment beyond the preliminary treatment and unlined cells that provide polishing and effluent dispersal into the ground. The system was designed to seep through the ground, by discharging first into the ground water and ultimately into the drain adjacent to the unlined wetland cells. A series of monitoring wells are installed for monitoring of the operation and compliance.

Because it was an innovative technology, it took more than 5 years of working with the State of Michigan to provide enough evidence on the system's effectiveness to gain acceptance of the project. The system was constructed in 2009-2010, with startup operation in August 2010. Monitoring data to date demonstrates excellent reduction of classic pollutants and meets the required State permit parameters. Though influent samples have not been required, the wastewater is classic domestic wastewater which for comparison has a BOD5 (mg/l) typically around 200 mg/l in the influent. The effluent delivered from the wetland system achieved a monitored range of <2 to 5mg/l (permit limit 10 mg/l).

Contact Information: John O'Meara, Environmental Consulting & Technology, Inc., 2200 Commonwealth Blvd., Suite 300, Ann Arbor, MI 48105, Phone 734-769-3004, Fax: 734-769-3164, Email: jomeara@ectinc.com

USING CONSTRUCTED WETLANDS FOR RECYCLING WASTE WATER TO PROTECT SURFACE AND GROUND WATER

M. L. Robinson and *Angela O'Callaghan*
University of Nevada College of Cooperative Extension, Las Vegas, Nevada, USA

As urban populations continue to grow, development is pushing further from the centralized wastewater treatment plants and more into rural areas. In many areas, the conventional septic tank/field line systems have proven to be inadequate for wastewater treatment. This is especially true for areas with high ground water tables or poor soil percolation rates. In the United States, there are over 25 million septic tanks in use. Nationwide, septic tank failures range from 36% to 72%. Contamination of both ground and surface water from various sources continues to be a problem.

It has long been recognized that natural wetlands such as marshes, swamps and bogs help protect water quality. At the same time natural water areas such as these need to be protected from contamination by waste water. Constructed (or artificial) wetland systems mimic the treatment that occurs in natural wetlands by relying on plants and a combination of naturally occurring biological, chemical, and physical processes to remove pollutants from water. Constructed Wetlands are less energy intensive and more environmentally sound ways of treating wastewater, conserving potable water and protecting natural wetlands. Constructed wetlands not only reclaim water, but provide needed habitat for wildlife. Even a small one (20' x 20') will serve as a lush oasis, attracting birds, butterflies, toads and other animals.

This presentation on wetlands will look at the basic principles of constructed wetlands including a functioning model, a small home, a larger school applications that could be also be used for a small business such as a strip mall or a nursery for runoff. It will look at applications in various climates. The demonstrated effectiveness of constructed wetlands for wastewater treatment provides useful lessons to create buffer zones for various types of contaminated water. Wetlands have been able to remove 76.8% BODs, and up to 99% E coli.

Contact Information: M. L. Robinson, Professor, Environmental Horticulture and Water conservation, University of Nevada Cooperative Extension, 8050 Paradise Rd # 100 Las Vegas, NV 89123, Phone: 702-257-5529, Fax: 702-222-3100, E-mail robinsonm@unce.unr.edu

DESIGNING CONSTRUCTED WETLANDS TO REDUCE MOSQUITO PRODUCTION: ALTERNATIVE EMERGENT MACROPHYTES

William E. Walton[1], *David A. Popko*[1], *Dagne Duguma*[1] and *Justin Richardson*[2]

[1]Department of Entomology, University of California, Riverside, California, USA

[2]Department of Environmental Studies, Dartmouth College, Hanover, New Hampshire, USA

The large macrophytes (i.e., *Phragmites*, *Typha*, *Schoenoplectus californicus*, *S. acutus*) planted commonly in constructed treatment wetlands create conditions that reduce the effectiveness of integrated mosquito management (IMM) programs for free water surface constructed wetlands. An alternative species to the large macrophytes, which reach 3-3.5 m in height, is alkali bulrush (*S. maritimus*) which is comparatively smaller (1-1.5 m in height) in stature and possesses characteristics that are less likely to compromise IMM for constructed treatment wetlands. We measured the growth response and nutrient composition of alkali bulrush across a nitrogen gradient (0.12 to 50 mg NH_4-N/liter), quantified the relative decomposition rates of dead culms of alkali and California bulrushes during cool and warm seasons, and assessed the impact of emergent macrophyte species and crepuscular sprinkler disturbance on mosquito abundance over a 2-year period in wetland mesocosms.

Alkali bulrush growth (above- and below-ground dry mass) at intermediate nutrient concentrations was greater than at the lowest (0.12 NH_4-N/liter) and highest (50 NH_4-N/liter) nitrogen levels examined. However, the nitrogen concentration of plant tissues was directly related to enrichment level across the entire nitrogen gradient.

Dead alkali bulrush culms sank more rapidly than did culms of California bulrush; *S. maritimus* culms were more refractory to decomposition than was dead California bulrush in a constructed wetland treating ammonia-dominated municipal effluent. Decomposition rate (loss of mass) of *S. californicus* was three times faster than *S. maritimus* during both seasons and 3- to 4-times faster during the summer than during the winter. The ratio of carbon to nitrogen in *S. californicus* tissue declined faster than in *S. maritimus* during the first month of inundation.

Mosquito oviposition and abundance of immature mosquitoes and aquatic invertebrates were monitored in monotypic plots of alkali bulrush and California bulrush without or with daily sprinkler showers to deter mosquito egg laying. Oviposition by culicine mosquitoes was reduced by > 99% and immature mosquito abundance was reduced by > 90% by sprinkler applications. For wetlands without daily sprinkler treatments at dawn and dusk, alkali bulrush wetlands contained more egg rafts but significantly fewer mosquito larvae than did California bulrush wetlands. Species-specific differences in growth form and rate of spread of the two bulrushes contributed to differences in the aquatic invertebrate communities which may have caused differential top-down regulatory effects on mosquito populations. Stem density, rate of spread, and autumnal mortality of alkali bulrush were higher than for California bulrush. Mosquito predators were more common and non-predacious macroinvertebrates were less common in alkali bulrush compared to California bulrush.

Contact Information: William E. Walton, Department of Entomology, University of California, Riverside, CA 92521 USA, Phone: 951-827-3919, Fax: 951-827-3086, Email: william.walton@ucr.edu

MODELING RESERVOIRS TO ENHANCE THE PHOSPHORUS REMOVAL PERFORMANCE OF EVERGLADES STORMWATER TREATMENT AREAS

***Naming Wang**, Jeremy C. McBryan, Zaki Moustafa* and *Walter Wilcox*
South Florida Water Management District, West Palm Beach, Florida, USA

Large-scale Stormwater Treatment Areas (STAs) have been constructed and operated by the South Florida Water Management District (SFWMD) since 1993 to reduce surface water phosphorus (P) loading entering the Everglades. Everglades STAs are expected to consistently achieve ultra-low outflow P concentrations, similar to levels observed in downstream pristine unimpacted Everglades marsh areas. As an integral part of South Florida's regional flood control system, STAs have to cope with peak flows and loads during wet seasons, as well as drought conditions and competing water supply demands during dry seasons. The wide range of seasonal fluctuations presents unique challenges for the planning, design and operations of STAs to consistently meet water quality targets. Strategically placed reservoirs have been proposed by SFWMD to act as flow equalization basins to improve and sustain the performance of STAs.

A suite of hydrological and water quality models was used by SFWMD to examine the potential effects of using reservoirs in conjunction with STAs to enhance their P removal performance. The South Florida Water Management Model (SFWMM) and Regional System Model (RSM) provided 41 years of regional flow boundary conditions based on historical hydrological conditions and planned future conditions. The Dynamic Model for Stormwater Treatment Areas (DMSTA2) was then used to simulate water flows within upstream reservoirs and STAs and to estimate the P removal performance in terms of flow weighted mean outflow concentrations at each STA outlet. Reservoir operations and release protocols were investigated as a method to optimize P removal performance in STAs while adhering to physical, hydrological, and water supply constraints. The objectives for optimization of reservoir operations were to maximize STA performance by providing steady optimal inflow conditions to STAs, attenuating the impact of peak flows and loads during wet seasons, and preventing dry-out conditions during dry seasons. Trade-off analyses between reservoir sizes and STA expansion areas to meet water quality targets were conducted. Results suggest that adequate reservoir size combined with optimized reservoir operations improve STA phosphorus removal efficiency and provide a robust system capable of accommodating highly variable hydrologic and phosphorus loading conditions.

Contact Information: Naiming Wang, Hydrologic and Environmental Systems Modeling, South Florida Water Management District, 3301 Gun Club Road, FL 33406 USA, Phone: 561-682-2123, Email: nwang@sfwmd.gov

RETENTION POTENTIAL OF AN OFFLINE POND-WETLAND COMBINED SYSTEM ON RIVER WATER'S PAHS THROUGH SUPERFICIAL SEDIMENTATION

Weidong Wang[1], *Jun Zheng*[1,2] and *Chengqing Yin*[1]

[1]State Key Laboratory of Environmental Aquatic Chemistry, Research Center for Eco-Environmental Sciences, the Chinese Academy of Sciences, Beijing, China

[2]Graduate School of the Chinese Academy of Sciences, Beijing, China

Shijiuyang Constructed Wetland (SJY-CW), the largest drinking water source treatment wetland in China, is located in the stream networks of Yangtze River delta. It covers 1.1 km^2 and continually supplies 250,000 tonnes treated raw water per day to the drinking water plant while stores another 1,200,000 tonnes water for buffering emergency for 3-4 days. The purified water amount accounts for about 10 % of the river discharge. SJY-CW had been designed as a typical huge offline system consisting of ponds and plant-bed/ditch wetlands as well as some auxiliary hydraulic structures, as far as the river source is concerned. The total water flow meandering pathways extend for about 10 km. Three years' daily monitoring data from the beginning of trial run showed that the wetland could ameliorate the source water quality by one level according to the Chinese national environmental standards for surface water.

This study aims to reveal the distribution and retention of polycyclic aromatic hydrocarbons (PAHs) through the wetland. It was found that SJY-CW could effectively trap PAHs from source water through superficial sedimentation. The PAHs source feeding the wetland came mainly from the upstream polluted river water and the atmospheric deposition could be neglected with regard to the water discharge and area effect. Surface sediments became the considerable sink for PAHs especially in the first one third part of the wetland. The sedimentation flux of PAHs ranged from 5.05 $\mu g/(m^2 \cdot d)$ to 341.36 $\mu g/(m^2 \cdot d)$ in the whole wetland. The Winsorized mean ± SE of PAHs flux in the first one third part (flow pathways ca. 4 km) was 112.57 ± 21.46 $\mu g/(m^2 \cdot d)$ that was about three times the flux of 38.12 ± 6.26 $\mu g/(m^2 \cdot d)$ in the latter two third part (flow pathways ca. 6 km). The pre-treatment channel, pre-treatment pond, and plant-bed/ditch wetlands were proved to be the "hotspots" for PAHs sedimentation. After about 2.5 operation years, the PAHs net burial amount in the hotspots area reached up to 22,875.35 g (amount about 70 % with area 36 %) more than the other zones' burial amount 10,107.75 g (amount about 30 % with area 64 %). The survey results on the sections along plant beds and ditches suggested that the reed-dominated ecotones might be an ideal site for PAHs' sorption and biological degradation. The weighted average of PAHs sedimentation flux for plant-bed/ditch wetlands was about 1.27 times that for ponds if only considering the functioning not the position of water flow pathways. In contrast to the sediment depth of 100 cm in the source river, the overall newly deposited sediment depth of the wetland ranged between 3 cm and 55 cm with a median of 10.25 cm after 2.5 years without dredging ever. The 30 cm depth sediment column profile data indicated that the effective surface sedimentation depth for PAHs lay above 10-20 cm. The total PAHs contents in the surface sediments were about 2.5-4.5 times those in the deep sediment which were approximately equal to the local background level (206.7 µg/kg). The total contents of 16 USEPA priority list PAHs in the surface sediments ranged from 96.7 µg/kg to 1593.7 µg/kg with a Winsorized mean ± SE of 500.51 ± 49.58 µg/kg. This value was at a relatively low and safe level compared with the upstream network (averagely 4130 µg/kg). The risk level of total sedimentary PAHs dropped dramatically from 756.60 µg/kg to 96.7 µg/kg along the water flow pathways, and 4-6 ring proportion decreased from 51.6 % to 13.9 % while 2-3 ring proportion increased from 48.4 % to 86.1 % comparatively. Thus the composition of sedimentary PAHs changed for the better revealing the mitigation of PAHs' carcinogenicity. This case study suggested that SJY-CW as a huge offline pond-wetland combined system had exhibited substantial retention potential on the river water's PAHs through superficial sedimentation during the initial operation period.

Contact Information: Weidong Wang, State Key Laboratory of Environmental Aquatic Chemistry, Research Center for Eco-Environmental Sciences, the Chinese Academy of Sciences, Beijing 100085, China, Phone: +86 10 6284 9307, Fax: +86 10 6292 3563, Email: wdwangh@yahoo.com

CONSTRUCTED WETLANDS - LONG-TERM SUSTAINABILITY

INFLUENCE OF WETLAND VEGETATION ON STABILITY OF ACCRETED PHOSPHORUS IN THE EVERGLADES STORMWATER TREATMENT AREAS

Rupesh Bhomia[1], *K R Reddy*[1] and *Delia Ivanoff*[2]
[1]Soil and Water Science Dept. University of Florida, Gainesville, Florida, USA
[2]South Florida Water Management District, West Palm Beach, Florida, USA

The Everglades Stormwater Treatment Areas (STAs) were constructed to reduce total phosphorus (P) loads to the Everglades Protection Area (EPA). Approximately 18,000 ha of effective treatment area have been created south of Lake Okeechobee in Florida. These wetlands have removed over 1,400 metric tons of P and reduced annual average outflow total P flow-weighted mean concentrations (FWMC) from 147 µg/L to 33 µg/L. The importance of wetland vegetation in P removal is well documented, however limited Information is available on the role of different vegetation types on stability of accreted P. Based on dominant vegetation species, existing cells of these STAs are designated and maintained as emergent aquatic vegetation (EAV) and submerged aquatic vegetation (SAV) cells.

We characterized recently accreted soil P into reactive and stable pools and compared these pools between SAV and EAV cells. We employed operationally defined P fractionation scheme and determined inorganic, organic and residual P fractions, of which first two fractions constituted reactive forms, while residual P represented stable form. The reactive P can potentially be remobilized following changes in nutrient status and/or hydrological regimes and may adversely impact STA performance. The study was aimed to explore the differences in vegetation types in terms of stability of P pools in accreted soils.

Intact soil cores were collected from 44 sites across 3 cells of STA-1W (1 SAV and 2 EAV) and 4 cells of STA-2 (2 SAV and 2 EAV). Soil cores were divided into three layers- floc, RAS and pre-STA soil. Floc and RAS accumulated after STA became operational, while underlying peat represents pre-STA soils. Across the studied cells, SAV and EAV cells did not differ significantly in relative proportion of reactive and stable P pools. Reactive P constituted 75% of TP in floc sections of EAV cells and 62% of TP in SAV cells. In RAS, the reactive P was 64% of TP for EAV and 67% of TP for SAV cells. However, floc and RAS sections of EAV cells showed higher organic P fractions (50% and 40% of TP) compared to SAV (23% and 37% of TP). This suggested accrual of more recalcitrant P in EAV cells than in SAV cells. This observation is directly supported by our understanding of dominant P removal pathway in these cells – SAV promoting removal in form of calcium (Ca) bound inorganic P while EAV enhances P storage primarily via plant uptake and peat burial. This Information could be useful for STA management in selecting the optimum vegetation type or mix for further improving and sustaining P removal, given variable hydraulic and P loads in different sub-basins of STAs.

<u>Contact Information</u>: Rupesh K Bhomia, Soil and Water Science Dept.,University of Florida, 102 Newell Hall, P.O. Box 110510, Gainesville, FL 32611. Phone: 352.392.1803 Extn. 327 Email: rbhomia@ufl.edu

A PERSPECTIVE ON FLORIDA'S LARGE-SCALE TREATMENT SYSTEMS FOR PHOSPHORUS REMOVAL

Thomas A. DeBusk[1] and *William F. DeBusk*[2]
[1]DB Environmental, Inc.
[2]Water Resources Group, LLC

This presentation provides an overview of the phosphorus (P) removal performance of several large-scale (> 100 ha) wetland treatment systems in north, central and south Florida. These wetlands represent a diversity of system configurations and vegetation types, and together they provide treatment of municipal wastewater effluents, agricultural runoff, and eutrophic lake water.

Wetlands that receive wastewater following secondary treatment include: Blue Heron treatment wetland in Titusville, in operation since 1990, a constructed wetland with a total area of ca. 110 ha, and Wolf Creek Swamp in Monticello, operational since 1988, a 13 ha constructed wetland combined with a 100 ha natural (forested) receiving wetland. Wetlands receiving effluent from advanced wastewater treatment (AWT) facilities include: Orange County Eastern Service Area Wetlands, operational since 1988, a hybrid constructed wetland, comprised of ca. 60 ha of combined constructed wetlands and ca. 60 ha of natural (forested) receiving wetlands; Orlando Easterly Wetlands, operational since 1987, a constructed wetland with a total area of ca. 500 ha, primarily as emergent marsh; and Bayou Marcus Wetland in Pensacola, operational since1998, a restored (previously hydrologically-altered) forested wetland with a total area of ca. 400 ha.

The Lake Apopka Marsh is a 310 ha constructed wetland, originally commissioned in 1990, designed for treatment of hypereutrophic waters near the outflow of Lake Apopka. The wetland is designed to reduce P concentration within the lake as well as downstream waters in the Upper Ocklawaha River Basin. Finally, the six Everglades Stormwater Treatment Areas (STA) in south Florida are a series of constructed wetland impoundments containing both emergent and submerged aquatic vegetation. Ranging in area from 913 to 6,695 ha, these wetlands were brought online during 1994-2004 and are designed largely for P removal, serving as a buffer between the Everglades and runoff from upstream watersheds with predominately agricultural land use. The relative effectiveness and sustainability of P removal in these wetlands will be examined and discussed in the context of their divergent characteristics, e.g., vegetation and soil type, influent P concentration, P mass loading and source waters.

Contract Information: Thomas A. DeBusk, DB Environmental, Inc., 365 Gus Hipp Blvd., Rockledge, FL 32955 USA, Phone: 321-631-0610, Fax: 321-631-3169, Email: tom@dbenv.com

PHOSPHORUS REMOVAL PERFORMANCE AND SUSTAINABILITY OF A SUBMERGED AQUATIC VEGETATION-DOMINATED CONSTRUCTED WETLAND FOR EVERGLADES (USA) RESTORATION

Forrest E. Dierberg[1], *Thomas A. DeBusk*[1], *Scott D. Jackson*[1], *Kevin Grace*[1], *Stacey Galloway*[1], *Nancy Chan*[1] and *Delia Ivanoff*[2]

[1]DB Environmental, Inc., Rockledge, Florida, USA

[2]South Florida Water Management District, West Palm Beach, Florida ,USA

Six large (913-6695 ha) treatment wetlands, known as stormwater treatment areas (STAs), have been constructed for removal of phosphorus (P) from agricultural drainage waters (ADW) and other sources prior to release into the Everglades (Florida, USA). The STAs typically are configured with emergent vegetation in the inflow region cells and submerged aquatic vegetation (SAV) species in the outflow region cells. While treatment wetlands dominated by emergent vegetation (e.g, *Typha, Scirpus*) have been studied intensively for decades, little is known about the long-term P removal effectiveness and P retention mechanisms of SAV-dominated wetlands. For this effort, we performed comprehensive surveys of surface and pore waters, vegetation, and soil P in a SAV-dominated flow path (Cell 3) within one of the STAs (STA-2).

Flow-through operation of STA-2 Cell 3 was initiated in 2001. During the period from July 2001 – December 2009, Cell 3 exhibited a P removal rate of 83%, reducing average (flow-weighted mean) inflow TP levels from 83 µg/L to 19 µg/L. This represents an average mass TP removal rate of 1.16 g P/m^2/yr. Porewater and soil sampling was conducted in September 2005, then repeated in January 2010; in the interim, the flow path accumulated soil at a rate equivalent to ca. 1 cm/yr. Analysis of accrued soils indicated a slight increase in TP content during this time, from 856 to 916 mg/kg in the inflow region, 616 to 735 mg/kg in the mid-region, and 603 to 688 mg/kg in the outflow region. The relatively low level of soil P and the absence of a temporal trend in outflow TP concentration suggest that the SAV-dominated Cell 3 wetland is capable of effective long-term P removal from inflow waters.

Contact Information: Forrest E. Dierberg, DB Environmental, Inc., 365 Gus Hipp Blvd., Rockledge, FL 32955 USA Phone: 321-639-4896; Fax: 321-631-3169. Email: woody@dbenv.com

LONG-TERM PHOSPHORUS REMOVAL PERFORMANCE BY A LARGE-SCALE CONSTRUCTED WETLAND TREATING LAKE WATER

Ed J. Dunne, *Michael F. Coveney, Erich R. Marzolf, Victoria R. Hoge, Roxanne Conrow, Robert Naleway, Edgar F. Lowe* and *Lawrence E. Battoe*
St. Johns River Water Management District, Palatka, Florida, USA

Constructed wetlands (CWs) treat various types of waters. However, few CWs treat lake water at a large-scale. We examined the efficacy of a large-scale (280 hectare) constructed wetland (the marsh flow-way), to treat water from Lake Apopka, FL. The long-term phosphorus performance goal is to maximize phosphorus removal, rather than attain a specific phosphorus concentration in outflow water.

The marsh flow-way was constructed on former agricultural land, which was previously used for intensive row crop agriculture for 40-50 years. Lake water enters the flow-way via screw gates and flows through each cell are operated independently. As water leaves each wetland cell, it collects in a basin and the treated water is pumped back into Lake Apopka. Vegetation within the system consists of shallow marsh and shrub swamp communities. Open water areas are common and cover about 17% of the treatment area.

During the seven years of flow-way operation (2003-2010), the hydraulic loading rate was high (36 m yr^{-1}) and this was equivocal to 40% of the lake's volume being treated per year. About 90% of the incoming phosphorus was in a particulate form. During the initial start-up period, which lasted three to four months, the system released P, mostly in dissolved forms. This was probably released from phosphorus laden site soils upon initial flooding. After this initial period, the system began to retain phosphorus. Annual areal mass removal rates ranged between 0.5 and 1.8 g of total phosphorus m^{-2} yr^{-1}, while the seven-year median was 0.9 g m^{-2} yr^{-1}. This equated to an efficiency of 28%, which was similar to our long-term goal of 30%.

During the seven years of operation, various techniques were used to help sustain phosphorus removal performance. These included drawdown, vegetation mowing, ditch cleaning and the intermittent use of alum. As Lake Apopka water continues to improve, we are using more passive techniques to help sustain phosphorus removal performance and sustainability. For example, operating all cells during cooler months (October through May), while not operating some cells during warmer months (June through September), as we see decreased phosphorus removal rates during these times.

Contact Information: Ed J. Dunne, St. Johns River Water Management District, Bureau of Environmental Sciences, Division of Water Resources, 4049 Reid Street, Palatka, FL 32177 USA, Phone: 386-329-4227, Email: ejsdunne@gmail.com

MACROPHYTE ZONATION AND SUSTAINABILITY IN STORMWATER WETLANDS IN SUBTROPICAL EASTERN AUSTRALIA: DESIGN AND FUNCTION

Margaret Greenway
Griffith University, Brisbane, Queensland, Australia

Vegetation plays an essential role in the treatment performance of stormwater wetlands. Wetland hydrology – flow velocity, water depth and hydroperiod, is crucial to macrophyte establishment and survival. Water depth and the extent of flooding and drying determine the macrophyte types and wetland zones. Extremes in climate from intense storm events and flash flooding to extended drought need to be considered in the design and long term sustainability of stormwater wetlands. Stormwater wetlands are usually designed with shallow and deep macrophyte zones and deeper ponds. However, problems of macrophyte establishment, survival and colonisation occur when aquatic plants growing in the ephemeral zone or shallow-marsh zone are inundated for prolonged periods or water levels drop during dry periods. Thus aquatic plants growing in stormwater wetlands are subjected to huge fluctuations in water depth. High flow velocities can also uproot plants, cause scouring and erosion. Improved designs incorporating bypass / overflow channels, riser outlets and regular maintenance are essential for long term sustainability of macrophytes, and hence wetland treatment performance.

A study of two stormwater wetlands in Brisbane, Australia highlighted many of the problems associated with establishing macrophyte zones in a subtropical climate with intense storm events. At Golden Pond Wetland, where there was no bypass channel, species with poorly developed root systems were washed away during intense storm events. An undersized sedimentation basin regularly filled with sand which overflowed and smothered plants. At Bridgewater Creek Wetland, the improved design incorporated a bypass channel and a series of interconnected wetlands with ephemeral, shallow and deep macrophyte zones and deeper ponds. Unfortunately, extended periods of inundation due to a poorly designed outlet combined with the lack of regular maintenance, resulted in the complete loss of all macrophytes over a period of 5 years. This system is now an open water lake. Both case studies demonstrate that regular maintenance as well as proper design is essential for macrophyte survival and long-term wetland sustainability.

<u>Contact Information</u>: Margaret Greenway, School of Environmental Engineering, Griffith University, Nathan Campus, Brisbane, Qld 4111, Australia. Phone 61 7 37355296; Email m.greenway@griffith.edu.au

INDICATOR BACTERIA SEQUESTRATION IN STORMWATER WETLANDS

Jon M. Hathaway[1] and *William F. Hunt*[2]
[1] Biohabitats, Inc., Raleigh, NC, USA
[2] North Carolina State University, Raleigh, NC, USA

As stormwater regulations continue to move toward stringent water quality thresholds, stormwater control measures (SCMs, also known as Water Sensitive Urban Designs or WSUDs) have become an integral part of watershed management strategies. Each SCM provides some combination of natural treatment mechanisms and fosters certain environmental conditions which are advantageous for water quality and quantity improvements. One such SCM is the stormwater wetland, which allows treatment of relatively large watersheds while providing water quality benefits and stormwater detention. Stormwater wetlands also provide numerous other benefits, such as habitat for wildlife and the potential for public education. Although stormwater wetlands have been studied in detail for many pollutants, there is still a relatively limited understanding of their ability to sequester indicator bacteria. Stormwater runoff is a transport mechanism for indicator bacteria to receiving waters, resulting in an increased risk to public health through consumption of contaminated shellfish or ingestion by swimmers. The resulting economic and public safety concerns are common throughout the world. Thus, understanding the ability of stormwater wetlands to sequester indicator bacteria is an important step in indicator bacteria management in urban watersheds.

Evaluations of indicator bacteria sequestration on five stormwater wetlands were performed in Wilmington, Charlotte, and Lenoir, North Carolina, USA. Performance was highly variable among sites, ranging from -18 to 96% sequestration of *E. coli* from the four sites in Wilmington and Charlotte. The effluent geometric mean concentrations from the sites were typically higher than the United States Environmental Protection Agency’s threshold for *E. coli* in surface waters (126 counts / 100 ml), suggesting that reaching these thresholds may be difficult when utilizing stormwater wetlands. Further investigation of indicator bacteria sequestration was possible at the stormwater wetland in Lenoir. The wetland was sampled during both storm and base flow at multiple points along its flow path, providing the opportunity to identify changes in fecal coliform concentrations through the wetland. Overall, large concentration reductions were noted from the inlet to the outlet of the system. The geometric mean fecal coliform concentrations at the wetland inlet and outlet were 7,980 and 1,931 CFU/100 ml, respectively. However, a baseline concentration of fecal coliform appeared to exist in the wetland, as concentrations remained fairly consistent from the mid-point of the wetland to the outlet. This implies that a background concentration of indicator bacteria may be present in stormwater wetlands. These systems are ecologically rich, potentially leading to production and/or persistence of indicator bacteria. The results of this study also suggest that maximizing flow path is important for stormwater wetlands implemented to mitigate microbial pollutants.

Contact Information: Jon M. Hathaway, Biohabitats, Inc., 8218 Creedmoor Road, Suite 200, Raleigh, NC 27613 USA, Phone: 919-518-0311, Email: jhathaway@biohabitats.com

CONSTRUCTED WETLANDS VERSUS PONDS FOR STORMWATER MANAGEMENT: A FRAMEWORK FOR ECOSYSTEM SERVICES ASSESSMENT

Trisha L.C. Moore and ***William F. Hunt***
North Carolina State University, Raleigh, NC, USA

Constructed stormwater ponds and constructed stormwater wetlands (CSWs) are two types of stormwater control measures (SCMs) designed to regulate runoff hydrology and quality from urban areas. However, these created ecosystems can also provide a range of other societal benefits, or ecosystem services, which are often acknowledged but rarely quantified. In this study, additional ecosystem services, including carbon sequestration, biodiversity, and cultural services, were assessed and compared between 20 ponds and 20 CSWs in North Carolina, USA.

Carbon sequestration was estimated through the carbon content of pond and wetland sediments across a chronosequence of pond and CSW systems. Biodiversity was quantified in terms of the richness and Shannon diversity index of vegetative and aquatic macroinvertebrate communities.

Cultural services were qualitatively assessed based on the potential for recreational and educational opportunities at each site. Ponds and wetlands were found to support similar levels of acroinvertebrate diversity, though differences in community composition arose between the two habitat types. CSWs demonstrated greater potential for soil carbon accumulation, vegetative diversity, and cultural ecosystem services. Although CSWs provided a more robust suite of ecosystem services compared to constructed ponds, the inclusion of a vegetated littoral shelf in pond systems diminished the difference in ecosystem service provision. This assessment provides an initial framework upon which future assessments of ecosystem service provision by SCMs can build.

Contact Information: William Hunt, North Carolina State University, Box 7625, Raleigh, NC 27695-7625, United States, Phone: 919-515-6739, Email: wfhunt@ncsu.edu

LONGEVITY OF PHOSPHORUS CONTROL MARSHES

Robert H. Kadlec
Wetland Management Services, Chelsea, MI, USA

The south Florida stormwater treatment areas (STAs) have been functioning at large scale since 1994. These have received a number of modifications, due to real and perceived opportunities for enhancement. Nonetheless, they have generally continued to perform much as anticipated, and therefore give credence to the concept of long-term sustainability. The interpretation of actual long records is the best way to infer what may happen to P-treatment wetlands over the course of time, and we now have such records.

It is the purpose of this paper to discuss some of the popular concepts of treatment wetland life expectancy, and to consider the design and operating strategies that may be required to allow a wetland functional lifetime of many decades. Wetlands utilize incoming phosphorus to fuel the biogeochemical cycle. A secondary consequence of the nutrient-rich aquatic environment is the stimulation of the biogeochemical cycle and the consequent enhancement of accretion of refractory residuals. This is borne out in the performance of wetlands that have been receiving nutrient laden discharges for long periods of time, as well as by the performance of wetlands that have been constructed and operated for up to two to three decades.

The long-term storages of phosphorus in treatment marshes are dominated by the formation and accretion of the new soils. Although some storage may occur in the development of new, larger standing crops of vegetation, that amount is important only in the first few years of operation. Phosphorus storage due to sorption, although quantifiable, is likewise not important after a few years. Plant uptake forms one of the first steps in the cycle that ultimately buries phosphorus-rich residuals. However, microbial and algal activities are also very important in phosphorus cycling, and by themselves are capable of driving high rates of phosphorus removal. These long-term sustainable processes that remove phosphorus in treatment marshes have an infinite lifetime, and there is no direct life limit to wetland efficacy on that account.

Thus, after a startup period, virtually all of the added phosphorus will be stored in new soils and sediments. Sedimentation of incoming suspended material is augmented by bio-accretion. Sediment deposition leads to soil accretion, which in turn sequesters phosphorus, if there is an important incoming sediment load. In many treatment wetlands, the internal production of new sediments far out-weighs the deposition of incoming materials. The retention of this internally generated material, together with its P content, is termed bio-accretion, to differentiate it from the retention of incoming particulate matter. Bio-accretion is likely to produce one or two centimeters per year of new solids, and over a period of many years, this may influence the wetland hydraulics. Such accretions have been quantified in the STAs and in the downstream receiving Everglades marshes. If the wetland is adequately maintained, by taking the steps necessary to accommodate bio-accretion, then there is no apparent limit to wetland lifetime for phosphorus removal.

Contact Information: Robert H. Kadlec, Wetland Management Services, Chelsea, MI 48118 USA, Phone: 734-475-7256, Email: rhkadlec@chartermi.net

EVERGLADES STORMWATER TREATMENT AREAS: TWO DECADES OF INTEGRATING SCIENCE AND ENGINEERING FOR ECOSYSTEM RESTORATION

Jeremy C. McBryan*, Tracey T. Piccone* and *Lawrence R. Gerry*
South Florida Water Management District, West Palm Beach, FL, USA

The Everglades Forever Act (EFA) was passed by the Florida Legislature in 1994, which required the South Florida Water Management District (SFWMD) to implement the Everglades Construction Project (ECP) consisting of large constructed wetlands, or Stormwater Treatment Areas (STAs), and the Everglades Agricultural Area Best Management Practices (BMPs) program. To date, over 45,000 acres (70 square miles) of STA have been completed and are in operation, and by July 2012, an additional 11,500 acres (18 square miles) of STA will be operational. The EFA also required SFWMD to implement a research program to optimize the design and operation of the STAs, including research to reduce outflow concentrations to levels needed to comply with water quality standards in the Everglades, including the phosphorus criterion. Over the past two decades, substantial progress toward reducing phosphorus levels discharging to the Everglades has been made. From October 1993 through April 2011, BMPs and STAs have collectively removed more than 3,800 metric tons of total phosphorus that otherwise would have entered the Everglades. Compared to the pre-STA/BMP period, phosphorus loads and concentrations discharged to the Everglades have declined while flows to the Everglades have increased.

The design, operation and management of STAs have continuously evolved to incorporate the scientific and engineering knowledge gained through optimization research and operational experience. There are several design and operational elements that are requisite to achieving and sustaining appropriate water quality treatment performance in STAs. Treatment cell topography is critical, especially when outflow phosphorus concentration targets are extremely low. Highly uneven topography results in non-uniform flow, hydraulic short-circuiting and the inability to maintain desirable water depths. After consecutive extremely active hurricane seasons in 2004 and 2005, it became apparent that enhancements were necessary to help reduce the impacts of wind and wave action within STAs during large storm events. Emergent vegetation strips were planted in numerous cells to reduce potential damage to submerged aquatic vegetation communities. STA dryout is a major concern due to potential spikes in phosphorus concentrations upon rehydration. Therefore, the development of strategies to effectively manage STAs during regional drought conditions have been developed and include proactive measures to maintain minimum water levels in priority treatment cells in an effort to reduce vegetation stress and maintain treatment performance. In addition, proactive management of both desirable and undesirable vegetation within STAs is critical to achieving and sustaining treatment performance. Periphyton-based STA (PSTA) systems, which are currently being studied by SFWMD, may provide improved treatment capability. Evaluation of the PSTA treatment technology research data is underway to determine the feasibility of future large-scale implementation.

Contact Information: Jeremy C. McBryan, South Florida Water Management District, 3301 Gun Club Road, West Palm Beach, FL 33406 USA, Phone: 561-682-6355, Fax: 561-682-5046, Email: jmcbryan@sfwmd.gov

LONG-TERM TREATMENT OF INDUSTRIAL DISCHARGE FOR METALS WITH CONSTRUCTED WETLANDS

Eric A. Nelson
Savannah River National Laboratory, Aiken, SC, USA

The Savannah River Site (SRS) is a large Department of Energy facility (80,267 hectares) located along the Savannah River in west central South Carolina. The SRS has numerous production and industrialized areas that produce industrial waste water discharges. These discharges are regulated by the state of South Carolina, and are subject to discharge limits for numerous possible contaminants. As part of the re-issuance of the National Pollutant Discharge Elimination System (NPDES) general permit for the SRS in the late 1990's, greatly reduced concentrations of metals (especially copper, lead and zinc) were included. One high volume industrial discharge, with a daily discharge of 3,700 cubic meters per day (one million gallons per day), was going to require some type of treatment of its effluent to meet the new permit requirement for copper (22 ug/L) and toxicity. After evaluation of numerous alternatives, a surface flow constructed wetland was chosen as the preferred treatment option. The facility consists of 3.25 hectares (8 acres) of wetland cells and a large retention basin to store normal discharge and stormwater from the facility for treatment in the wetlands. The constructed wetland treatment facility was licensed by the state as a permitted water treatment facility in 2000, and has been monitored for water quality parameters since that time. Data representing twelve years of function and performance relating to water quality, metal removal, and cost will be presented.

A new general NPDES permit was again issued in 2005 with additional restrictions on metal discharges (copper limit of 7 ug/L). Because of the performance history of the initial installation, its low cost of construction, and the extremely low operating and maintenance costs compared to conventional treatment facilities, a constructed wetland treatment facility was designed for an outfall with lower nominal discharges and was sized accordingly. Additionally, because wetland facilities increase the dissolved organic carbon in the effluent as part of the normal wetland function, the bioavailability of metals exiting from the wetlands is also greatly reduced to biological receptor species. Because of this, the discharge limits for individual outfalls can be negotiated with the regulators based on water effects ratios and biotic ligand models that have been approved.

The long term performance of these wetland treatment systems in the Southeast US has been exceptional, both in terms of the removal efficiency of metals from the influent water and in terms of the low cost of operation. The "design life" of the facility is 20 years, but the actual performance life will be considerably longer. No hazardous waste is being created in the wetland cells due to the low concentrations of metals that are being accumulated and sequestered in the organic sediments and the soil profile.

Contact Information: Eric A. Nelson, Environmental Science Group, Building 773-42A, Savannah River National Laboratory, Aiken, SC 29808 USA, Phone: 803-725-5212, Email: eric.nelson@srnl.doe.gov

SPARTINA ALTERNIFLORA MARSH DEVELOPMENT ON NUTRIENT-RICH DREDGED MATERIALS IN A LARGE-SCALE RESTORATION PROJECT IN MID-CHESAPEAKE BAY: A CASE OF SILICON DEPLETION?

Lorie W. Staver[1]*, J. Court Stevenson*[1]*, Jeffrey C. Cornwell*[1]*, Michael Owens*[1] and *Philippe Hensel*[2]
[1]University of Maryland Center for Environmental Science, Cambridge, MD, USA
[2]NOAA, National Geodetic Survey, Silver Spring, MD, USA

As part of the Poplar Island Environmental Restoration Project there is a plan to create approximately 298 hectares of tidal marsh habitat, primarily using material dredged from shipping channels in the upper Chesapeake Bay. Unlike the sandy material used in many coastal marsh restoration projects, this material is fine-grained and nutrient rich. The first wetland cell completed was constructed using locally obtained sand while subsequent cells were constructed with the upper Bay dredged material, providing an on-site comparison. Striking differences in the vegetation quickly developed on the two substrates, including sparser vegetation and higher recruitment of new species on sand, higher biomass production and lower root:shoot ratios on dredged material, and severe dieback on dredged material but not on sand. Lodging, intense muskrat grazing and high rates of fungal infection were also observed on dredged material but not on sand. We hypothesize that growth-induced silica deficiency may result from the high nitrogen and phosphorus supply and contributes to symptoms observed in the dredged material marsh, as it does in highly fertilized rice and sugarcane, and that a silicon amendment may help alleviate these symptoms. Subsidence in the dredged material cells due to compaction may also contribute to dieback. Since external inorganic sediment inputs are limited in this system due to the limited drainage area, belowground biomass production is especially important for vertical accretion, which is necessary to keep abreast of local sea-level rise (SLR), currently ~3.2 mm y^{-1} in Chesapeake Bay and expected to at least double over the next century. Sediment elevation tables and marker horizons have been deployed to evaluate elevation changes, which must keep up with SLR given the goal of creating self-sustaining, productive marshes.

<u>Contact Information</u>: Lorie W. Staver, University of Maryland Center for Environmental Science, Horn Point Laboratory, P.O. Box 775, Cambridge, MD 21613 USA, Phone: 410-221-8446; Fax: 410-221-8290, Email: lstaver@umces.edu.

CONSTRUCTED STORMWATER WETLANDS: DESIGN AND FUNCTION

Bridget M. Wadzuk and *Robert G. Traver*
Villanova University, Villanova, PA, USA

The Villanova University Constructed Stormwater Wetland (CSW) is a stormwater control measure used to reduce peak flow rates and improve water quality of the storm runoff over the 20 ha watershed that enters a tributary to the Schyulkill River. The CSW is a retrofitted detention basin. In 1999 the detention basin was converted into a CSW, however about half the area was left relatively undesigned as campus expansion plans called for using this area. A decade later, campus expansion plans had not materialized and the site was reconstructed in 2010 to utilize the entire 0.4 ha area.

The 2010 reconstruction used knowledge gained from active research on the original CSW as well as the growing field of stormwater control measures to design a site that could provide several ecosystem services: mitigate storm hydrology, retain and promote nutrient cycling within the CSW, promote carbon sequestration, and provide habitat. To meet the goals of nutrient cycling and carbon sequestration, alternating zones of aerobic and anaerobic and both woody and herbaceous plants were featured. To meet the goal of improving peak flow reduction, the flow length was increased using a series of meanders to increase the hydraulic residence time. The CSW has been and will continue to be an active research site, so the site was designed and instrumented to monitor water quantity and quality. Monitoring has occurred since construction was completed in fall 2010 to discern the effect of vegetation establishment on the CSW hydraulics and water quality.

The original CSW proved significantly reduce peak flows and improving water quality (Wadzuk et al., 2010); total suspended solids, total phosphorous, reactive phosphorous, and total nitrogen were all significantly reduced in terms of load and concentration. Soil samples at various depths were taken to quantify the amount of organic matter and organic carbon retained within the soil. There was substantial amount of organic carbon within the upper layer of the soil stratum. The reconstructed CSW was completed in fall 2010 and was planted in spring 2011. In the first year of monitoring since construction, the CSW has shown peak flow reduction and water quality improvement of nutrient concentrations from inlet to outlet. Additionally, there is evidence of nitrogen cycling (nitrification / denitrification), which requires aerobic and anaerobic conditions, respectively, demonstrating that the design is functioning as expected. Soil samples have been taken and will continue to be monitored over time to assess the development of the soil organic matter and carbon sequestration potential.

Contact Information: Bridget M. Wadzuk, Department of Civil and Environmental Engineering, Villanova University, Villanova, PA 19085, USA, Phone: 610-519-5365, Fax: 610-519-6754, Email: bridget.wadzuk@villanova.edu

SPATIAL SOIL CHARACTERISTICS AND PHOSPHORUS STABILITY IN EMERGENT AND SUBMERGED AQUATIC VEGETATION CELLS OF STORMWATER TREATMENT AREAS

Delia Ivanoff[1], *Rupesh Bhomia*[2] and ***Manuel Zamorano***[1]
[1]South Florida Water Management District, West Palm Beach, FL, USA
[2] University of Florida, Gainesville, FL, USA

The Everglades Stormwater Treatment Areas (STAs) were constructed to reduce phosphorus (P) from agricultural runoff and other sources to reduce P loading to the Everglades. These areas are compartmentalized into cells which are managed for emergent aquatic vegetation (EAV), submerged aquatic vegetation (SAV). Soil physico-chemical characteristics, P uptake mechanism, and pattern of soil and phosphorus accrual generally differ among vegetation types. This study compares Cell 2 (EAV) and Cell 3 (SAV) of STA-2 to determine the influence of dominant vegetation type on soil and P accrual, and P stability. This Information is useful in identifying factors that may potentially influence outflow TP concentration. Data indicates enrichment in the floc and recently accrued soil, and floc TP is significantly higher in Cell 2 than Cell 3. Cell 3 has significantly higher stored P (g m^{-2}) than Cell 2, likely as a result of differences in the type of accreted material, bulk density, and hydrologic patterns between the two cells.

The estimated soil accretion rates were 1.1 ± 0.3 cm yr^{-1} and 1.2 ± 0.4 cm yr^{-1} for Cells 2 and 3, respectively, while P accretion rates were 1.6 ± 0.41 g $m\text{-}^{2}$ yr^{-1} and 2.5 ± 1 g $m\text{-}^{2}$ yr^{-1} in Cells 2 and 3, respectively. To determine the stability of the accrued P, intact soil cores from these two cells were collected in May 2011 and analyzed for various soil physico-chemical properties and soil P fractionation in floc, recently accreted soil (RAS), and pre-STA soil. Results show that although floc TP was higher in Cell 2, TP in RAS was higher in Cell 3. Loss-on-ignition characteristic also indicates that floc is predominantly inorganic in SAV cell while EAV floc is highly organic. Spatial plots between calcium (Ca) and TP indicate that Ca has a major influence on P removal in Cell 3 while no significant effect of Ca was observed in Cell 2. Results of P fractionation from these two cells indicate that inorganic P was relatively higher in the SAV cell floc than in the EAV cell floc. Inorganic P fractions in the floc, RAS, and pre-STA were similar; however organic P fraction was higher in RAS than in floc, indicating relatively stable pool in RAS. Residual fraction in floc was highest among all the fractions, followed by RAS. The overall percentages of residual fractions were higher in SAV in comparison to EAV cells, but may not be statistically significant. Over time, as floc consolidates and becomes part of the RAS, it preserves some of the floc attributes indicative of the vegetation effects.

Contact Information: Delia Ivanoff, Water Quality Treatment Technology Section, Applied Science Bureau, Water Resource Division, South Florida Water Management District, 3301 Gun Club Road, West Palm Beach, FL33406, USA. Phone: 561-682-2681, Email: divanoff@sfwmd.gov

ECOSYSTEM RESTORATION - GOVERNANCE POLICY AND POLITICS

GOVERNMENTAL LAWS, RULES AND POLICIES, ARE THEY KEEPING UP WITH RESTORATION OBJECTIVES

Kenneth G. Ammon
WRScompass, West Palm Beach, FL, USA

From local construction impact and inspection fees, through regional, state and federal wetland mitigation requirements to construction and operational constraints imposed by the Endangered Species Act (ESA), twenty-first century environmental restoration projects are subjected to laws, rules and policies (LRP's) that in most cases were historically formulated to offset impacts caused by commercial, industrial, residential and agricultural activities. Few of these LRP's have been re-addressed to consider the cumulative societal costs, overwhelming ecosystem benefits and the need for consistent and reliable operations of environmental restoration projects.

While some local governments insist on impact fees based on a percentage of construction, others have actually withheld project canal and right of way easement transfers hostage until these fees have been paid or other demands have been met. These types of issues should be addressed by the state through encompassing legislation pertaining to environmental restoration projects.

A holistic regulatory approach needs to be formulated by local, state and federal authorities as to the uniqueness of environmental restoration projects as compared to other development activities. The same taxpayers are ultimately funding these projects at four levels government, local, state, regional and federal, so maximizing benefits and minimizing costs needs to be integral in revisions to governmental LRP's. While there has been some very positive policy interpretation progress primarily through the Army Civil Works Attorney's office, this progress has primarily involved general policies with room for interpretation vs. laws and rules which are much more rigid. Part of our charge in minimizing costs should be to reduce regulatory hurdles, reduce planning timeframes and provide more implementation flexibility such as consistency in federal vs. local sponsor regulatory requirements.

Likewise, there is a clear expectation of operational performance of each project from a quantity, quality, timing, distribution and seasonal delivery perspective, including a congressional expectation in the case of Everglades Restoration that has proved to be elusive. The reliability of operations which drives the environmental benefits of the projects can be compromised because once completed, many are attractants to endangered species and migratory birds for which current LRP's require a change in project operations to protect. Ultimately these projects provide and overall benefit to both endangered species and migratory birds regardless of operations but proper and consistent operations will provide many more benefits that could be lost if current LRP's are not revised. These other benefits include nutrient reduction, wetland rehydration, flow equalization, groundwater recharge, redistribution, water supply, seepage control and increased wildlife habitat.

These LRP consistency issues should not be viewed as an affront on existing LRP's but simply a recognition that true environmental restoration projects are implemented for the public good, improve our quality of life, provide multiple ecosystem-wide benefits, are paid for by all taxpayers on multiple levels and as such, should have special regulatory status at all levels of government.

<u>Contact Information</u>: Kenneth G. Ammon, WRScompass, 2400 Centrepark West Drive, Suite 125, West Palm Beach, Fl. 33409 USA, Phone: 561-684-5474 Ext. 239, Fax: 561-684-5419, Email: Kammon@WRScompass.com

COUNTY-BASED GOVERNANCE OF PARTICIPATORY RESTORATION AND SURVEY FOR WETLANDS IN TAIWAN

Chia-Hong Hong[1]*, Terrence Lee*[1] and ***Wei-Ta Fang***[2]
[1]Urban and Rural Development Branch, Construction and Planning Agency, Ministry of the Interior, Republic of China, Taiwan
[2]SWS Asia Chapter, Taiwan Wetland Society, Taipei, Taiwan

Since the 8th INTECOL International Wetland Conference (2008) and COP 15 Copenhagen Climate Summit (2009) have been held from the years of 2008 and 2009 due to climate rapid change, wetlands have been explored their outstanding capabilities to reduce greenhouse gases. The conservation of wetlands has become more and more crucial during current years. According to CPA's Rule, the Urban and Rural Development Branch (The Branch), CPA has developed the guideline for three objectives, such as: 1) wise uses of wetlands resources; 2) construction of entire national ecological network of important wetlands; 3) and enforcement of international exchanges to promote wetland conservation. The branch proceeded to develop "Wetland Conservation Act (draft)", promote wetland biodiversity monitoring system of standard operating procedures (SOP), build national survey database for the importance of wetlands, join the Society of Wetland Scientists (SWS), organize the "First SWS Asia Chapter's 2008 Asian Wetland Convention" as well as host a series of activities. These performances have promoted the conservation planning and management systems. Furthermore, the branch provided opportunities to educate people to understand the importance of wetlands and how to use wetlands resources properly.

The branch has promoted restoration projects, a total of 23 projects by 18 local municipalities, of the "National Important Wetland Conservation Plan" have been implemented since 2009. These projects were counted to cover 25 wetlands within 75 Wetlands of National Importance. Supported from subsidies, local governments, NGOs, communities, and research institutions acted as the main units who have involved all activities, such as: joint-patrol organization, ecological survey, landscape restoration, etc. The bottom-up approaches with all implementation contributed by local organizations, governments, and institutions have been obtained broad achievements as well as supported by some efforts of public participation and social education. This annual research is truly detected entire record of the year, from central to local government as well as the people who have been involved by their hard working jobs with all results they obtained and follows.

Contact Information: Prof. Wei-Ta Fang, Taiwan Wetland Society 5F, 63-3 Hsing-An St. Taipei, Taiwan, Phone: +886-939859399; Email: wawaf@hotmail.com

MANAGING CRISES, CLIMATE CHANGE AND ECOLOGICAL RESILIENCE IN COMPLEX RESOURCE SYSTEMS

Lance Gunderson[1] and *Kathleen D. White*[2]
[1]Emory University, Atlanta, GA USA
[2]U.S. Army Corps of Engineers, Institute for Water Resources, Washington DC, USA

Managed natural resource systems are complex, dynamic systems with strong interdependencies among human and ecological components. Management of these systems has become more difficult, as scales, impacts and consequences have increased. Increasingly, a co-dependence and co-evolution of the human and ecological components has developed.

Over the past century, resource management has focused on control in order to meet social objectives of economic efficiency. However, successes in controlling and stabilizing key ecological process leads to an increased vulnerability as the system looses resilience and becomes more vulnerable to unwanted change. This inevitably leads to periods of crises and surprise, which in turn have lead to new institutional arrangements that adopt ecosystem management or adaptive management approaches. Often, these crises are revealed by the shift in ecological regime.

Two different problems faced by ecosystem managers relate to ecological resilience; one focuses on maintaining a desired ecosystem state, the other problem (called ecosystem restoration) occurs when plans and actions attempt to move out of an alternative state into a more desired configuration. Governance networks, such as the Glen Canyon Adaptive Management Program of the Colorado River has conducted adaptive management experiments to facilitate ecosystem restoration. In contrast, in the Everglades, such networks have been unable facilitate ecosystem experimentation necessary to understand transitions among ecological states.

We submit that coping with changing climate will require more emphasis on managing ecological resilience. Managing ecological resilience requires the recognition of multiple regimes, the complex processes by which people relate to and value specific regimes, the feasibility and practicality of reversing unwanted regime shifts and the capacity to transform from one type to another. Developing resilient and flexible outcomes in the management of these complex systems in the face of greater climatic uncertainty will require creating opportunities for experimentation and policy reorientation that respond positively to changing climate and other global drivers.

Contact Information: Lance Gunderson, Dept. of Environmental Studies, 524 Mathematics and Science Center, 400 Dowman Drive, Emory University, Atlanta, GA 30322 USA, Phone: (404) 727-2429, Fax: (404) 727-4448, Email: lgunder@emory.edu

THE FEN RIVER WATERSHED HYDRO-ECOSYSTEM RESTORATION

Hongji Jia and ***Xinxi Guo***
Shanxi Provincial Department of Water Resources, Taiyuan City, Shanxi Province, China

Shanxi Province is located in the western quadrant of North China. The middle reaches the Yellow River and the eastern edge of the Loess Plateau. The total land area is 156,000 km^2, forming a long, narrow parallelogram from north to south, with encompassing mountains and rivers. The interior landscape of Shanxi can be divided into three major regions — the eastern mountains, the western plateau and the middle basin. Mountains and hills account for over 80 percent of the total area; plains are mainly distributed in the middle basin. Shanxi has a population of 35.7 million. The Fen River is the largest river and runs through the middle basin of the Shanxi. Taiyuan is the capital city and is located at the upper middle reach of the Fen River. Since the 1980s, the Fen River watershed region has experienced a rapid economic growth coupled with the tremendous water use demands. As a result, a series of water-ecological problems have emerged, such as groundwater levels dropping drastically, river base flow reducing even drying out during the dry season, the river being polluted, and aquatic lives reducing dramatically. Entering the new century, the Government of Shanxi Province has realized the importance of environment protection in order to maintain the sustainable economic developments. A new economic development strategy, namely to maintain the rapid and quality economic growth with the emphasis on water and human harmony, has been promoted province-wide. Given the importance of the Fen River to the Shanxi province, the Shanxi Government has been targeting Fen River as a pilot watershed to conduct hydrologic & ecosystem restoration and comprehensive watershed planning. The major components of Fen River Watershed Restoration project includes, but not limited to: increasing the upstream water conservation by planting vegetation, increasing groundwater recharge, construction of artificial wetlands along existing flooding plains, increasing urban green space and open-water surface, inter-basin water transferring, and maintaining the minimum base flow for the Fen River. With all of these efforts, the Fen River hydro-ecological environment has improved noticeably. This paper will provide assessment of the Fen River restoration. The Fen River restoration will provide us first-hand knowledge and scientific foundation for the other river restorations in the Shanxi Province.

Contact Information: Xinxi Guo, Shanxi Provincial Department of Water Resources, 45 Xinjian Road, Taiyuan City, Shanxi Province 030002, P.R. China. Tel: 86-351-4666543, Fax: 86-351-4666221, Email: gxinxi@qq.com

SEAGRASS RESTORATION AND MITIGATION: POLICY CHANGE RECOMMENDATIONS

***Althea S. Hotaling**, R. Benjamin Lingle* and *Thomas T. Ankersen*
University of Florida, Gainesville, Florida, USA

In coastal Florida, the development and maintenance of docks, marinas, and channels frequently cause destruction of seagrass beds. Seagrass loss is accompanied by a loss of the ecosystem services the beds provide, such as sediment stabilization, water filtration, protection from storms, and habitat and nursery grounds for fish species. The current legal framework for seagrass protection and the implementation of mitigation for seagrass loss could be improved. In this Article, the authors argue that policymakers could revise the Uniform Mitigation Assessment Method to include more assessments related specifically to the ecology of seagrass beds and their ecosystem services. Seagrass mitigation is currently carried out by the permittee that applied to create or maintain the seagrass-impacting development. In comparison, wetland mitigation is typically carried out by publicly or privately operated mitigation banks. The creation of mitigation banks for seagrass restoration would streamline the process of seagrass mitigation and promote the public's interest in seagrass restoration.

Contact Information: Althea Hotaling, University of Florida, Bldg. 803, McCarty Dr., Gainesville, FL 32611 United States, Phone: 352-392-6237 Email: theah@ufl.edu

MOVING BEYOND LEGAL COMPLIANCE TO SELF CONTROL: CHANGE ORIENTATED LEARNING FOR WETLAND SUSTAINABILITY PRACTICES

David Lindley
Wildlife & Environment Society of South Africa, Pretoria, Gauteng, South Africa

One of the most critical concerns in environmental conservation is the inability of people to act in conserving, managing and wisely using natural resources, despite being aware of their importance, having the technological knowledge to do so, and the legal instruments to force compliance towards the wise use of natural resources. This is cause for concern in the technicist world that we live in today, where often linear and reductionist technological solutions are expected to solve complex and systemic problems. Due to the social-ecological complexities of wetland use, the governance of wetlands is multifaceted and extremely challenging. The wide range of differing interests, values, beliefs, and ideologies of those that use and manage wetlands and their associated ecosystem services and benefits, further adds to the complexity. Compliance with legislation can certainly support wetland sustainability practices, if it is adequately developed and efficiently enforced. However this is seldom the case and it is only part of the solution. Long term social change rarely occurs due solely to legal compliance. Society needs to become more critically reflexive and move towards the improved governance of wetlands through the self control of implementing wetland sustainability practices. Since sustainability practices are orientated to the transformation of society towards a more sustainable and equitable future, they therefore include change orientated learning processes in supporting society to move towards this self control.

Drawing on current research within a corporate plantation forestry context, the Mondi Wetlands Programme will share its experiences of how it has learnt to work better with wetland owners and users to support social change for improved wetland management. The concept of sustainability being a social learning ***"process"*** rather than an expert pre-determined transferable "***product"*** such as a policy, code of conduct or standard will be explained. The value and role of expansive social learning, and its relevance to social change as revealed by the research will be shared. The change orientated informal adult learning processes that the research has illuminated as being appropriate for strengthening wetland sustainability practices amongst wetland owners, users and decision makers will be explained. This research therefore highlights the importance of social learning processes for guiding "***how"*** a wetland conservation programme can work more meaningfully with people to bring about social change for better wetland management; which is just as important as the technical "***what"*** of wetland conservation that needs to be worked on. It is this insight and experience of change orientated learning that will be shared with participants at the conference.

Contact Information: David Lindley, Mondi Wetlands Programme, Wildlife & Environment Society of South Africa, PO Box 338, Irene, Pretoria, South Africa. Phone: +27-83-2229155. Fax: +27-12-6675720. Email: lindley@wetland.org.za

IMPACT OF POLICY IMPLEMENTATION ON ECOSYSTEMS AND WATER QUALITY IN SOUTH AFRICA

Mbofho S. Liphadzi
Water Research Commission, Gezina, Pretoria, South Africa

This study collated and evaluated the available water quality data as a basis for an overview of water quality across the entire Olifants River catchment in South Africa and has also identified many of the likely sources or causes of poor water quality. This was meant to enable water resource decision-makers in central, provincial and local government, industry and agriculture to define those areas that require priority attention and urgent remediation. In addition, the Information also provides a scientifically defensible rationale for developing and implementing measures to improve land use practices across the catchment, as well as a basis for working with counterpart authorities in neighboring countries. The ultimate beneficiaries of the recommendations presented in this study will be the aquatic ecosystems (including wetlands) within the catchment, as well as every person in the catchment that relies on good quality water for their lives and livelihoods. This study focused on the quality characteristics of the surface waters (wetlands and rivers) present in the catchment and has compiled a wealth of detail on the seasonal and inter-annual variations in water quality and the trends of change in water quality. There has been a progressive decline in water quality along the main stem of the river and in several important tributaries over the last twenty years. As a result of poor environmental water quality, the ecological health integrity of the water-linked ecosystems has also declined. It will require a far greater emphasis on effective water quality management across the entire catchment to halt and reverse this situation as quickly as possible. While the water quality data and indices provide clear indications as to the type of land-use activity that has contributed to this poor water quality, the available data are not sufficient to allow a precise determination of the specific source of a particular contaminant.

Contact Information: M.S Liphadzi, Water-Linked Ecosystems, Water Research Commission, 491 -18th Avenue, Gezina, Pretoria, 0031, South Africa, Phone: +27 12 330 0340; Fax: +27 27 331 2565, Email: stanleyl@wrc.org.za

PRIVATE NATURAL RESERVES AS A STRATEGY FOR THE CONSERVATION OF THE BRAZILIAN PANTANAL

Cristina Cuiabália Rodrigues Pimentel Neves and *Sueli Angelo Furlan*
Post graduation Program in Environmental Science, University of São Paulo, SP, Brazil

The imminent possibility of changes in the Brazilian Forest Code tends to make it less restrictive to the negative impacts inherent to the economic activities, mainly in the agribusiness. In this way, the biodiversity conservation and the traditional knowledge related to it will be in risk. The pantanal is an extensive floodplain, one of the most representative wetlands in the planet that can have its landscape negatively affected by the threats brought by these changes.

In this perspective, this article aims at emphasizing current strategies for the conservation of the socio-biodiversity of the Brazilian pantanal, which can generate positive results appropriate for the complexity of this context. Among these strategies, the private natural heritage reserves (RPPN) are the main focus of this research, which aims specifically to present a panorama of these reserves in this biome and verify, through a case study, how they can contribute to conservation. It is a research with a mixed approach, that is, qualitative-quantitative. The survey of secondary data occurred through a bibliographic research, and the primary data, through a documental research, open and semi-structured interviews. The multi-referential data were gathered and analyzed symmetrically.

It was verified that the RPPN category, despite some aspects that have to be improved, has had significant quantitative and qualitative advances, appearing as a fundamental strategy that goes against the context of flexibility to the restrictions for the private areas whose main aim is the agricultural production. Currently, in the pantanal there are 24 units, that cover 289.858,89 hectares and that represent about 38,7% of the biome. Among these, the RPPN SESC Pantanal, in Barão de Melgaço (Mato Grosso), is the largest in area (106.335,86 hectares) recognized by the management being developed for 13 years. The initiative of establishing private areas for the conservation has been growing in similar categories such as the Private Reserve of Sustainable Development (RPDS) in the state of Amazons that aims at conciliating both conservationist activities with those of direct use of natural resources by the local communities.

So, the initiative of the landowners in transforming their areas into reserves should be stimulated through incentives, since it is an important tool to promote the conservation of the biodiversity in a voluntary way and to give the opportunity to the other conservation strategies. Among the challenges to be overcome, a participant and sharing process in keeping and maintaining these areas can contribute even more for the protection of the pantaneiras landscapes, combining the biodiversity conservation with the social and economical development of the region.

Contact Information: Cristina Cuiabália Rodrigues Pimentel Neves, Programa de Pós-Graduação em Ciência Ambiental, Universidade de São Paulo, Avenida Prof. Luciano Gualberto, 1289, Cidade Universitária, Butantã, São Paulo, SP, CEP: 05508-010, Brasil, Phone: 11 3091-3235, Email: cuiabalia@gmail.com

INDIANA TOLL ROAD MITIGATION, URBAN RESTORATION IN GARY, INDIANA

Greg Quartucci
Cardno JFNew, Monee, IL, USA

To accommodate increases in traffic capacity and improve vehicle transportation on I-90 in Gary, Indiana, the Indiana Toll Road Concession Company retained the Indiana Toll Road Contractors (ITRC) to improve the Indiana Toll Road from MP 10.6 to MP 14.0, including roadway widening. The project area lies in a part of Gary, Indiana, that is relatively rich in natural resources, including several nature preserves, wet prairies, and dune and swale wetland complexes. While most wetland impacts were avoided, impacts to just over one acre of low-quality wetlands in roadside swales and ditches did occur, as well as discharge of 10 cubic yards of rip-rap within the Grand Calumet River.

The ITRC and ITRCC developed a mitigation plan consistent with the Chicago Wilderness's strategic initiatives focusing on public outreach, transportation planning and biodiversity, and urban sustainability and management. This project directly addresses the Restoration and Management Strategic Initiative. Rather than replace the impacted roadside swales and ditches, the restoration team of ITRC, ITRCC, and JFNew developed a strategy to maximize wetland mitigation value by conserving and adding to urban biodiversity. Through collaboration with federal and state agencies and local environmental groups, the team developed an urban-focused mitigation plan, including restoration of one acre of globally threatened dune and swale habitat in Gary's urban core, restoration and preservation of a high quality prairie, and purchase of 1.5 acres of wet prairie from the Lake Station Wetland Bank. The proposed dune and swale restoration site is adjacent to the Ivanhoe Nature Preserve, located directly south of the project area. The Nature Conservancy currently manages the nature preserve and is involved in the reestablishment of the Karner blue butterfly, a federally protected species, at this site.

The projects were completed in 2011. The presentation will focus on how this mitigation approach was developed and the lessons learned and challenges faced in the first year. Natural restoration and maintenance techniques will also be addressed.

Contact Information: Greg Quartucci, Senior Consultant, Cardno JFNew6605 Steger Road, Unit A, Monee, IL 60449 USA, Phone: 708-932-7203, Fax: 708-534-3480 Email: g.quartucci@comcast.net

PALMER POINT PARK: A WETLAND RESTORATION DESIGN LIMITED BY SITE AND STAKEHOLDER CONDITIONS

Jimmy Sellers[1], *Jenna Vogt-Phillips*[1] and *Curtis Smith*[2]
[1]Coastal Technology Corporation, Vero Beach, FL, USA
[2]Sarasota County Public Works, Sarasota, FL USA

The Gulf Intracoastal Waterway (GIWW) passes through Little Sarasota Bay in Sarasota County, FL and was constructed by Local Sponsors and the U.S. Army Corps of Engineers (USACE) in the 1950's and 1960's. The common practice for construction of the GIWW was to hydraulically dredge the channel and pump the spoil to nearby locations in the bay. Traditional open-water spoil islands were often created this way; however, in the case of the site which is now part of Palmer Point Park, the spoil was pumped into a semi-sheltered corner formed on one side by the barrier island Casey Key and on the other by the mangrove-lined interior shoreline of Midnight Pass. The elevated spoil mound subsequently attracted the recruitment of exotic invasive species. Decades later, the spoil mound is a circular 1.75 acre isolated upland dominated by invasive exotic tree species and surrounded by fringing mangrove tidal swamp. To the north, the historic Midnight Pass is home to a healthy community of seagrasses. Casey Key, to the west, is now developed with high-value properties along a privately-owned road. A salt flat has formed beyond the southern tidal swamp and to the east is an extremely shallow area of Little Sarasota Bay. Access to the isolated upland and design of its restoration were limited by these environmental conditions. Stakeholder conditions were found to limit access and design as well.

Although the USACE had initially identified this portion of Palmer Point Park for restoration and evaluated conceptual designs as part of a Section 1135 Study, Sarasota County (County) took the lead to conclude design and permitting in 2007 and hired Coastal Technology Corporation to do that work. Stakeholders were engaged for both design considerations and construction access possibilities. The design concept which gained the most traction with stakeholders and met other project constraints was to create mangrove swamp in place of the existing 1.75 acre upland. Construction of the recommended inter-tidal design would require heavy equipment for exotic removal and the excavation and transport of approximately 6,000 cubic yards of material. Another result of stakeholder engagement was elimination of terrestrial access to the site via the privately-owned North Casey Key Road. As a result, waterborne construction access was required.

The waterborne construction access had to traverse the seagrasses *and* the mangrove swamp bordering the upland. Transport of the excavated material also had to be waterborne. Additional permitting requirements of both the Florida Department of Environmental Protection (FDEP) and the USACE led to micro-siting of flushing channels, selection of a suitable construction access location and proposal of a temporary ramp, both to minimize impacts to the seagrasses and mangrove swamp. Additional minimization measures included a commitment to hand-remove exotics within wetland jurisdiction, use of vehicular mats within jurisdictional areas, and a detailed sediment management plan. Stakeholder input, negotiation of regulatory requirements, funding commitments and contractor selection all extended for over 3 years leading up to the start of a 120 day construction effort.

<u>Contact Information</u>: Jimmy Sellers, Coastal Technology Corporation, 3625 20th St., Vero Beach, FL 32960 USA, Phone: 772-562-8580, Fax: 772-562-8432, Email: jsellers@coastaltechcorp.com

THE ROLE OF POLITICS IN WETLANDS MANAGEMENT, CASE OF THE KILOMBERO VALLEY FLOOD PLAIN RAMSAR SITE IN MOROGORO TANZANIA

Donasian O. Shayo

Ministry of Natural Resources and Tourism, Wildlife Division, United Republic of Tanzania

The development and implementation of an integrated management plan is a key strategy in the management of the wise use principle in a Ramsar site. Political support and social economic developments at all levels has proved to be key areas for consideration to achieve a success in it implementation. The Kiilombero Valley Flood Plain Ramsar Site (KVRS) highly valued for its species endemism and a valuate f habitats is an important source of livelihoods for the valleys residents. Majority of these residents maintain an average of 80% direct dependence to the valley wetlands resources. The KVRS is however faced with a degradation resulting from an overuse due to increased demands from the ever increasing human and livestock populations. Taking note of these threats to the fragile resources of the wetlands, the United Republic of Tanzania, Vice Presidents Office on 03/04/2006, issued an order for removal of farmers and livestock keepers from the KVRS among 4 other basins to safeguard the fragility o the wetlands. Literature review indicates an increasing rate in environmental degradation and resources depletion. This is substantiated by dry season aerial wildlife census surveys over the past 13 years, with little considerations to the survey month, indicated by a drastic reduction of keystone species. The Puku population dropped by 74% and 92% for Buffaloes population in the past 13 years (1996 to 2008). The data is a dry season data with little considerations. Research on livestock and large wildlife mammals in 2007 proved that, the abundance of cattle and goats is negatively related to the abundance of large mammals (Elephants, Buffalo and Puku). Furthermore the local community report a decreasing trend I the wildlife populations with the increasing livestock numbers over the past two decades. In 2011, a research on Ramsar convention and sustainable wetlands management clearly indicate that the wetlands can no longer sustain the ever increasing demand and calls for urgent actions. The local community consider implementation of the national declaration would enhance ownership of the resources they once controlled. Attempts to its implementation have proved to require more political support.

Contact Information: Donasiani O. Shayo, Kilombero Valley Flood Plain Ramsar Site, Ministry of Natural Resources and Tourism, Wildlife Division, United Republic of Tanzania, Phone: +255 784 474 228, Email: doshayo@yahoo.com

EQUITABLE WATER RIGHTS: A HOLISTIC PERSPECTIVE ON ECO-CULTURAL RESTORATION TO SUSTAIN BIODIVERSITY, ECOSYSTEM FUNCTIONS, AND SOCIAL JUSTICE IN THE TIGRIS EUPHRATES WATERSHED

Michelle L. Stevens
California State University California and Hima Mesopotamia Non-Profit Corporation, Sacramento, California, USA

The success of ecological and cultural restoration in the Tigris Euphrates basin is dependent on equitable water availability and management. The Twin Rivers Basins are vulnerable to periods of water scarcity, inequitable sharing of water rights, and lands subject to potential desertification. Climate change trends are expected to further exacerbate challenges to the cultural, ecological and agricultural systems of Mesopotamia. The boundary conditions of water security; dam construction & operation; and the long-term implications of equitable water allocation and water scarcity are analyzed in the Tigris Euphrates watershed. Ecological health, biodiversity, social well-being and cultural integrity in Turkey, Iraq and Kuwait will be reviewed relative to basin wide water allocation. Over 26 large dams are planned or under construction in the watershed headwaters in Turkey. Dams and upstream diversions have reduced mean annual flow at the Euphrates River Hindiya Barrage gauging station from pre-war levels of 400- 800 m^3/s to as low as 250 m^3/s in 1999. The Mesopotamian Marshes of southern Iraq and Iran are the largest wetland ecosystem in the Middle East and Western Eurasia, historically covering over 12,000-20,000 km^2 of interconnected lakes, mudflats, and wetlands. Water level estimates for the marshes have fluctuated dramatically; marsh areal estimates vary from a high of 58% in 2004-2005 during “good” water years down to 10-20% in the past two years. Water scarcity has resulted in a small patchwork of degraded and fragmented wetlands that are functionally impaired, with reduced water availability in the Mesopotamian Marshes and Gulf. Unfortunately, the regional trajectory appears to be toward catastrophic failure of cultural and physical systems. Along with changes to water levels, there are changes in ecosystem-level metrics: salinity has increased and fish populations, agricultural productivity, reed availability, and water buffalo forage resources have declined. With the lower flows, water quality in the Shat al Arab has declined as salt concentrations have increased (from 1 ppt to 9-13 ppt). Successful local restoration projects have been undertaken through hydraulic modification on the Euphrates River. One of the most challenging aspects of the development of this area will be ensuring the delicate balance between improving the standard of life locally, and respecting the traditional way of life of the inhabitants of the Marshlands. Drainage of the marshes, water shortages from upstream water diversions, prolonged drought, and deterioration of water quality due to salinization and pollution have caused major ecological and socioeconomic problems in the marshes. The people who stay in the marshes suffer from the lack of clean, sweet water to support human health and hygiene; employment or subsistence opportunities; lack of education and health care; and loss of biodiversity and fish and waterfowl production. Further, low flows and impaired water quality are adversely affecting fish production and biodiversity in the Shat al Arab and northern Gulf. Loss of fisheries will also have profound adverse impacts on socio-economics and human well being in the vicinity. An international effort to develop a system of basin planning and equitable water rights allocation is urgently needed.

Contact Information: Michelle Stevens, Hima Mesopotamia, 3436 Wemberley Drive, Sacramento, CA 95864, United States, Phone: 916-765-7397 Email: stevensm@csus.edu

FORECASTING IN LARGE SCALE RESTORATION PLANNING

Jeff Trulick
U.S. Army Corps of Engineers, Washington DC, USA

As part of any large civil works project, the planning of an ecosystem restoration project (or any project for that matter) involves several steps, one of which is forecasting. The forecasting of the "future without project" condition is critical to ensuring the correct restoration actions are being implemented and that the environmental outputs will be sustainable in the future as the conditions change. This forecasted condition is different from the existing conditions in the planning area and needs to be projected over a substantial amount of time. The U.S. Army Corps of Engineers (USACE) usually uses a 50 year planning period of analysis when conducting a planning study. For smaller scale projects, this may not be too complex a task. However, for projects at larger scales, there can be many factors adding to the uncertainty that planning restoration actions will indeed lead to the intended habitat outputs and effects on the species using those restored habitats. As important as forecasting is to set the baseline prior to plan formulation, it can be one of the weakest part of any project planning effort.

This presentation will discuss some examples of forecasting which have been prepared for USACE planning reports for large scale restoration projects. It will also discuss some ideas for reducing the uncertainty in restoration planning, such as various types of planning models, incremental planning, and other planning tools from planning efforts across the United States.

Contact Information: Jeff Trulick, U.S. Army Corps of Engineers, 441 G Street, NW, Washington DC 20314, United States, Phone: 202-761-1380, Email: jeff.trulick@usace.army.mil

ECOSYSTEM RESTORATION - INDICATOR AND PERFORMANCE MEASURES

GENERATING CERP PERFORMANCE MEASURES FROM SPATIO-TEMPORAL HABITAT SUITABILITY INDICES

***James M. Beerens*[1]**, *Erik G. Noonburg*[1], *Dale E. Gawlik*[1] and *Douglas D. Donalson*[2]
[1]Florida Atlantic University, Boca Raton, FL, USA
[2]US Army Corps of Engineers, Jacksonville, FL, USA

The Comprehensive Everglades Restoration Plan (CERP) was implemented to reintroduce historic water flow patterns in order to recover and sustain the defining characteristics of the greater Everglades. As a component of CERP, performance measures (PM) have been developed to serve as indicators of conditions that have been determined to be characteristic of a healthy, restored ecosystem. One of the primary characteristics of the ecosystem's historical hydrology was an abundant and productive wading bird population.

The PM proposed here is based on the response of wading birds to landscape conditions during pre-breeding and breeding phases from 2000-2009. A *nesting response* model examines landscape processes that influence the yearly nesting effort response by the three species chosen to represent wading birds in this study: Great Egret, White Ibis, and Wood Stork. A *temporal foraging conditions* model groups foraging observations over the Greater Everglades landscape and predicts overall landscape flocks throughout the nesting season. A series of models predict daily use from available landscape conditions (i.e., selection) and then evaluate landscape use in terms of the daily abundance of flocks in the Everglades system. The output represents a quality 'score' rather than an absolute value of predicted flocks. A *spatial foraging conditions* model uses a different approach by grouping foraging observations over time and integrating spatial dynamics unaccounted for by the chosen set of predictors (i.e., spatial correlation). This model focuses on characteristics of cells that are used over time and provides a visual depiction of landscape productivity, via annual frequency of cell use.

Habitat suitability models were forecasted into hydrological scenarios obtained from the South Florida Water Management Model (SFWMM) to evaluate how many years among restoration scenarios produce a favorable nesting and spatio-temporal foraging response among the indicator species. Examining habitat quality through the entire breeding period over multiple scales reduces uncertainly in model predictions and confirms ecological patterns robust to spatio-temporal variation. Of specific interest to this study is the trade-off between the species' response to prey densities that occur from a long period of inundation versus water-level recession through a concentration effect. Future restoration efforts will benefit from a mechanistic understanding of how foraging responses interacted with historic water management to shape species-specific population trends. These models are the first to group foraging observations independently through both space and time to demonstrate unique responses to spatial and temporal environmental variation.

Contact Information: James M. Beerens, Florida Atlantic University, 777 Glades Rd, Boca Raton, FL 33431 USA, Phone: 561-809-9793, Email: J.M.Beerens@gmail.com

ASSESSING WETLAND FUNCTION USING PHOSPHOROUS SPECIATION

Kurt Chowanski, *PV Sundareshwar* and *Christine Sandvik*
South Dakota School of Mines and Technology, Institute of Atmospheric Sciences, Rapid City, SD, USA

Wetlands provide important ecological functions including providing wildlife habitat, hydrologic buffering of floods and drought, buffering of water quality, and nutrient cycling. While the amount of wetlands continues to decline, many wetlands are being restored; evaluating the relationship between structure and function, or the success of the restoration efforts has been challenging. A tool that would be broadly applicable for the evaluation of wetland restoration would need to be economical; therefore it is important to identify a common location across wetland types so that one sample can be used for the evaluation tool. ^{31}Phoshorous Nuclear Magnetic Resonance (P-NMR) spectrometry was used to 'visualize' the diverse chemical forms of soil phosphorous (P) along a toposequence within wetland catchments to evaluate the applicability of P transformation as a time-integrated index of ecosystem function in prairie wetlands. Soil P was extracted for P-NMR spectrometry using a sodium hydroxide plus EDTA extraction; total P in the soil was compared to the total P in the extraction. A higher extraction efficiency gives greater confidence that the P-NMR spectroscopy is actually seeing all of the P and can be used as a tool to evaluate wetland ecosystem function. Low extraction efficiencies prompted modification of the extraction procedure to include a 5% hydrochloric acid pretreatment for 1 hour; this increased the extraction efficiencies to 60-70% in the marsh landscape position and 20-30% at the mid-slope and shoulder-slope positions and shows a decrease with distance from the wetland center. Calcium in the soil may be binding to the P and causing the differences in extraction efficiencies. While the sodium hydroxide plus EDTA extraction and P-NMR spectroscopy may work well for soils rich in iron and aluminum, it may not be suitable for systems rich in calcium. While the wet-meadow location has the greatest P diversity, the greater extraction efficiency for the marsh location suggests using the marsh location when using P diversity as an assessment tool of multiple wetland systems at a national scale.

Contact Information: Kurt Chowanski, South Dakota School of Mines and Technology, 501 E Saint Joseph Street, Rapid City, SD 57701, United States, Phone: 303-718-7069, Email: kurt.chowanski@mines.sdsmt.edu

IMPLEMENTATION AND OPERATION OF AN EVERGLADES PHYSICAL MODEL: THE LOXAHATCHEE IMPOUNDMENT LANDSCAPE ASSESSMENT (LILA)

Eric Cline
South Florida Water Management District, West Palm Beach, FL USA

The Loxahatchee Impoundment Landscape Assessment (LILA) project is a large scale physical model of the Everglades constructed in 2003. As a controlled research platform, LILA allows scientist to devise experiments that investigate the impacts of hydrology on the Everglades landscape. Landscape features of the Everglades constructed in each of the four 20-acre cells or macrocosms are tree islands, ridges and sloughs. Each macrocosm contains two tree islands, one with a peat core and the other with a limestone core, to simulate two basic types of tree islands found in the Everglades. Found within each macrocosm are also a series of ridges, deep and shallow sloughs and "gator holes". These features allow the study of the impacts of flow on vegetation and wildlife as well as the morphology of these landscape features.

LILA was built to be a rain driven, closed-loop system to control water quality within the macrocosms. Using a large electric pump and a series of water control structures, flow rate through the macrocosms can be controlled and the water depth adjusted and maintained according to a predetermined hydrograph. Limitations to maintaining flow velocities and water depth are the availability of water and the volume of water that the pump can move to the macrocosms.

Since its construction, LILA has hosted a number of studies which include wading bird feeding success, drought response, crayfish migratory behavior, tree survival, growth and morphology, and ground water/surface water hydrology and chemistry.

The success of research at LILA depends on proper design within the LILA framework. All research proposed must be approved by the LILA Science and Coordination committee. This committee is made up of multi-disciplinary researchers from the South Florida Water Management District, ARM Loxahatchee National Wildlife Refuge, Florida International University and Florida Atlantic University. Another key to the success of research at LILA is the coordination and integration of concurrent projects on the site. This presentation will elaborate on the ongoing and completed research at LILA and how site operations influenced the outcome of that research.

Contact Information: Eric Cline. Everglades Ecosystem Assessment Section, Applied Sciences Bureau, Water Resources Division, South Florida Water Management District, MSC 4352, 3301 Gun Club Road, West Palm Beach, FL 33406, Phone: (561) 734-3897, Email: ecline@sfwmd.gov

A WATER LEVEL PERFORMANCE MEASURE FOR EVERGLADES RESTORATION – INTEGRATING EVERGLADES AND FLORIDA BAY RESTORATION REQUIREMENTS

***Donald R. Deis*[1]**, *Frank E. Marshall*[2], *Patrick A. Pitts*[3] and *Andrew D. Gottlieb*[1]

[1]Atkins, Jacksonville, FL, USA
[2]Cetacean Logic Foundation, New Smyrna Beach, FL, USA
[3]U.S. Fish & Wildlife Service, Vero Beach, FL, USA

Water levels in the southern Everglades are determined by freshwater flows (overland and groundwater), rainfall, and evaporation. Therefore, freshwater stage integrates and reflects the recent hydrologic activity. Because of the interconnection of freshwater, brackish, and marine waters in the Everglades, freshwater stage (water level) is an important factor in determining salinity regimes in the estuaries along with the uncontrollable effects of wind and oceanic influence. Restoring water levels in the wetlands of the Everglades that will achieve established salinity restoration targets in the southern estuaries is a Comprehensive Everglades Restoration Program goal. The original salinity performance measures in the Restudy (U.S. Army Corps of Engineers 1999) for the estuaries in Everglades National Park used relationships generated between salinity and upstream freshwater stage data. The water levels required for salinity restoration targets are also the water levels required for resumption of sheet flow and related patterns of hydroperiod and water depth. These water levels could significantly help to restore and sustain the microtopography, directionality, and spatial extent of ridges and sloughs and improve the health of tree islands in the ridge and slough landscape in the Everglades.

A new water level performance measure is proposed to provide the integration of freshwater water depth requirements and the stage required to attain salinity restoration targets.

Contact Information**:** Donald R. Deis, Atkins, 7406 Fullerton Street, Suite 350, Jacksonville, Florida 32256 USA, Tel: (904) 363 8442, Fax: (904) 363 8811, Email: don.deis@atkinsglobal.com

CAN THE SOIL SEED BANK PROVIDE A MEANS FOR THE RESTORATION OF RIPARIAN ECOSYSTEMS?

Siobhan B. Gorham and *Stephen T. Threlkeld*
University of Mississippi, University, MS, USA

The riparian plant community composition under different types of hydrological alteration was examined at five sites in the Yazoo River watershed in Northern Mississippi: a highly incised riparian terrace isolated from the stream channel, a deforested channelized stream currently managed for marsh conditions, a forested original stream with reduced flow due to channelization, a stream above a reservoir delta, and a stream below an embankment dam. The five study sites were established in original floodplains of modified streams. At each site plant surveys were conducted using modular quadrats with nested sampling quadrats to assess plant community composition, functional group richness, and the influence of environmental variables on plant community assemblages using dominance and richness evaluations, ANOVA, and NMS and CCA ordination. Functional group richness and species richness were strongly correlated. All sites showed an abundance of facultative species in the plant community assemblages. Wetland functional groups were outnumbered by facultative functional groups at all sites except for the site that is managed as a marsh. Sites with canopy openings showed greater wetland species diversity. The reservoir delta preserved riparian vegetation and included a number of upland species to create an environment with high diversity and functional group richness.

Contact Information: Siobhan B. Gorham, 2737 4th Ave North, St Petersburg, FL, 33713 USA, Phone: 662-801-8277, Email: siobhangorham@gmail.com

WETLAND RESTORATION ON THE TEXAS GULF COAST: HEAVY CLAY AND HIGH PH

Dan Keesee
USDA-NRCS, Temple, Texas, USA

Along the upper coastal plain of Texas, shrink-swell clays are the major component of the soil landscape. Taxonomically, these soils are classified as Vertisols and those soils in Vertic sub-groups. Within the 12 counties roughly comprising the upper coast of Texas, an area of over 11 thousand square miles, over six thousand of those square miles are mapped as Vertisols and soils in Vertic sub-groups. Almost six of every ten acres are mapped as heavy, shrink-swell clays.

When these soils are dry, cracks up to several inches wide extending three feet or more deep form at the surface. Through the cracks, water enters the soil very rapidly, but due to the soil's shrink-swell nature, the cracks close or seal rapidly as the soil moistens. Once the cracks close, water enters these soils very slowly. Within these soils' profiles, evidence of the shrink-swell phenomena manifests itself in the formation of slickensides, which are stress surfaces produced by soil masses sliding past each other.

Despite the difficulties associated with manipulating Vertisols and soils with Vertic sub-groups, they are productive soils that have been extensively cultivated along the Texas coastal plain. Due to their relatively flat slopes and capability to efficiently pond water, many areas were cultivated for rice. Historically, huge swaths of these areas supported tall-grass prairies with woody vegetation generally confined to limited areas along watercourses.

Wetland restoration on these soils presents numerous challenges, particularly when the vegetative restoration effort focuses on establishing woody vegetation. Several inherent soil properties, including their capability to retain and pond water, their soil reaction or pH, and the shrink-swell phenomena, can work directly and indirectly against the establishment of both naturally occurring and planted seedlings on these soils. Overcoming these limitations requires special design, extra maintenance, and costly alteration. Results are often less than expected.

Contact Information: Dan Keesee, USDA–Natural Resources Conservation Service, 101 S Main ST, Temple, Texas 76501 USA. Phone: (254) 742-9833. E-mail: dan.keesee@tx.usda.gov

EFFECTS OF WATER CONDITION ON SURVIVAL AND GROWTH OF *PERSICARIA THUNBERGII* SEEDLING

Do Hee Kim, ***Heung-Tae Kim*** and *Jae Geun Kim*
USeoul National University, Seoul, Republic of Korea

To determine the critical environmental factors for the establishment of *P. thunbergii* seedling, we analyzed vegetation, water and soil characteristics from *P. thunbergii* dominant sites in May. We investigate the effects of water level on the survival and growth of *P. thunbergii* seedlings in the different growth stage under three different water levels (0cm, the seedling height, the double of seedling height). And we investigated the growth and biomass allocation of *P. thunbergii* seedlings under four different water conditions (5%, 10%, 0cm, 3cm). After 5 weeks, the plants were harvested, separated to above- and below-ground parts, oven-dried, and weighed.

In the field, *P. thunbergii* seedlings exist mainly with annual or biannual plants like *Bidens frondosa* and *Humulus japonicus* excluding perennial emergent species. The environmental factors of water and soil were variable except the water level which was relatively constant in the range of 0 and 5cm. In glasshouse experiment, more than double water level of the seedling height caused all seedlings to death regardless of the leaf stages. The shoot:root ratio of the cotyledon-seedlings in the water level of 0cm was higher than that in the water level of the seedling height. However, the ratios of the seedlings in 2 and 4 leaf stages were not different between the water levels. At the loamy sand-type substrate, the height and biomass of the seedlings with cotyledon increased with the more water condition. In contrast, the shoot:root ratios decreased. At the sand-type substrate, the height and biomass of the plant in the water conditions of 5% and 3 cm was lower than in the water conditions of 10% and 0cm. The shoot:root ratios generally were lower than the ratios at the loamy sand-type substrate. Our results suggested that the survival of the seedlings depends on the relative water level to the seedling height. And in the water-logged conditions, *P. thunbergii* allocates more energy to below-ground parts.

Contact Information: Jae Geun Kim, Department of Biology Education, Seoul National University, Seoul 151-748, Republic of Korea, Phone: +82-2-880-9077, Fax: +82-2-886-2117, Email: jaegkim@snu.ac.kr

HYDROPERIOD, RESOURCES, AND COMPETITOR DENSITY AFFECTS CONDITION OF EVERGLADES' FISH AND CRAYFISH

Jessica A. Klassen and *Dale E. Gawlik*
Florida Atlantic University, Boca Raton, FL, USA

A primary goal of the Comprehensive Everglades Restoration Plan (CERP) is to improve habitat and functional quality while improving animal species diversity and abundance. One performance measure for this goal is density of freshwater fishes that are prey for wading birds. However, density alone does not provide an accurate measure of habitat quality for freshwater fish. Body condition is an alternate metric that integrates habitat space, food resources, and the individual's ability to acquire suitable habitat and resources. Additionally, fish body condition affects the quantity and quality of caloric energy that can be transferred to higher trophic levels, such as predatory wading birds. Our goal was to determine how changing habitat, resources, and competitor density affects prey-species body condition.

We quantified the body condition of fish and crayfish using length and weight measurements from 39,638 individuals captured in throw-traps from 2005–2011. The throw-trap samples were gathered across the Everglades system, including the Water Conservation Areas, Everglades National Park, and Big Cypress National Preserve. We used hydroperiod, determined by the Everglade Depth Estimation Network (EDEN), as a proxy for habitat. We used flocculent layer thickness within each throw-trap as a measure of available resources. Lastly, we used the number of fish or crayfish within a throw-trap as a measure of competitor density. We used Akaike's Information Criterion (AIC) to select the best set of predictive models for body condition of seven common fish, and two crayfish species. We considered models with ΔAIC < 2 to have high support.

The global model was the only model with high support for predicting the body condition of Bluefin Killifish (*Lucania goodie*; *w*=0.99) and Marsh Killifish (*Fundulus confluentus*; *w*=1.0). The interaction term hydroperiod* flocculent thickness had high support for predicting Least Killifish (*Heterandria formosa*; *w*=0.56) and Mosquito Fish (*Gambusia holbrooki*; *w*=0.89) body condition. Body condition for the Sailfin Molly (*Poecilia latipinna*) was best supported by the hydroperiod* flocculent thickness interaction model (*w*=0.53) and the flocculent thickness (*w*=0.26) model. Flagfish (*Jordanellae floridae*) body condition was best supported by the fish density model (*w*=0.83). Top models for Golden Topminnow (*Fundulus chrysotus*) body condition were the hydroperiod model (*w*=0.64) and the global model (*w*=0.35). We found different body condition predictors for the two species of crayfish. The global model (*w*=0.99) for *Procambarus alleni* body condition was the only model with high support, whereas *Procambarus fallax* was best supported by the model containing flocculent thickness and density of crayfish (*w*=0.57) and the global model (*w*=0.42). Our results suggest that changes in habitat conditions differentially affect the body condition of common aquatic prey species in the Everglades. Such body condition changes can have emanating impacts on wading bird foraging and nesting success.

Contact Information: Jessica A. Klassen, Florida Atlantic University, Department of Biological Sciences, Boca Raton, FL 33431 USA, Phone: 561-297-0671, Fax: 703-648-6953, Email: jklassen@fau.edu

DIATOM-BASED ASSESSMENT OF HYDROLOGY AND CALCAREOUS PERIPHYTON ABUNDANCE IN A SUBTROPICAL WETLAND

Sylvia S. Lee*, Evelyn E. Gaiser* and *Joel C. Trexler*
Florida International University, Miami, FL, USA

We developed diatom-based prediction models of hydrology and periphyton to inform paleoecologically-based restoration target setting for a highly altered and highly managed subtropical wetland. Periphyton plays an important role in many wetlands by regulating water chemistry and sustaining the food web. If specific diatom assemblages are found to inhabit periphyton mats of differing abundance or quality, inferences about past conditions of the wetland ecosystem could be made using diatoms as proxies. Inferences could then inform future management decisions based on how diatom assemblages are changing. The distribution of diatoms occurring in calcareous periphyton mats in the Florida Everglades was examined among 86 sites. We found relationships between diatom assemblage composition and three types of habitat characteristics: hydrology, periphyton quantity (biovolume), and the quality (nutrient and organic content) of the periphyton matrix they inhabit. Although the relative abundance of species varied among wetland subsets of differing natural and management conditions, responses to habitat characteristics were similar, enabling development of diatom-based prediction models that can be applied across the system. Calibration models were developed for hydroperiod and periphyton biovolume using the weighted-average abundance and tolerance of diatoms. These models produced estimates with r^2=0.63 (boot r^2=0.19; RMSEP=55 days) and r^2=0.56 (boot r^2=0.41; RMSEP=520 mL m^{-2}) for hydroperiod and periphyton biovolume, respectively. The models were mapped to show the utility of diatoms in interpreting landscape-scale spatial patterns. This study is the first to capture wetland diatom responses to a wide gradient of hydroperiod and periphyton characteristics and shows that species composition may elucidate complex relationships better than coarser measurements (i.e., biomass), especially in dynamic systems such as wetlands.

Contact Information: Sylvia S. Lee, Department of Biological Sciences, Florida International University, 11200 SW 8th Street, Miami, FL, 33199 USA, Phone: 305-348-7286, Email: sylvia.lee1@fiu.edu

CAN MINE PIT LAKES BE REPRESENTATIVE OF REGIONAL WATER BODIES? A CASE STUDY FROM SILICA SAND MINING

Mark A. Lund[1] and *Clint D. McCullough*[1,2]
[1]School of Natural Sciences, Edith Cowan University, WA Australia
[2]Golder Associates, West Perth, Western Australia, Australia

In many regions, regulators view lakes formed as a result of mining activity (pit lakes) as akin to natural lakes and impose similar guidelines with regards to long-term water quality and biodiversity. Where the likely closure endpoint is return of the mine lease to a state conservation reserve, then the minimum likely regulator/community expectation is for the pit lake to be representative of regional natural water bodies.

The Swan Coastal Plain (SCP) consists of a series of sand dunes, with wetlands forming in the inter-dunal depressions primarily as expressions of shallow groundwater aquifers. At Kemerton (located on the SCP, near Bunbury, Western Australia), extraction of high grade silica sands is creating large dredge ponds, up to 15 m deep. The company has employed a policy of rehabilitation-as-you-go by splitting the active dredge pond into smaller lakes, shaped with dredge spoil and saved topsoils.

This paper reports on the water quality and aquatic macroinvertebrate biodiversity of the first rehabilitated dredge pond, a constructed shallow wetland, an unrehabilitated dredge trial pond and smaller satellite areas of the main dredge pond relative to 15 nearby reference natural wetlands. The wetlands of the SCP tend to be seasonally dry and <2 m deep whereas the dredge pond was approximately 7 m deep with permanent water. Although catchment rehabilitation had successfully returned some terrestrial vegetation, the pond edge lacked a developed riparian zone. Species diversity and abundance substantially lower (approximately 50% and 10% respectively) than in the reference wetlands. Overall the dredge pond macroinvertebrate community was significantly different to the reference wetlands.

Although the dredge ponds could not be considered equivalent of the reference wetlands, water quality was still comparable with parameter ranges documented on the SCP. Similarly, although macroinvertebrate communities are poorly developed, they still contain representative species of SCP wetlands. We discuss what value wetland representativeness may have in this context.

Contact Information: Mark A. Lund, School of Natural Sciences, Edith Cowan University, 270 Joondalup Drive, WA 6027, Australia, Phone: +618-6304-5644, Fax:+618-6304-5070, Email: m.lund@ecu.edu.au

PLANT SPECIES RESPONSE TO THE RESTORATION OF DEGRADED FENS IN NORTH-WEST WALES

Nina M. Menichino
Bangor University, Wales, UK

Fen systems provide an essential ecosystem service and are vital for human well-being. Freshwater catchments filter contaminants to provide drinking water for human consumption and are fundamental for controlling climate change as carbon is sequestered here. Despite their importance, fens in the UK have degraded primarily because of dereliction (cessation of traditional burning, cutting and grazing) which has led to a negative impact on fen functionality and biodiversity. Fens support a seral (intermediate ecological state) community which require management to avoid succession by woody species. This transition from wetland to dry land impedes their ability to provide the aforementioned ecosystem services. Management and intervention of calcareous and alkaline fens are the focus of this research as these are rare and in major decline in the UK respectively.

Given the importance of these ecosystems and the significant reserves of carbon held in peat and their vegetation communities it is surprising how little attention has been given to plant physiognomy in fens under different restoration regimes. Uniquely, these fens receive alkaline water through lateral (topogenous fen) and vertical (soligenous fen) movement over limestone rock, which facilitates optimum nutrient and hydrological regimes but this alone cannot sustain these systems. A re-introduction of positive anthropogenic activities will be implemented (treatments) such as (1) hand strimming British National Vegetation Community M13 (*Schoenus nigricans - Juncus subnodulosus mire*) which is favourable and species rich and (2) mowing *Cladio-molinietum*, which is unfavourable and species poor. It is hypothesised that biomass removal will increase plant diversity in both vegetation communities and the monocultures that exist in *Cladio molinietum* will be eradicated as new species colonise and compete for resources. Pre and post treatment nutrient and DOC concentrations and changes in plant species will be measured over time; dissolved organic matter is a major contributor to biochemical activities in the soil which acts as a nitrogen, phosphorus and carbon supplier to plants. Harvesting the dead organic matter will increase competition between plant species and will favour the nutrient-poor fen plants which are predicted to colonise under the new nutrient regime. After the initial perturbation (nutrient and DOC pulses are predicted), DOC exports to headwaters will be reduced which will have a positive impact on drinking water quality and greenhouse gas emissions. At the ecosystem scale we hypothesise that post restoration of the fen systems will support efficient functioning by removing higher concentrations of DOC and export lower levels of greenhouse gases as well as becoming more resilient to climate change as the system increases in biological diversity and is ecologically restored.

Contact Information: Nina M. Menichino, Bangor University, College of Natural Sciences, School of Biological Sciences, Wolfson Carbon Capture Laboratory, Deiniol Road, Bangor, Gwynedd. LL57 2UW, Wales, UK. Phone: 011 44 1248 382098; Email: afpe4e@bangor.ac.uk

A SALINITY PERFORMANCE MEASURE FOR EVERGLADES RESTORATION PLANNING AND ASSESSMENT

Patrick A. Pitts[1], *Susan Kemp*[2] and *David Rudnick*[3]
[1]U.S. Fish and Wildlife Service, Vero Beach, Florida, USA
[2]U.S. Army Corps of Engineers, USA
[3]South Florida Water Management District, USA

The Restoration Coordination and Verification (RECOVER) Program of the Comprehensive Everglades Restoration Plan (CERP) is charged with evaluating restoration alternatives and assessing empirical data to provide a regional and system-wide view of this large-scale restoration effort. One of the primary means by which to accomplish this objective is to develop and utilize regional performance measures. To facilitate the evaluation and assessment goals, RECOVER subdivides the greater Everglades ecosystem into four regions, one of which is the Southern Coastal System that includes Biscayne Bay, Florida Bay, and the estuaries along the southwest Florida coast. The Southern Coastal Systems Subteam of RECOVER has recently completed a major revision of the salinity performance measure that it will use in the Florida Bay region. The purpose of this presentation is to describe this performance measure and show examples of its use.

The performance measure is comprised of three separate, but inter-related metrics. The target for each of the metrics is a 36-year time series simulation of the salinity regime in Florida Bay prior to water management changes that altered salinity conditions. The target time series are produced at 19 sentinel sites in Florida Bay using a combination of model simulations that are adjusted using paleoecological Information. For each performance measure metric, either simulations of CERP alternatives or monitoring data are compared against the target. One metric examines the central tendency of salinity distributions by comparing the overlap between the mid-ranges of the target and the observed or simulated time series. The mid-range is defined as the salinity range between the 25th and 75th percentiles and is evaluated on a monthly basis. Results are presented as ribbon plots and each site is scored as a percentage of the observed or alternative simulation values that overlap within the target mid range. A second metric quantifies the offset or difference between the monthly means of the target and observed or simulated data. The third metric compares the frequency of occurrence of hypersalinity events (in days) between the target and observed/simulated time series (hypersalinity threshold used is 37 psu). All three metrics and the manner in which they are assessed and evaluated are applicable to any estuarine system. To aid managers and non-scientists in the interpretation of results, the performance measure output can be translated into a “stoplight” report card.

Contact Information: Patrick A. Pitts, U.S. Fish and Wildlife Service, 1339 20th Street, Vero Beach, Florida 32960, USA; Phone: 772-562-3909 x250; FAX: 772-562-4288; Email: Patrick_pitts@fws.gov

ECOLOGICAL BENEFITS QUANTIFICATION METHOD AND RESULTS FROM PIR-1 OF THE CERP WCA-3 DECOMPARTMENTALIZATION AND SHEETFLOW ENHANCEMENT (DECOMP) PROJECT

Gregg A. Reynolds[1], *A. McLean*[1] and *M. Nassuti*[2]
[1]NPS South Florida Ecosystem Office, Homestead, FL, USA
[2]USACE Jacksonville District, Jacksonville, FL, USA

Compartmentalization, canals and changing hydrology have altered the ridge and slough communities of the Everglades landscape, causing the topography and vegetation to become more uniform (Sklar, 2000; Richards, 2008). The Decompartmentalization and Sheetflow Enhancement Project (DECOMP), Project Implementation Report 1 (PIR-1), focuses on options to backfill or plug a portion of the Miami Canal, remove spoil mounds and re-hydrate northern Water Conservation Area 3A (WCA-3A) within the central Everglades. Predictive Performance Measures (PMs) are used to measure hydrologic metrics important for restoring the ecosystem, such as hydroperiod and dry-down duration. PM metric scores are derived from alternative water depths, and flow, simulated using the Regional Simulation Model (RSM). To facilitate evaluation of the alternatives, the DECOMP Benefits Quantification method (DBQ) is then used to aggregate PM scores from key locations across the entire project footprint (WCA-3 and Everglades National Park).

The DBQ method provides numerical values that represent the ecosystem restoration benefits expected from each of the DECOMP PIR 1 alternatives in relation to each other, baseline conditions and to restoration targets. These values are then used in a cost-effectiveness / incremental cost analysis to select a cost-effective alternative from the alternatives providing the greatest ecological benefits.

The benefits evaluation consisted of three types of analyses, each briefly described below:

1. DECOMP Benefits Quantification (DBQ). A method used to re-scale PM scores to a common 0 to 100 scale, to spatially aggregate scores, and to generate Habitat Units (HUs). In the DBQ, PMs are differentially weighted separately for each Project Objective, relative to their importance in meeting each objective.

2. Non-metric multidimensional scaling (NMDS). NMDS provided an independent quality check on the DBQ results. NMDS is used to evaluate correlations among PMs, uncertainty in the results, the degree of differentiation between alternatives, and to test the sensitivity of the DBQ weighting system.

3. Independent ecologic and hydrologic performance evaluation of alternative plans by best professional judgment. Alternative performance is ranked based on review of water depth maps, flow vector maps, hydroperiod maps, drought intensity maps, depth-duration curves and depth-frequency curves.

We examine the benefits of each DECOMP evaluation method and compare alternative scores from the DBQ with results from the NMDS and best professional judgment evaluations.

Contact Information: Gregg A. Reynolds, National Park Service, South Florida Natural Resources Center, Everglades National Park, Homestead, FL 33030, Phone: 305-224-4236; Fax: 305-224-4147, Email: Gregg_Reynolds@nps.gov

EVALUATION OF VEGETATION DATA AS A MANAGEMENT TOOL IN EVERGLADES NATIONAL PARK

Jimi Sadle
Everglades National Park, Homestead, FL, USA

Preservation of plant communities in Everglades National Park (ENP) represents one of the fundamental reasons for the establishment of the park. Park managers are tasked with maintaining vegetation communities that represent to the extent possible, natural patterns and processes within ENP. Major drivers of vegetation patterns in ENP include water management practices, nutrient loading, fire patterns, sea level rise and establishment and spread of invasive species. Often these drivers interact in complex ways to shape ENP plant communities. Vegetation monitoring can be used to detect plant community changes that can then be linked to the major drivers and guide decision making. However, implementing an effective vegetation monitoring program in an expansive area with limited resources presents significant challenges to park managers. Incorporating this Information into an ongoing restoration planning process represents an additional difficulty. This presentation will provide an overview of past and ongoing vegetation studies in ENP to highlight the successes and failures ENP managers have encountered in recognizing vegetation changes in the park, understanding the cause of those changes and implementing decisions based on the results of those studies.

Contact Information: Jimi Sadle, Everglades National Park, 40001 State Road 9336, Homestead, FL 33034 USA, Phone: 305-242-7806; Fax: 305-242-7836, Email: jimi_sadle@nps.gov

ADAPTING RESTORATION PERFORMANCE MEASURES TO THE A.R.M. LOXAHATCHEE NATIONAL WILDLIFE REFUGE

Donatto D. Surratt[1] and *Rebekah E. Gibble*[2]

[1]Everglades National Park c/o A.R.M. Loxahatchee National Wildlife Refuge, Boynton Beach, FL, USA

[2]A.R.M. Loxahatchee National Wildlife Refuge, Boynton Beach, FL, USA

The A.R.M. Loxahatchee National Wildlife Refuge (Refuge), last remnant of the historic Florida Everglades, is part of the world's largest environmental restoration effort and assessing restoration strategies and success is critical to achieving restoration. Restoring historic surface water flow patterns (sheetflow) and water quality are the major efforts applied to restoring the Everglades ecosystems. Both of these approaches are challenging for the Refuge because the system is isolated from the Everglades by a series of boundary canals, which ultimately prevent sheetflow and make the marsh dependent on nutrient enriched waters to support the Refuge hydrology. For the Greater Everglades, there are performance measures (PM) designed to either evaluate restoration strategies or assess restoration success, however, most of these are not directly applicable to the Refuge. In 2011, the Refuge held a science workshop designed to assess the state of PMs and the applicability to the Refuge. From this workshop, a number of PMs from the suite applied to the Everglades were assessed and determined to be applicable to the Refuge, while several other PMs were identified that should be applied to the Refuge, but are not currently. Another outcome of the workshop was the development of ecological indicators (targets) and necessary research needs for each of the PMs that were determined as priorities for developing and applying in the Refuge. Based on the science workshop, several assessment and evaluations PMs from the Greater Everglades were deemed acceptable for the Refuge with some modification. Assessment PMs aid in determining the success of restoration and those from the workshop include: alligator density, exotic/invasive species (i.e., birds, reptiles, and fish) density, tree island cover, periphyton composition, and prey-based fish density. Evaluation PMs aid in determining the impact of a management strategy and for the Refuge include: high-water stage duration, stage reversal intensity, and water level recession rates. This presentation briefly describes (1) these PMs, (2) needs to develop associated targets, and (3) a case study applying a recently developed PM designed to evaluate Refuge hydrologic response to operational decisions.

<u>Contact Information</u>: Donatto D. Surratt, Everglades Program Team, Everglades National Park c/o A.R.M. Loxahatchee National Wildlife Refuge, Boynton Beach, FL 33473. Phone: 561-735-6003. Fax: 561-735-6008. Email: donatto_surratt@nps.gov

SEDIMENT-SLURRY ADDITION IN SALT MARSH RESTORATION: A VIEWPOINT FROM THE BENTHIC MACROINVERTEBRATE

Chunfu Tong
State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai, China

Salt marshes, distributed worldwide in estuaries and coastal areas in middle and high latitudes, are one of the most productive ecosystems in the world. But unfortunately, these coastal marshes are being lost at high rates across the globe. Increasing marsh elevation is often key in reversing the processes causing wetland loss, such as sea level rise and sediment subsidence, and restoring intertidal salt marshes. One of the effective restoration techniques is sediment-slurry addition.

In the mono-dominant vegetation area, its effectiveness has already been proved by previous studies on the plant and the soil conditions. In 2010, it had also been proved by the surveys we did on the benthic macroinvertebrate in a restored site of Louisiana *Spartina* salt marsh, seven years after the sediment-slurry addition application. We found that the proper sediment addition can also restore the macroinvertebrate community to levels equivalent to those in reference marshes, while too much sediment impairs recovery. However, the optimal threshold of sediment-slurry addition is location dependent.

In the multi-species zonation area, the situation might be more complicated. For example, in Yangtze Estuary, the vegetation has obvious zonation pattern along the elevation gradient. In 2006, we carried out monthly surveys on the benthic macroinvertebrate in different vegetation zones along an elevation gradient in the salt marsh of Chongming Dongtan in the Yangtze Estuary. The results proved that the elevation had significant effects on the species richness and abundance of the benthic macroinvertebrates (ANOVA, $P<0.01$). Different vegetation zones along the elevation gradient have different benthic macroinvertebrate assemblages and monthly variation characteristics. It might be more important to sustain the elevation gradient of the whole area than only to improve the elevation of some sites. Furthermore, as the environmental factors vary along the elevation gradient, the impacts caused by sea level rise and sediment subsidence on the salt marsh ecosystem, including the benthic macroinvertebrates, can also be different in different vegetation areas of different elevations. The optimal threshold of sediment-slurry addition might be different in different vegetation zones and need to be studied specifically.

Contact Information: Chunfu Tong, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, 3663 North Zhongshan Road, Shanghai 200062, P.R. China, Phone: 86-21-62232174, Fax: 86-21-62546441, Email: cftong@sklec.ecnu.edu.cn

LINKING WETLANDS HYDROLOGY TO ESTUARINE SALINITY IN THE EVERGLADES: INTEGRATED SOLUTIONS TO ESTABLISH RESTORATION TARGETS

G. Lynn Wingard[1] and *Frank E. Marshall*[2]

[1] U.S. Geological Survey, Reston, VA, USA

[2] Cetacean Logic Foundation, New Smyrna Beach, FL, USA

Restoration of the Greater Everglades Ecosystem is dependent on re-establishing historical hydrologic conditions of freshwater flow through the wetlands and into the southern estuaries to the extent possible in the current setting. Theoretically-based mechanistic models of restored hydrology in south Florida and the Everglades have not produced the low salinities in the estuaries that paleoecologic and anecdotal data indicate existed, prior to significant development and construction of water control structures around 1900 CE. Land management agencies needed a method to estimate historical flows and stage in the wetlands and salinity in the estuaries in order to set empirically based targets for restoration.

To address this problem, we developed a 3-phase method that couples paleoecological data on historical salinity conditions in the estuaries to freshwater flow and stage data from the wetlands. Phase one is the paleosalinity analysis of radiometrically-dated sediment cores collected in the estuaries. The molluscan assemblages in the cores are identified, counted, and compared to a modern analog dataset. Average salinity values from the modern dataset are weighted by the abundance of that species in each sample, and a cumulative weighted average salinity is produced for each 2-cm core segment. The paleosalinity estimates from about 1900 CE are the phase one output. Phase two produces linear regression models based on modern hydrologic station data that link freshwater stage and flow at locations in the wetlands to salinity in Florida Bay. Phase three couples the paleosalinity estimates with the hydrologic models, by inserting the paleosalinity into the regression equations and solving for flow and stage. The output predicts what the historical flow and stage in the Everglades wetlands would have been, in order to produce the salinities indicated by the faunal assemblages in the cores.

This approach has been applied to five sediment cores in Florida Bay. Our results show a "wetter Everglades" prior to 20th century water management practices. Stage in the Everglades around 1900 CE was from 0.6 to 1.2 feet higher, depending upon location. Flow into Shark River Slough at Tamiami Trail was about 1500 cfs higher and at Taylor Slough Bridge about 120 cfs higher than existing flows. The resulting salinity in Florida Bay averaged 12 salinity units lower in the nearshore transition zones and about 3 salinity units lower on the western margin of the bay near the Gulf of Mexico connection. These results are being used by the Southern Coastal Systems Sub-team of RECOVER (Restoration Coordination and Verification; a multi-agency group) to develop performance measures and targets for salinity in the estuaries for use by restoration managers to establish guidelines for the wetlands.

Contact Information: G. Lynn Wingard, Eastern Geology and Paleoclimate Science Center, U.S. Geological Survey, MS926A, National Center, Reston, VA 20192 USA; Phone: 703-648-5352; Fax: 703-648-6953; Email: lwingard@usgs.gov

ECOSYSTEM RESTORATION - LARGE SCALE RESTORATION PROGRAMS

REPACKAGING IS NOT AS SIMPLE AS IT SEEMS: LESSONS LEARNED ON THE C-44 PROJECT

Brooke Ahrens
HDR Engineering, West Palm Beach, Florida, USA

The proposed C-44 Reservoir/Stormwater Treatment Area Project (Project) is located on 12,000 acres owned by the South Florida Water Management District (SFWMD) in Martin County, FL and supports the goals and objectives of the Comprehensive Everglades Restoration Plan (CERP). The Project, one of several components recommended in the Indian River Lagoon South Project Implementation Report (March 2004), consists of an above-ground reservoir, pump station, canals, stormwater treatment area and associated structures to capture and treat runoff from the C-44 watershed. Components are designed for flow attenuation to the St. Lucie Estuary, water quality benefits from reduced nutrient loading and pollutants contained in runoff to the estuary, and water supply benefits. In June 2007, the Project design was completed as one 3-year construction contract; nevertheless, due to changes in CERP execution and available funds, it was put on hold.

In late 2009, the US Army Corps of Engineers (USACE), a 50/50 cost share partner with SFWMD on the Project, received funding to construct the Project in phases; with several smaller portions of construction to be performed by SFWMD. The main Project features will be constructed by the USACE through three construction contracts over eight years. The SFWMD construction efforts include canals and pumping facilities to coordinate with an adjacent drainage district, the C-132 and Northern C-133 Canals and associated wetlands mitigation, the C-44 Communications Tower, distribution and transmission line relocations, and the alleviation of ecological risks from residual agricultural chemicals in soils onsite.

During the design repackaging process, there have been many lessons learned, especially related to the "shelf life" of a design, different contracting approaches of two agencies, and the effort to create biddable contract packages from a once comprehensive package. For example, SFWMD construction delivery approach is lump sum and typically a single bid item. USACE project delivery approach for the Project is several bid items with a mixture of unit prices. Additionally, the nature of splitting a single cohesive package into eleven separate packages to be constructed at various times over several years requires adjustments for transitions and other issues that would not have otherwise existed; including design changes related to the relocation of staging areas, dewatering, and access points. Additionally, complexities arise from repackaging related to the distribution of agency responsibilities for each construction contract. All of these items have been observed during coordination for both the SFWMD construction efforts, as well as planning for the first phase of the USACE construction, and will be considered during future design update phases to support optimal project execution. Due to the size of these projects to achieve restoration, challenges will always exist in funding mechanisms to support construction in one contract. Conscientious planning that permits parties to construct and project flexibility that accommodates for several construction phases that match available funding will always be necessary.

Contact Information: Brooke Ahrens, HDR Engineering, 1400 Centrepark Boulevard, Ste 1000, West Palm Beach, FL 33401
Phone: 561-209-6623 Email: brooke.ahrens@hdrinc.com

THE C-111 SPREADER CANAL PROJECT, A UNIQUE EXAMPLE OF PUBLIC INVOLVEMENT AND ADAPTIVE MANAGEMENT

Kenneth G. Ammon[1]*, Devon Utler*[1] and *Jorge Jaramillo*[2]
[1]WRScompass, West Palm Beach, FL, USA
[2]South Florida Water Management District, West Palm Beach, FL, USA

From planning to design through construction, the C-111 Spreader Canal project is one the first Comprehensive Everglades Restoration projects to include a unique all-inclusive stakeholder planning process as well as an iterative adaptive management design and construction technique which together have resulted in universal acceptance of the project, a substantial savings to the taxpayers, faster implementation and a more reliable facility.

The C-111 canal in south Miami-Dade County is the southernmost canal in the Central and South Florida Flood (C&SF) Control Project. The C&SF Project was authorized by Congress in 1949 to provide flood control, water supply and other benefits to South Florida after a series of devastating hurricanes in the 1920's and 40's. The project has served its purpose well for over 60 years but unfortunately has had devastating impacts to the coastal, central and southern ecosystems of South Florida. The C&SF Project has drastically altered the timing, distribution quality, quantity and seasonal availability of ground and surface water, the very waters that have sustained South Florida's ecosystems for thousands of years.

The C-111 Spreader Canal Western Project includes structural and operational changes to improve the quantity, timing and distribution of water delivered to Florida Bay via Taylor Slough and to improve hydroperiods within the wetlands of the Southern Glades and Model Lands without adversely impacting existing levels of flood protection provided to adjacent agricultural and urban lands.

The South Florida Water Management District accelerated planning, design and construction of the C-111 project prior to congressional authorization or appropriation and in so doing were not subject to the Federal Advisory Committee Act (FACA). All stakeholders and governmental agencies were invited to sit at the table during the planning process to allow their comments and concerns to be heard, answered and incorporated into the final plan. This planning process resulted in a consensus and was completed in eighteen months compared to other CERP projects which have lasted four years or more.

During planning, design and construction of the project, adaptive management techniques were also employed to address uncertainties. During the planning process there was debate as to the appropriate alignment of a spreader berm to rehydrate the model lands as well as flood protection issues. It was decided to break the plan into two phases (eastern and western) until these issues could be resolved and to incorporate monitoring into the first phase (western) in order to address the uncertainties in the eastern phase.

During design it was determined that one section of canal could be eliminated with less wetland impacts by use of an existing canal on leased property which had recently been terminated. During construction a unique contamination issue was addressed by incorporating the contaminants deep inside the project berms and lastly, to reduce offsite impacts of flooding, a concrete channel was utilized to reduce seepage losses.

Contact Information: Kenneth G. Ammon, WRScompass, 2400 Centrepark West Drive, Suite 125, West Palm Beach, Fl. 33409 USA, Phone: 561-684-5474 Ext. 239, Fax: 561-684-5419, Email: Kammon@WRScompass.com

MEETING THE CHALLENGE OF BARRIER ISLAND RESTORATION: AN OVERVIEW OF THE LCA TERREBONNE BASIN BARRIER SHORELINE RESTORATION PLANNING PROCESS

A. Bass
CH2MHILL, Baton Rouge, LA, USA

Louisiana's coastal wetlands and barrier islands are being lost at an alarming rate. Current data indicate that shoreline erosion is accelerating and that many of Louisiana's barrier islands will disappear within the next fifty years if no action is taken. Barrier island loss is attributed to erosion and breaching, subsidence, sea level rise, diminished sediment input, and hydrologic modifications resulting from the excavation and maintenance of navigation and oil and gas canals. These losses have affected wildlife and fisheries resources adversely, including threatened and endangered species. Loss of the barrier island habitat also exposes the fragile saline, brackish, and fresh marshes to high energy marine coastal processes, and thus exacerbates wetland loss. The barrier islands also protect oil and gas infrastructure investments including hundreds of wells and pipelines that are of regional and national importance. Furthermore, numerical modeling has demonstrated that the barrier islands reduce storm surges and wave heights, which can mitigate storm-induced damages on human populations and infrastructure.

Title VII of the 2007 Water Resources Development Act authorized the formation of the Louisiana Coastal Area (LCA) Near-Term Plan, which required feasibility level analysis of six conditionally-authorized restoration projects. Recognizing the important role that barrier islands play, the Terrebonne Basin Barrier Shoreline Restoration (TBBSR) Study was selected as one of the six restoration projects.

The primary goal of the TBBSR Study was to develop a cost-effective plan that would restore and maintain the geomorphologic form and ecological function of the Terrebonne Basin Barrier Islands. This study area encompasses seven individual islands (Raccoon, Whiskey, Trinity, East, Wine, Timbalier, and East Timbalier) totaling 2,926 acres and nine potential borrow areas. The Study was led by a multidisciplinary team of scientists, engineers, and planners, the Louisiana Coastal Protection and Restoration Authority, and the USACE New Orleans District.

The Study team prepared an integrated feasibility study and environmental impact statement in accordance with the U.S. Army Corps of Engineers (USACE) six step planning process defined in Engineer Regulation 1105-2-100. The six-step process includes: 1) identifying objectives and constraints; 2) inventorying existing conditions and forecasting future conditions; 3) formulating alternative plans; 4) evaluating alternative plans; 5) comparing alternative plans; and 6) selecting the National Ecosystem Restoration (NER) plan. This presentation focuses on Steps 3 through 6, which are collectively referred to as the plan formulation process.

Contact Information: Aaron Bass, CH2MHILL, 700 Main Street, Suite 400, Baton Rouge, LA 70802, USA. Phone: 225-663-5191, Fax: 225-381-0869. Email: Aaron.Bass@ch2m.com

HYDROLOGIC INFLUENCES ON WATER QUALITY IN BLUE CYPRESS MARSH CONSERVATION AREA

Angelique M. K. Bochnak, *Steven J. Miller, Lawrence W. Keenan* and *Dean Dobberfuhl*
St. John's River Water Management District, Palatka, Florida, USA

Blue Cypress Marsh Conservation Area (BCMCA) is managed by the St. John's River Water Management District (SJRWMD) as part of the U.S. Army Corps of Engineers Upper St John's River Basin Project (USJRBP) Water Control Plan (COEWCP) to temporarily retain floodwater, provide long-term water conservation storage, and to restore and preserve floodplain wetlands. BCMCA consists of approximately 29,500 acres of freshwater marsh underlain by deep organic peat soils and 6,500-acre Blue Cypress Lake (BCL). The BCMCA is bounded by levees, canals and water levels are managed by water control structures. Historically, BCL was a low nutrient, low productivity lake that received natural sheetflow off the surrounding floodplain marsh. The management efforts have been such as to try to maintain the historical hydro-patterns of this system.

Long-term water quality monitoring within BCL as been ongoing since the early 1980's. A recent assessment of this water quality database indicates that the once low nutrient concentrations of BCL are on the rise. There has been a steady incline in the Trophic State Index (TSI) since the mid 1990's which indicates the lake has shifted from one with good water quality to one with fair to poor water quality. The rise in TSI is primarily due to the considerable increase in TP and TKN, and not large increases in productivity (chl-a concentrations). There has been a 96% change in TP from the early 90's to 2009, increasing from 74 µg L^{-1} to 146 µg L^{-1}, respectively. In addition to an increase in TSI and the associated water quality parameters, we have also observed significant increase in total organic carbon (TOC) concentrations in the lake. The concentration of TOC increased by 59% from 18.9 mg L^{-1} to 30.1 mg L^{-1} from the mid 90's to 2009, respectively.

An in depth analysis of the managed water levels of the surrounding floodplain marsh and the continued rise in TOC in BCL indicate a strong relationship between the median marsh water level and the annual TOC accumulation rate in the late ($r^2 = 0.7362$). During years when median water level is low in the marsh, we observe the highest TOC accumulation rates in the lake. This strongly suggests that long exposure periods of the peat soil is having a negative impact on the water quality of the lake. With growing demands on water supply and the continued development of the surrounding watershed, it is imperative that the water quality degradation of BCL is addressed and the floodplain marsh is managed for the proper water regime to maintain and protect the deep organic peat soils before continued decline is observed and/or irreversible.

Contact Information: Angelique M.K. Bochnak, St John's River Water Management District, Division of Water Resources, Bureau of Environmental Sciences, 4049 Reid St, Palatka, FL 32177 USA, Phone: 386-312-2309; FAX: 386-329-4585, Email: abochnak@sjrwmd.com

ASSESSING HYDROPERIOD RESTORATION ALTERNATIVES IN FLATFORD SWAMP, FLORIDA

B.J. Bukata[1], *J. Loper*[2], *M. Szafraniec*[3], *K. Kaufman*[3], *L. Morris*[3] and *K. Boulicault*[4]

[1]Jones Edmunds & Associates, Inc., Gainesville, FL, USA
[2]Interflow Engineering LLC, Tampa, FL, USA
[3]Southwest Florida Water Management District, Brooksville, FL, USA
[4]Singhofen & Associates, Inc., Winter Park, FL, USA

The Upper Myakka River Watershed is a hydrologically altered system. Environmental damage from excess water has been attributed to agricultural operations, land-use changes, and drainage modifications within the watershed. Much of this damage has occurred in the form of tree mortality within the 12-square-kilometer wetland area known as Flatford Swamp. The stress of prolonged flooding within Flatford Swamp has altered the structure and composition of vegetative communities. Flatford Swamp has experienced an ecological shift from desirable seed-germinating wetland hardwoods such as swamp tupelo (*Nyssa sylvatica* var. *biflora*) to transitional habitats dominated by clonal trees and shrubs with an increasing prevalence of invasive species.

The project goals were twofold: 1) restore the hydroperiod of Flatford Swamp to historical conditions and 2) assess vegetative restoration alternatives. Previous project tasks have included developing, calibrating, and applying an existing and historical conditions continuous-simulation water-budget model of the watershed using the MIKE SHE/MIKE-11 integrated groundwater/surface-water-modeling platform.

The Flatford Swamp Flow Diversion Scenario Evaluation was a first step in evaluating the feasibility of restoring the hydroperiod of the Flatford Swamp area. The main purpose of this effort was to evaluate the sensitivity of Flatford Swamp hydroperiods using the calibrated MIKE SHE/MIKE 11 model for six potential methods of diverting or extracting water from the swamp itself or from the streams that function as tributary inflow points. The scenarios were then ranked with respect to environmental and other criteria developed by the project team. Additional components of this effort included developing a high-resolution baseline vegetation community map of Flatford Swamp, assessing soil nutrients at creek inflow locations, and developing restoration alternatives.

Results of the six scenarios indicated that a strategy of diverting the excess flows at or near the main tributary inflow points to Flatford Swamp holds the greatest promise for reducing the existing dry and wet-season inundation impacts. The recommended conceptual scenario involves diverting water at three main tributary inflow locations to a large storage facility using a combination of passive diversion features (i.e., open channels with culverts or gated control structures) and active diversion features (pumps). The project team classified the high-resolution vegetation map to species level when feasible to assist in identifying primrose willow (*Ludwigia peruviana*) and cattail (*Typha* spp.) dominated areas. Results of the soil-nutrient investigation determined that muck soils in Flatford Swamp are eutrophied and likely facilitating the dominance of cattail and primrose willow. Due to the prevalence of these nuisance and exotic species, vegetation management will be investigated to facilitate native vegetation restoration of Flatford Swamp. Restoration alternatives that will be evaluated in addition to hydrologic restoration include implementing controlled burns of primrose willow dominated areas, and supplemental planting and aerial seeding of swamp tupelo.

Contact Information: B.J. Bukata, MS, PWS, Jones Edmunds & Associates, Inc., Gainesville, FL, 32641, USA; Phone: 352-377-5821; Fax: 352-377-3166; Email: bbukata@jonesedmunds.com

MANAGING IMPLEMENTATION OF A MULTI-DECADAL ECOSYSTEM RESTORATION PROGRAM

Eric Bush
U.S. Army Corps of Engineers, Jacksonville District, Jacksonville, FL, USA

Initial planning for the South Florida Everglades Restoration Program began in the early 1990s, culminating with approval of the Comprehensive Everglades Restoration Plan (CERP) and initial Congressional authorization in 2000. The restoration program includes multiple projects and program-level activities with an overall estimated program cost exceeding approximately $20 billion involving all phases of project implementation: planning and environmental analysis; design and procurement; construction; and, long-term operations, maintenance, and repair. To manage this enormously complex program, the U.S. Army Corps of Engineers and the South Florida Water Management District have developed and implemented management policies, procedures, and tools. This presentation will provide: (1) an overview of program and project management guidance, including linkages to legal authorities and cost-sharing requirements; and (2) an overview of program and project management procedures and tools.

Contact Information: Eric Bush, U. S. Army Corps of Engineers, Jacksonville District, 701 San Marco Blvd, Jacksonville, FL 32207 USA, Phone 904-232-1517, Email: Eric.L.Bush@usace.army.mil

SEDIMENT DYNAMICS IN RESTORED TIDAL WETLANDS OF SAN FRANCISCO BAY

John C. Callaway[1], *Lisa M. Schile*[2], *Evyan L. Borgnis*[3], *V. Thomas Parker*[3] and *Donna Ball*[4]
[1]University of San Francisco, San Francisco, CA, USA
[2]University of California, Berkeley, CA, USA
[3]San Francisco State University, San Francisco, CA, USA
[4]H.T. Harvey & Associates, Los Gatos, CA, USA

There is large-scale interest in restoring tidal wetlands in the San Francisco Bay Estuary, with recent projects ranging from a few hectares to thousands of hectares. Many of these restoration sites have subsided substantially, including those within the South Bay Salt Pond Restoration Project, as well as many other large-scale restoration sites. When levees are breached at subsided sites, significant sediment accumulation is necessary to reach threshold elevations for plant establishment. In addition to these issues, there is growing concern concerning impacts from increases in rates of sea-level rise and reductions in suspended sediment concentrations within the Bay. We have been measuring sedimentation rates at a number of restored and natural wetlands across the Bay in order to evaluate sediment dynamics that will affect the development of restored tidal wetlands in San Francisco Bay. Highly subsided sites within the South Bay have the potential for very rapid accumulation, as they are frequently inundated and suspended sediment rates within the South Bay are relatively high. More than 20 cm of sediment accumulated in the first three years post-breach at one salt pond that was restored in the South Bay, with a gradual reduction in sediment accumulation over time as the site increased in elevation. Vegetation established rapidly at the site once suitable elevations were reached. A more subsided salt pond was breached in December 2010, with rapid accumulation at this site during the first year post-breach. However, this pond still needs to accumulate at least 30 cm of sediment before elevations are suitable for plant establishment. Other restoration projects that we have monitored have not accumulated sediment as rapidly as the subsided salt ponds in the South Bay, likely due to restrictions in tidal flow, higher initial elevations, or local restrictions to sediment supply. On-going monitoring of a range of wetlands within the Bay will allow for the development of models which can be used to predict sediment dynamics in future restoration projects, as well to understand longer-term development of restored wetlands under scenarios of increased sea-level rise and reduced suspended sediment concentrations.

<u>Contact Information</u>: John C. Callaway, Department of Environmental Science, University of San Francisco, 2130 Fulton St., San Francisco, CA 94117, USA, Phone: 1.415.422.5702, Fax: 1.415.422.6387, Email: callaway@usfca.edu

A HOLISTIC ASSESSMENT OF LAKE AND WETLAND RESTORATION BEST MANAGEMENT PRACTICES IN FLORIDA

Ni-Bin Chang*, Martin Wanielista, Jamie Jones* and *Kamrul Islam*
Stormwater Management Academy, Orlando, FL, USA

The Florida Fish and Wildlife Conservation Commission (FFWCC) is working with the Florida Department of Environmental Protection (FDEP) to develop a Manual of Best Management Practices (BMPs) for aquatic restoration activities conducted by FFWCC. Some of these activities will be permitted under FDEP's Environmental Restoration Permitting (ERP) and the U.S. Army Corps of Engineers (USACE) Dredge-and-Fill permitting protocol. A suite of BMPs for these activities is requested by the permitting agencies; however, many of these activities (sediment removal under inundated conditions [hydraulic dredging] and dewatered conditions; aquatic plant removal using floating equipment [harvesters and barge-mounted excavators]; hydrologic restoration [e.g., ditch filling and plugging], stream restoration, etc.) currently do not have a consistent and approved set of construction and operation procedures associated with them.

The objective of this study is to develop a manual of construction Best Management Practices (BMPs) for application during aquatic restoration activities conducted in freshwater surface-water and wetland environments. The primary purpose of these BMPs is to prevent violations to State Water Quality Standards pursuant to Chapter 62-302, Florida Administrative Code (F.A.C.), beyond any authorized mixing zone established in accordance with Rule 62-4.244, F.A.C. The four primary aquatic restoration activities to be covered within the manual are: 1) aquatic plant removal, 2) sediment manipulation 3) wetland restoration, and 4) stream restoration. The manual will also address BMPs appropriate for soil erosion control to prevent introduction of soils or sediments into surrounding surface waters or wetlands during aquatic restoration activities.

The study will summarize the experience learned from several on-going lake and stream restoration sites state-wide. These sites may include, but are not limited to, lakes and wetlands which are undergoing restoration work or expect to have projects in the near future. In this presentation, study sites within Florida at least include: 1) Lake Istokpoga (aquatic plant removal); 2) Osceola National Forest ponds (sediment manipulation; littoral creation); 3) Fanning Springs (sediment manipulation; dredging); 4) Fellsmere WMA (sediment manipulation; micro-habitat creation); 5) Lake Beauclair (sediment manipulation; dredging);and 6) Sheep Island Lake (wetland restoration).

Contact Information: N. B. Chang, Stormwater Management Academy, University of Central Florida, Orlando, FL 32816, USA, Phone: 407-754-7521, Fax: 407-823-3315, Email: nchang@ucf.edu

TEN YEARS OF CERP: IDEALISM, CONFUSION, RECESSION, REALITY. A HISTORY OF THE UPS AND DOWNS OF EVERGLADES RESTORATION.

Barbara Cintron
Planning and Policy Division, U.S. Army Corps of Engineers, Jacksonville, FL, USA

In 2001T, the Comprehensive Everglades Restoration Plan was kicked-off by a cast of hundreds in a conference at the Peabody Hotel in Orlando. Senior managers of the Corps of Engineers, including participants from South Atlantic Division and Headquarters; Representatives of the U.S. Department of the Interior, including the South Florida Ecosystem Restoration Task Force, the Fish and Wildlife Service, U.S. Geological Service and Everglades National Park; Representatives of the non-federal sponsor, the South Florida Water Management District, other State agencies, and non-governmental groups including the Everglades Coalition, Friends of the Everglades, members of the Governor's Commission and others attended and heard how the recently authorized CERP would work. Just over 10 years into the federal program, progress has been slower than most of us ever imagined it could be, but significant progress has been made. First to be approved at Corps headquarters and authorized by Congress, the Picayune Strand Restoration and Indian River Lagoon –South Restoration Projects are under construction. Some projects awaiting Federal authorization were put into the ground by the South Florida Water Management District and are already providing visible, measurable benefits. The last water project authorization bill, known as WRDA 2007, authorized more CERP projects but also burdened projects with additional layers of time-consuming independent review. The Central "River of Grass" described in Marjory Stoneman Douglass' book, shrunken in size by development, has still to experience any significant restoration. We have 'nibbled around the edges' without tackling the central River's many problems and constraints, but we're going there now.

There were many reasons for these delays, political, geo-political, and economic. We made some mistakes in our first-cut rules for the restoration, including requirements to show stand-alone and additive benefits of each individual CERP component (even though we knew that many would be interdependent). We underestimated the costs of many CERP components, not expecting the land boom of the early 2000s, the great inflation of fuel costs, or the subsequent bursting of the real estate bubble. We also suffered several severe hurricanes that exposed the vulnerability of other major Corps projects, especially Herbert Hoover Dike. We weathered disagreement about Federal participation credit for State land acquisition and over our participation in water quality improvements; and, above all, suffered through inflation and recession that led to loss of state property tax receipts, budget cuts, staff cuts and belt-tightening in State agencies; and, at the federal level, a seemingly endless cycle of reviews required after reports are written.

We present a timetable of significant CERP "events" and some of the "bumps" along the way, as well as the major successes of the program to date.

<u>Contact Information</u>: Barbara B. Cintron, Planning and Policy Division, U.S. Army Corps of Engineers, 701 San Marco Blvd, Jacksonville, FL 32207 USA, Phone: 904-232-1692; Fax:904-232-3442. Email: Barbara.b.cintron@usace.army.mil.

ENHANCED ADAPTIVE MANAGEMENT FOR EVERGLADES IN RESPONSE TO CLIMATE CHANGE

Matteo Convertino[1,2], *Christy M. Foran*[1], *Jeffrey M. Keisler*[3], *Lynn Scarlett*[4], *Andy LoSchiavo*[5], *Gregory A. Kiker*[2] and *Igor Linkov*[1]

[1]United States Army Corps of Engineers, Engineer Research and Development Center, Environmental Laboratory, Concord, MA, USA
[2]Agricultural and Biological Engineering Department, University of Florida, Gainesville, FL, USA
[3]University of Massachusetts, Boston, Department of Management Science and Information Systems, Boston MA, USA
[4]Resources for the Future, Washington, DC, USA
[5]US Army Corps of Engineers, Jacksonville District, Jacksonville, FL, USA

Variability in future climate conditions, as well as increasing resource scarcity, have been driving forces in the recognition and utilization of adaptive management strategies for large-scale environmental restoration. However, many applications of adaptive management have been criticized for shortcomings. We propose to enhance existing adaptive management efforts with a formalized decision-analytical approach that can guide the initial selection of restoration alternatives and can also allow for the adjustment of these alternatives in the course of action based on continuously acquired monitoring Information and changing socio-political environments. Here we demonstrate an application of enhanced adaptive management for a wetland restoration case study inspired by the Florida Everglades restoration. We find that alternatives designed to reconstruct the pre-drainage flow may be beneficial for the environment, but may also have very high operational costs and marginal flood control benefits. The results of the model show that the variability associated with climate, such as the variation of the average annual rainfall, significantly impacts the performance of different restoration alternatives. In response to this climatic variability, selecting the intensity of ecosystem monitoring programs within an adaptive strategy can illuminate or obscure the critical habitat shifts. While a decrease in monitoring resources can overlook important qualities, the uncertainty reduction through an over-extension of monitoring programs can expend limited resources with little impact on the selection of restoration alternatives. Investment in operational modeling and monitoring efforts should thus be guided by scenario and value of Information analysis to support optimal actions in the face of uncertain and changing Information. An important element in our adaptive decision approach shows that the ability to change restoration alternatives in the future brings an additional payoff for all the alternatives considered. Decision modeling enhances the adaptive management process in a way that allows for identification, summarization, exploration and valuation of the uncertainties and controversies resulting from climate change.

Contact Information: M. Convertino, USACE ERDC, Risk and Decision Science Team, New England District, Concord, MA, 01742, Phone: 781-645-6070, Email: mconvertino@ufl.edu

JOINT ECOSYSTEM MODELING (JEM) STANDARDS-DRIVEN SOFTWARE DEVELOPMENT: BENEFITING GREATER EVERGLADES AND THE NATION

Craig Conzelmann[1], *Stephanie S. Romañach*[2], *Kevin Suir*[3], *Christina Hunnicutt*[3], *Mark McKelvy*[3] and *Sumani Chimmula*[4]

[1]U.S. Geological Survey, Lafayette, LA, USA
[2]U.S. Geological Survey, Gainesville, FL, USA
[3]Five Rivers Services, LLC, Colorado Springs, CO, USA
[4]University of Louisiana, Lafayette, LA, USA

Called by some "a living laboratory", the Greater Everglades restoration efforts act as an incubator for ecological modeling ideas, which influence resource management across the nation. The South Florida-based Joint Ecosystem Modeling (JEM) community has facilitated collaboration between federal and state agencies, universities, and other organizations, resulting in well-defined data standards and the release of numerous modeling and visualization tools. Introduction of the Comprehensive Everglades Restoration Plan (CERP) NetCDF metadata conventions has enabled agencies to reuse models, data manipulation and visualization tools, and source code from JEM. Further, JEM has developed several ecological models for assessment and planning efforts across the Everglades, as well as the cross-platform EverVIEW Data Viewer (EverVIEW).

The ability to visualize model output greatly impacts the decision-making and model design process, because it allows researchers to quickly identify problem areas and target resources more effectively. By producing standards-compliant output, local and national agencies are able to leverage the EverVIEW platform, resulting in increased confidence in both the models, and the management decisions they inform. For example, the Louisiana Coastal Protection and Restoration Authority recently completed an extensive coastwide ecological modeling effort. Incorporating CERP conventions, the upper trophic and ecosystem services model outputs were easily visualized and assessed with EverVIEW.

Impressed by the standards-compliant visualization platform, multiple agencies are working to extend the functionality of EverVIEW. Everglades National Park (ENP) utilizes the EverVIEW Transect Tool to assess stage outputs from various hydrological models. User-defined transect lines are used to generate charts of stage values as a function of distance from transect origin, with custom landmark points to ground the data in reality. Likewise, the Natural Resource Conservation Service (NRCS) has funded the development of six ecosystem services models and the EverVIEW Reporting Tool for the Lower Mississippi Valley (LMV) regional assessment, through its Conservation Effects Assessment Program. Adherence to standards ensures both the models and the Reporting Tool are useful to resource managers outside the LMV region. By developing the EverVIEW Climate Envelope Modeling Tool, the US Fish and Wildlife Service, US Geological Survey, University of Florida, and ENP were able to geospatially visualize the output of predictive models describing potential climate change effects on 26 threatened and endangered vertebrate species occurring in the Greater Everglades, and easily share their findings via common web data standards.

JEM tools benefit both a targeted audience and the wider resource management community. With this in mind, JEM remains committed to its standards-driven development philosophy, knowing that its products will be relevant to restoration efforts well beyond the South Florida region.

Contact Information: Craig Conzelmann, National Wetlands Research Center, U.S. Geological Survey, 700 Cajundome Blvd, Lafayette, LA 70506, Phone: 337-266-8842, email: conzelmannc@usgs.gov

VISUALIZING UPPER TROPHIC AND ECOSYSTEM MODELING OUTPUTS WITH EVERVIEW TO INFORM THE DECISION PROCESS IN COASTAL LOUISIANA

***Craig Conzelmann*[1]**, *Carol Parsons Richards*[2], *Kevin Suir*[3], *Sumani Chimmula*[4] and *Mark McKelvy*[3]

[1]U.S. Geological Survey, Lafayette, LA, USA
[2]LA Office Coastal Protection and Restoration, Baton Rouge, LA, USA
[3]Five Rivers Services, LLC, Colorado Springs, CO, USA
[4]University of Louisiana, Lafayette, LA, USA

State and Federal resource management agencies must periodically review and revise policies regarding ecological restoration and management. As the science of predictive modeling in coastal environments matures, these agencies are driven to include this new science into planning and decision making processes. Such is the case with the Louisiana Coastal Restoration and Protection Authority (CPRA) who enlisted a suite of predictive models to better inform the decisions leading to an updated 2012 Master Plan for ecosystem restoration and hurricane protection in coastal Louisiana. A portion of the modeling effort focused on ecosystem metrics based on either a single organism (ex: alligator, river otter), a combination of organisms (ex: three waterfowl species) and other ecosystem related metrics (ex: storm surge attenuation). With literally tens of thousands of modeling inputs and outputs, data visualization plays an important role in identifying where decision makers should focus when sifting through such large data stores. Borrowed from the Greater Everglades Joint Ecosystem Modeling community, EverVIEW, a standards compliant data viewer, was extensively used to visualize and compare modeling inputs and outputs. This visualization platform allows the user to view modeling output spatially and temporally using a 3D global environment and provides a table viewer for inspection of data at the modeling cell level. Using the EverVIEW software allowed CPRA managers to perform quality review on model inputs and outputs which included the ability to assess the decision rules of specific models and locate data anomalies. Recent additions to the platform include tools which allow the user to quickly generate difference maps along with a reporting tool allowing a user to generate spatial and temporal statistics. As resource managers continue to struggle with the challenges surrounding large-scale resource management, standards compliant assessment and visualization tools will continue to be valuable assets.

Contact Information: Craig Conzelmann, National Wetlands Research Center, U.S. Geological Survey, Lafayette, LA 70506 USA, Phone: 337-266-8842, Fax: 377-266-8616, Email: conzelmannc@usgs.gov

RESTORING ECOSYSTEM FUNCTION IN THE P-ENRICHED EVERGLADES: IMPROVING HABITAT FOR WILDLIFE

Mark I. Cook[1], *Susan Newman*[1], *Scot E. Hagerthey*[2] and *R. Mac Kobza*[3]

[1]South Florida Water Management District, West Palm Beach, FL, USA
[2]U.S. Environmental Protection Agency, Arlington, VA, USA
[3]Boulder County Parks and Open Space, Longmont, CO, USA

Anthropogenic nutrient inputs can induce extensive changes in the structure and function of wetland systems. In the Florida Everglades, four decades of phosphorus enrichment has resulted in a regime shift from the original slough and sawgrass (*Cladium jamaicense)* matrix to 14,000 ha of dense stands of monotypic cattail *Typha* spp. In these enriched cattail areas, a key constraint in ecosystem function is the high density of the vegetation, which results in net heterotrophic production and limits access to foraging wading birds. A landscape-scale experiment, the cattail habitat improvement project (CHIP), using fifteen 6.25 ha plots, was initiated to test our ability to restore *Typha* areas. The two primary objectives were to 1) assess whether creating openings in dense *Typha* areas sufficiently alter trophic dynamics such that fish and bird diversity and abundance is increased and, 2) determine to what extent the functions of these created open areas compare to the natural Everglades. Plots were monitored over a four-year period for responses from the aquatic (small fishes and macroinvertebrates) and avian communities. Nutrient enrichment and the creation of openings in dense vegetation significantly affected the production and species composition of the aquatic community. This provided habitat that attracted and sustained very large populations of foraging wading birds from very early in the dry season until the plots dried later in the dry season. However, the cattail plots also had ecological value because they supported a greater density and diversity of secretive marsh birds than created openings and natural slough areas. We will conclude by discussing the considerable environmental benefits and water management flexibility that is obtained with the implementation of such active marsh improvement strategies.

Contact Information: Mark I. Cook, Everglades Systems Assessment Section, Applied Sciences Bureau, Water Resources Division, South Florida Water Management District, P.O. Box 24680, West Palm Beach, FL 33416-4680, USA, Phone: 561-686-8800 x4539; Email: mcook@sfwmd.gov

THE MISSISSIPPI RIVER COMMISSION – HISTORY OF THE MANAGEMENT OF THE MISSISSIPPI RIVER

Travis Creel and *Timothy Axtman*
U.S. Army Corps of Engineers, New Orleans, LA, USA

By the mid-to-late nineteenth century Congress recognized the need for river improvements on the Mississippi River through a central organization. On June 28, 1879 the legislature, led by Senator L.Q.C. Lamar of Mississippi and Representative Randall L. Gibson of Louisiana and assisted by the efforts of a congressional coalition of navigation and flood-control interests, established the Mississippi River Commission (MRC) as an executive body reporting directly to the Secretary of War.

The legislation granted the MRC extensive jurisdiction on the Mississippi River from its headwaters at Lake Itasca, Minnesota, to the Head of Passes near the Gulf of Mexico. The act empowered the MRC to conduct investigations to improve the river channel, protect the banks, improve navigation, prevent destructive floods, and promote commerce. The mandated membership of the MRC called for three officers from the U.S. Corps of Engineers, one member from the U.S. Coast and Geodetic Survey (now the National Oceanic and Atmospheric Administration), and three civilians—all nominated by the President and confirmed by the Senate. This mix of membership reflected a desire to heal a burgeoning schism between the military and civilian engineering communities.

In 1880, the MRC, relying heavily on input from local partners, developed a general plan of improvement based on contracting the low-water channel with permeable dikes and protecting the riverbanks from erosion with various forms of revetment. The first federal flood control act, passed in 1917, facilitated the final implementation of a “levees-only” program. Ten years later, the great Mississippi River flood of 1927 forced a wholesale reappraisal of the federal government's levee policy and galvanized legislative, engineering, and popular support for a comprehensive river improvement plan buttressed by large appropriations. The support for such a plan was manifested through the Flood Control Act of 1928.

Today the MRC oversees the implementation of the comprehensive Mississippi River and Tributaries (MR&T) project under the supervision of the Chief of Engineers. From 1928 through 2004, the nation contributed nearly $12 billion toward the MR&T project and received an estimated $425.5 billion return on that investment. No project levee has ever failed despite several major floods since the inception of the project. Subsequently, the frequency of flooding in protected areas has declined, resulting in a sharp drop in flood damages.

The duties of the MRC include the recommendation of policy and work programs, the studying and reporting upon modifications or additions to the flood control and navigation project, recommendation upon any matters authorized by law, inspection trips, and holding public hearings. Since the MRC’s inception the Corps of Engineers as also been directed to undertake environmental restoration as a mission. On the Upper Mississippi River an Environmental Pool Management Plan was implemented to eliminate adverse environmental impacts caused by artificially high water levels in the navigation pools. In the Lower MR&T system the Flood Control Act of 1965 as modified by the Water Resources Development Acts of 1974, 1986 and 1996, authorized freshwater diversion structures to enhance critical fish and wildlife habitat.

<u>Contact Information</u>: Travis Creel, Regional Planning and Environmental Division South, U.S. Army Corps of Engineers, P.O. Box 60267, New Orleans, LA 70160 USA, Phone: 504-862-1071, Fax: 504-862-1892, E-mail: travis.j.creel@usace.army.mil

SUPPORTING GULF OF MEXICO RESTORATION: ISSUES, CHALLENGES, AND SOLUTIONS IDENTIFIED BY THE GULF COAST ECOSYSTEM RESTORATION TASK FORCE SCIENCE COORDINATION TEAM

Alyssa Dausman[1], *Shelby Walker*[2] and *Dawn Lavoie*[1]
[1]USGS, Stennis Space Center, MS, USA
[2]NOAA, USA

The Gulf Coast Ecosystem Restoration Task Force (GCERTF) was established by Executive Order 13554 as a result of recommendations from "America's Gulf Coast: A Long-term Recovery Plan after the Deepwater Horizon Oil Spill" by Secretary of the Navy Ray Mabus (Mabus Report). The GCERTF consists of members from 11 Federal agencies and representatives from each state bordering the Gulf of Mexico. The GCERTF was charged to develop a holistic, long-term, science-based Regional Ecosystem Restoration Strategy for the Gulf of Mexico. Federal and state agencies staffed the GCERTF with experts in fields such as policy, budgeting, and science to help develop the Strategy.

As part of this effort, a Science Coordination Team (SCT) was formed to provide scientific input to the development of the Strategy, which was released on Dec. 5th, 2011. The SCT consisted of over 70 scientists from the state and federal GCERTF Member agencies. Starting with the ecosystem restoration goals described in the Mabus Report, the SCT described current conditions in the Gulf, from inland watersheds to the offshore waters. Using this Information, the team identified scientific gaps in understanding and high-level activities, with associated performance indicators, necessary to accomplish the goals of GCERTF. The SCT also developed a Science Plan for the Gulf of Mexico to support the GCERTF restoration actions. The Science Plan includes a detailed section on Adaptive Management, as well as identifies monitoring, modeling, and research essential to support restoration actions as defined in the Strategy. The work of the SCT is soon to be released in the document, "Gulf of Mexico Ecosystem Science Assessment and Needs". The overall scientific assessment in the document reveals that, Gulf-wide, the ecosystem continues to suffer from extensive degradation, and that integrated, science-based restoration initiatives, backed by a robust adaptive management framework, are necessary to develop a healthy, resilient, and sustainable Gulf of Mexico ecosystem.

<u>Contact Information</u>: Alyssa Dausman, U.S. Geological Survey, BLDG 1100, RM 108, Stennis Space Center, MS 39529, United States, Phone: 954-288-2165, Email: adausman@usgs.gov

INTEGRATED HYDROLOGIC MODELING FOR WETLAND RESTORATION - LESSONS FROM PICAYUNE STRAND PROJECT

Ke Feng[1], *Ananta Nath*[1], *Michael Duever*[2] and *Andrew Potts*[1]
[1]South Florida Water Management District, Naples, FL, USA
[2]Natural Ecosystems LLC, Naples, FL, USA

The Picayune Strand Restoration Project is the first Comprehensive Everglades Restoration Plan (CERP) project under construction. The project involves the restoration of natural water flow across a 220 square- kilometer rural area in western Collier County in southwest Florida. The project area was drained in the 1960s in anticipation of extensive residential development. The canal and road infrastructures associated with the development drastically altered the natural landscape, changing a healthy mosaic of upland and wetland ecosystem into a distressed environment. Wetlands and historic sheet-flows in Picayune Strand and in adjacent public lands will be restored by plugging of canals and removal of roads, while maintaining the existing level of flood protection by a network of pump stations and levees. Over a decade of extensive hydrologic-hydraulic modeling had proved to be critical in developing the project from initial plan formulation to project implementation. Due to very close interaction of surface and groundwater flows in the region, evaluation of pre-development, existing and restored hydrologic conditions involved dynamic simulation of the surface and ground water flow characteristics in an integrated fashion. The paper will assess the overall experiences and lessons learned regarding the do's and don'ts of integrated modeling applied to a complex wetland restoration project.

<u>Contact Information</u>: Ke Feng, Hydrologic and Environmental Systems Modeling, South Florida Water Management District, 2660 Horseshoe Drive N., Naples, FL 34104, USA, Phone: 239-263-7615, Fax: 239-263-8166, Email: kfeng@sfwmd.gov

IT TAKES MORE THAN SCIENCE AND ENGINEERING! BENEFITS OF EFFECTIVE PROGRAM MANAGEMENT IN ECOSYSTEM RESTORATION

Brian K. Files
Parsons, Jacksonville, FL, USA

The purpose of this presentation is to provide all professionals working on ecosystem restoration efforts with a better understanding of the concepts of program management for ecosystem restoration programs as well as the challenges for large-scale ecosystem restoration project implementation. A similar presentation was made at the 2010 Greater Everglades Ecosystem Restoration Conference (GEER) and the 2011 National Conference on Ecosystem Restoration (NCER).

The South Florida Ecosystem Restoration Program, including the Comprehensive Everglades Restoration Plan (CERP), has provided recent lessons learned in ecosystem restoration program management and large-scale project implementation. Several CERP projects are currently moving from planning to construction. The project delivery teams (PDTs), managers, and senior leaders have experienced significant challenges in meeting the various technical and policy requirements necessary for successful project implementation. These challenges include program and project scheduling, State and Federal funding, engineering and design issues, regulatory, real estate acquisition, contracting, legal authority, project transfer, maintenance and repair responsibilities, and operations planning. Solving these challenges has required consistent overall CERP program management, the development of various processes and tools, and clear project implementation processes to assist the PDTs and managers. Other national and international ecosystem restoration programs face similar challenges, and all programs can benefit from sharing lessons learned.

Program management is the centralized coordinated management of a program to achieve strategic objectives and benefits. It emphasizes the prioritization and coordination of limited resources across multiple projects, using economies of scale to optimize the overall costs and risks of the program. The presentation will highlight the various federal and state authorities for ecosystem restoration programs, program budgeting and funding considerations, and individual project sequencing and scheduling. It will also include ecosystem restoration program governance, issue resolution processes, and change control systems. Finally, it will include ecosystem restoration program outreach and strategic communication.

The presentation will provide an overview of large-scale ecosystem restoration project implementation. Successful project implementation is a complex process involving interrelated technical, regulatory, and policy requirements that must be coordinated and executed in a timely manner. It includes the various phases and technical activities required for implementing ecosystem restoration projects, including engineering and design, construction, and monitoring, operations and maintenance.

Contact Information: Brian K. Files, P.E., P.M.P., Parsons, 1300 Riverplace Boulevard, Suite 200, Jacksonville, FL 32207 USA, Phone: 904-232-2170, Fax: 904-232-1056, E-Mail: brian.files@parsons.com

APPLYING THE COASTAL LOUISIANA RISK ASSESSMENT MODEL TO ASSESS LONG-TERM BENEFITS FROM FLOOD RISK REDUCTION PROJECTS

Jordan R. Fischbach[1], *David R. Johnson*[2] and *David S. Ortiz*[1]
[1]Rand Corporation, Pittsburgh, PA, USA
[2]Pardee Rand Graduate School, Santa Monica, CA, USA

The State of Louisiana is currently finalizing its *2012 Master Plan for a Sustainable Coast*, which will specify a set of storm surge flood risk reduction projects to be implemented over the next fifty years to help protect coastal communities from the effects of catastrophic hurricanes. The state is currently evaluating a series of proposed projects to determine the extent to which each action reduces the economic damages from storm surge flooding. Proposed projects include flood protection infrastructure such as levees, floodwalls, and gates, as well as nonstructural mitigation approaches such as floodproofing of buildings, home elevations, and acquisitions and relocation.

Complicating these comparisons, however, is substantial uncertainty about future flood risk in the region from a variety of different drivers, including coastal subsidence and land loss, population shifts, and climate change effects. We developed the Coastal Louisiana Risk Assessment Model (CLARA) to address this challenge and support the selection of effective risk reduction projects. CLARA is designed to specifically evaluate future flood risk under a wide range of uncertain scenarios about sea level rise, subsidence, and land loss; nonstationarity in future hurricane characteristics; future population growth; and the reliability of hurricane protection systems or other risk reduction actions. The CLARA model is intended to be useful for long-range planning over a 50-year time horizon and large-scale scenario analysis rather than to provide detailed analysis for engineering design.

CLARA incorporates methods used in recent efforts to estimate flood risk on the Louisiana coast and also includes a series of methodological advances. To flexibly compare the risk reduction achievable by potential projects, we developed innovative methods for sampling storms and estimating flood depths interior to a protection system based on the probability distributions of surge levels at points along the exterior of the system. These provide computational and statistical efficiencies to allow us to evaluate many scenarios within feasible limits on computing resources. In addition, the model considers the fragility of hurricane protection systems by estimating the probability of multiple modes of failure and incorporating these into overall risk estimates using Monte Carlo simulation. Flood damages are estimated using an inventory of coastal assets updated with 2010 Census data, and rely on relationships between flood depths and damages described in the literature. Flood depths and residual economic risk are reported as 50-, 100-, and 500-year exceedance values and in terms of expected annual damage (EAD). We discuss these new methodologies and present key insights from model results.

Contact Information: Jordan R. Fischbach, Rand Corporation, 4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213 USA, Phone: 412-683-2300x4608, Email: jordanf@rand.org

MODEL ANALYSIS OF EUTROPHICATION CONSTRAINTS ON AN EVERGLADES RESTORATION PROJECT

H. Carl Fitz[1,2], *Rajendra Paudel*[1,2] and *Andrew Loschiavo*[3]
[1]Ft. Lauderdale Research & Education Center, University of Florida, Davie, FL, USA
[2]Soil and Water Science Department, University of Florida, Gainesville, FL, USA
[3]US Army Corps of Engineers, Planning Division, RECOVER Branch, Jacksonville, FL, USA

The Comprehensive Everglades Restoration Plan involves a large number of projects whose net result will lead to increased water flows to the freshwater and estuarine systems of the greater Everglades system. The "Decomp" Project is central to the overall restoration plan, with a goal to increase and/or redistribute water flows and restore the hydro-ecology of the central Everglades. However, with increased water flow volumes into marshes, phosphorus (P) loads to the ecosystems can increase, potentially posing constraints on the allowable inflows to the oligotrophic Everglades. For the first phase of Decomp, a multi-agency team is using the Everglades Landscape Model (ELM, http://ecolandmod.ifas.ufl.edu) to help evaluate achievement of possible competing objectives between the benefits of altered water flows simulated by a water management model (RSM, Regional Simulation Model), and the potential P eutrophication from inflows of P at 10 ppb in the landscape simulated by ELM. The team is currently analyzing ELM Performance Indicator output from seven planning Alternatives and two Baseline runs, but in general there did not appear to be ecologically significant increases in eutrophication in the Alternatives relative to a Future WithOut CERP baseline. The multi-agency team is finalizing its overall planning conclusions at the time of submission of this abstract.

<u>Contact Information</u>: H. Carl Fitz, Ft. Lauderdale Research & Education Center, University of Florida, 3205 College Avenue, Davie, FL, 33314 USA. Phone: +1-954-577-6363. Email: cfitz@ufl.edu

INTEGRATING SCIENCE, POLICY, AND STAKEHOLDER OUTREACH TO ACCELERATE RESTORATION

Angelina M. Freeman*[1]*, *G. Paul Kemp*[2] and *Alisha Renfro*
[1]Environmental Defense Fund, Washington, DC, USA
[2]National Audubon Society, Baton Rouge, LA, USA
[3]National Wildlife Federation, New Orleans, LA, USA

The environmental community is undertaking a determined effort to advance restoration of the Mississippi River Delta through the application of sound science integrated with policy and stakeholder outreach. Our approach is to team up scientists and lawyers and incorporating stakeholder outreach to reverse the historical mismanagement of the Mississippi River and Delta systems. Congress authorized large-scale coastal Louisiana restoration and provided strong directives in passing the 2007 Water Resources Development Act. The Environmental Defense Fund the National Audubon Society, the National Wildlife Federation, the Nature Conservancy, four national environmental organizations, have formed a coalition with local environmental groups to catalyze action in the development, authorization, funding, and implementation of large-scale restoration and protection efforts in Louisiana.

We have concentrated our efforts on critical questions surrounding the feasibility of restoration of the Mississippi River Delta at scale. Our focus is on addressing barriers to restoration, conceptualizing solutions, and identifying opportunities for moving forward with large-scale restoration. During the 20th century Louisiana lost approximately 5000 square kilometers of land, and impacts on communities, fisheries, infrastructure, wildlife, and the environment are considerable with increasing land loss. Restoring natural deltaic land building processes is one of the most pressing concerns to increase resiliency of this ecosystem vulnerable to sea level rise. Our coalition is fostering coordination of policy, science, and economics for several near-term restoration efforts including an authorized land-building diversion, and developing the framework for the large-scale restoration required to prevent system collapse. An expansive stakeholder outreach effort is underway to communicate the science and build state and national support.

Contact Information: Angelina Freeman, Environmental Defense Fund, 1875 Connecticut Avenue NW, Washington, DC 20009 USA, Phone: 202-572-3373, Email: afreeman@edf.org

ECOSYSTEM-WIDE ASSESSMENT OF WETLAND RESTORATION USING PERIPHYTON-BASED METRICS

Evelyn Gaiser
Florida International University, Miami, FL, USA

Periphyton is a key indicator of change in benthic ecosystems, as it is ubiquitous and sensitive at appropriate time scales to environmental change, especially to alterations in water quantity and quality. In the Everglades, periphyton is an integral component of conceptual ecological models used to understand and assess marsh response to restoration and is one of eight system-wide indicators reported in a biannual “stoplight report-card” to the South Florida Ecosystem Restoration Task Force for the purpose of assessing the success of the Comprehensive Everglades Restoration Plan (CERP). Here we review the (1) justification for incorporation of periphyton into Everglades restoration assessment, (2) role of periphyton in Everglades conceptual ecological models and hypotheses guiding CERP assessment, (3) spatial and temporal assessment of system-wide patterns and trends, (4) development of modeling tools for predicting future change, and (5) current status and trends reported in the System-Wide Ecological Indicators for Everglades Restoration Stoplight Report Card.

Development of a periphyton-based model to guide Everglades restoration (PERIMOD) included constructing a comprehensive periphyton database containing consistent metrics of periphyton quantity, quality and composition. A parallel database was constructed that included potential driving or predictor variables. The periphyton attribute data were a subset of those used for stoplight assessment and system status reporting. This process was used to screen the dataset for outlier values what would obscure hydrology-driven inferences. The periphyton attribute and predictor datasets were then joined through multivariate regression to determine the strongest predictor and response variables. These were then fed into partial regression models to determine the best model equations for one quantity, one quality and one compositional metric. These equations produce predictions that can be validated with a test dataset. The equations can receive manipulated inputs, including output from the Everglades Landscape Model (ELM) which includes all of the PERIMOD predictors (including periphyton TP, water depth, hydroperiod and soil depth). The output from PERIMOD can then be evaluated in the same way that current system status is assessed (through the stoplight system, using the same criteria) and can be fed into other models that rely on periphyton attributes as inputs.

One of the expected outcomes from the development of PERIMOD is the natural extension to other models that already exist or are currently under development. For instance, periphyton dry mass and organic content predictions could feed back into ELM to improve predictions of soil accretion throughout the system. Predictions of periphyton edibility could be used in food web models dependent on food source abundance and quality. In this way, the PERIMOD works to assess not only system-wide effects of restoration but also provides an indicator relevant to other key attributes of the Everglades ecosystem. We are exploring the application of this model in other karstic wetlands in the Caribbean region and comparing its utility to periphyton-based models developed for other types of wetlands.

Contact Information: Evelyn Gaiser, Southeast Environmental Research Center, Florida International University, Miami, FL 33199 USA, Phone: 305-348-6145, Fax: 305-348-4096, Email: gaisere@fiu.edu

PERFORMANCE MEASURES AND ADAPTIVE MANAGEMENT OF THE FLORIDA EVERGLADES

Rebekah E. Gibble[1] and *Donatto D. Surratt*[2]

[1]A.R.M. Loxahatchee National Wildlife Refuge, U.S. Fish and Wildlife Service, Boynton Beach, FL, USA

[2]Everglades National Park c/o A.R.M. Loxahatchee National Wildlife Refuge, Boynton Beach, FL, USA

Integrating science into all phases of Everglades restoration is critical to providing flexibility and increasing the robustness of the adaptive management processes used for refining restoration strategies. Science can be integrated into decision-making processes through routine monitoring and assessment. The Comprehensive Everglades Restoration Plan (CERP) is strongly based on an adaptive management approach and a variety of tools and methods, including performance measures (PM) have been developed to evaluate and assess CERP projects. Performance measures used in CERP have been developed and applied by the CERP Restoration, Coordination, and Verification (RECOVER) team.

Performance measures developed by RECOVER are geared toward the greater Everglades or specific habitats and though some are relevant to the Refuge most are not directly applicable. While several RECOVER PMs focus on indicators or species that are highly relevant to the Refuge, the indicators are not appropriate because of the Refuge's unique characteristics such as water quality, spatial position, and hydrology. Indicators used by RECOVER that are relevant to the Refuge include wading birds, periphyton, alligators, tree islands, and aquatic prey density. These indicators have been selected as priorities for the Refuge to develop as Refuge-specific PMs because they are defining characteristics of the Refuge, or are directly related to the Refuge management objectives, such as serving as an inviolate sanctuary for wading birds. Prioritizing and developing Refuge-specific PMs to facilitate an adaptive management approach to achieving Refuge goals is a primary objective for the Refuge.

Contact Information: Rebekah E. Gibble, A.R.M. Loxahatchee National Wildlife Refuge, Boynton Beach, FL 33473, Phone: 561-735-6038. Fax: 561-369-7190. Email: rebekah_gibble@fws.gov

"GETTING THE WATER RIGHT," PRACTICAL EXPERIENCE IN LARGE-SCALE WETLANDS RESTORATION

Mitchell L. Griffin[1]*, Richard T. Morrison*[1] and *Martha L. Burlingame*[1]
[1]CH2M HILL, Gainesville, FL, USA

Many natural wetlands have been extensively modified over the years by ditching, diking, or grading to create agricultural land suitable for pasture, grazing, or other intensive uses. Government agencies are purchasing these lands for conservation purposes with the intent to restore the natural functions to the properties. These restorations may include both vegetation community modification and limited construction to undo previous modifications. The goal of the typical wetland restoration project is to restore the hydrology and ecology of the site using the least amount of design, management, and long-term operational support to achieve the greatest possibility of restoring natural wetland communities with minimal or no adverse affects to onsite resources or to offsite properties. Often, restoring native vegetation and invasive species control will not be successful unless the hydrology of the wetlands is addressed first.

For the past 6 years, the authors have been providing consulting engineering services to the U.S. Department of Agriculture to restore properties enrolled in the Wetland Reserve Program (WRP). To date, CH2M HILL has completed 22 projects/farms addressing restoration on over 25,000 acres with 17 of these sites constructed by mid-2012. Projects have ranged from 37 to 2,900 acres in area. The team has worked on other sites outside of Florida where wetlands were either constructed or restored as part of non-WRP land. Restoration projects require a multidisciplinary approach to evaluate the soils, existing vegetation and cultural resources, surveying, and evaluating local and maybe regional hydrology. The presentation will describe how these projects are evaluated (scope, tools, and methods) and the type of activities implemented to restore the hydrologic regime in disturbed wetlands.

Contact Information: Mitchell L. Griffin, CH2M HILL, 3011 SW Williston Road, Gainesville, FL 32608, USA, Phone: 352-384-7078, Fax: 352-215-3045, Email: Mitch.Griffin@ch2m.com

A PRIORITIZATION TOOL FOR AQUATIC RESTORATION AND ENHANCEMENT OF FLORIDA PUBLIC LAKES

Jessica L. Griffith[1], *Michael Allen*[2], *J. Beacham Furse*[3] and *Jennifer Bock*[4]
[1]Florida Fish and Wildlife Conservation Commission, Kissimmee, FL, USA
[2]Southwest Georgia Technical College, Thomasville, GA, USA
[3]Florida Fish and Wildlife Conservation Commission, Okeechobee, FL, USA
[4]Florida Fish and Wildlife Conservation Commission, Tallahassee, FL, USA

The development of a restoration prioritization method was considered a critical component of executing a more expedient and cost effective framework for freshwater ecosystem management in Florida. Because lake ecosystems provide unique habitat for numerous fish and wildlife species and substantial socio-economic benefits, management and protection of high quality habitats and restoration of degraded habitats are considered paramount. Therefore, the Florida Fish and Wildlife Conservation Commission's (FWC) Aquatic Habitat Conservation and Restoration Section (AHCR) created an Aquatic Restoration Prioritization and Evaluation Tool (ARPET) based on a Geographic Information System (GIS) framework. ARPET is a science-based planning tool that identifies and prioritizes public lakes based on socio-economic importance, benefits to aquatic resources as assessed by fish and wildlife function, ecological value and restoration opportunity and restoration need.

The prioritization of 324 lakes greater than 50 acres that have public access was performed. Automated GIS tools were developed for 21 parameters. Parameters were selected based on pre-existing data that emphasized public use, fish and wildlife utilization, and the desire for restoration. Examples of data-sets used included public boat ramps, public recreational trails, lake size, surrounding land use contiguous to each lake, and threatened and endangered species. Analysis of each parameter was based on a quantitative scoring system and was implemented with automation techniques available in ArcGIS 9.3. Calculated values and standardized parameter scores were generated to group lakes into five priority management classes. Four prioritized lists have been generated utilizing GIS, including an overall prioritized lake list, consisting of a combination of three categories, Socio-Economic Importance, Fish and Wildlife Populations, and Management Emphasis, as well as a list for each of the individual categories.

With more than 300 public lakes located throughout the state and the large number of potential restoration opportunities, the prioritization of these lakes will help resource managers focus aquatic habitat restoration efforts on high-priority aquatic resources.

Contact Information: Jessica L. Griffith, Aquatic Habitat Conservation and Restoration Section, Florida Fish and Wildlife Conservation Commission, 1601 Scotty's Road, Kissimmee, FL 34744, USA; Office: 407-846-5191, Mobile: 407-509-4468, Fax: 407-846-5310, Email: jessica.griffith@myfwc.com

APPLYING FUNCTIONAL DIVERSITY ANALYSIS TO ANALYZE ENVIRONMENTAL FILTERING DURING FEN RESTORATION

Håkan Rydin[1], ***Petter*** *Hedberg*[2], *Sebastian Sundberg*[1], *Wiktor Kotowski*[2], *Peter Saetre*[3] and *Kalle Mälson*[4]

[1]Uppsala University, Uppsala, Sweden

[2]University of Warsaw, Warsaw, Poland

[3]Karolinska Institutet and Hospital, Stockholm, Sweden

[4]Uppsala County Administrative Board, Uppsala, Sweden

During the 20th century large mire areas were drained for forestry and agricultural purposes, resulting in the decline of characteristic biodiversity. Two measures commonly suggested for restoring mires is ditch blocking, in order to raise the groundwater table, and cutting trees, in order to increase light availability and reduce loss of water from transpiration. Studies of the relative effect, spatial potential as well as possible interaction of these two methods when applied jointly are lacking. In addition, studies covering longer time periods are missing. In 2002, we initiated restoration experiments, including ditch blocking and tree removal, in three former rich fens that had been drained for forestry purposes. During the following eight years we measured species cover of vascular plants and bryophytes along transects perpendicular to the ditch for all four treatment combinations of tree removal/trees remaining and rewetting/still drained.

Results were analyzed in terms of functional groups and functional diversity indexes. The indexes used were Functional Richness, Functional Evenness, Functional Divergence and Functional Dispersion. Community Weighted Means for the traits was also included as an index, to analyze if any trait influenced the species cover significantly. Diversity indexes were analyzed seperately for vascular plants and bryophytes, as well as a joint analysis including both vascular plants and bryophytes. The traits used for calculating the indexes were canopy height, seed mass and specific leaf area, were specific leaf area was used only for vascular plants.

Our results show that water level increased significantly in the rewetted treatment which suppressed the regrowth of trees near the ditch in the rewetted treatment. Cutting resulted in a significant increase of sedge cover. Functional Dispersion increased significantly for vascular plants, in response to cutting. This indicates that the previous shading from trees limited the trait richness for vascular plants, acting as a trait filter.

Our results also show that the effect of ditch blocking and tree removal is spatially limited. The hydrological effects and tree suppression decreased with increasing distance from the ditch, because of peat subsidence close to ditch since drainage, forming a trough. Rich fen indicators of vascular plants and bryophytes did not respond to the restoration treatments. We attribute this to a narrow ecological amplitude of these species and/or dispersal limitation. This indicates that species introduction is needed to achieve a greater success, and that the habitat may have changed too much for some species with narrow ecological amplitude, making their reestablishment unlikely. Nevertheless, rewetting and tree removal offer the potential to restore trough liked shape peatlands locally without flooding surrounding economically valuable land.

Contact Information: Petter. Hedberg, Department of Plant Ecology and Environmental Conservation, Institute of Botany, University of Warsaw, Al. Ujazdowskie 4, 00-478 Warszawa, Poland. Phone: +48 604 078 020, Email: phedberg@biol.uw.edu.pl

SAN DIEGUITO WETLANDS RESTORATION: A TWENTY YEAR ODYSSEY IN RESTORING A SOUTHERN CALIFORNIA LAGOON

Michael Josselyn[1]*, Hany Elwany*[2]*, Tracey Alsobrook*[3] and *David Kay*[3]

[1]WRA, San Rafael, CA, USA
[2]Coastal Environments, La Jolla, CA, USA
[3]Southern California Edison, Rosemead, CA, USA

Planning for the restoration of the San Dieguito Lagoon began in 1991 and the final construction elements were completed in 2011. The wetland restoration was required as mitigation for the once through cooling system impacts to marine fisheries by the San Onofre Nuclear Power Plant in southern California. The $90 million construction project resulted in the excavation and creation of over 160 acres of tidal wetlands, the development of shorebird nesting sites, and the maintenance of tidal influence through a non-jettied entrance. During the twenty years of planning, environmental review, and construction; the project overcame many challenges that required compromises between optimizing natural habitat design criteria with public safety and policy.

Key features of the project included the inclusion of 8,000 lineal feet of engineered earthen berms to protect the newly created wetland from flood-borne sediments and capable of withstanding a 100 year flood event without altering sediment delivery to the beach. The project involved the excavation of over 2 million cubic yards of material to create salt marsh and fish habitat and the increase in tidal prism improved the ability of the lagoon mouth to stay open throughout the year. However, because jetties were not an acceptable solution on this public beach, an inlet maintenance plan was also required to remove sand that accumulates in the inlet. Nesting sites for shorebirds were also created with fencing and other measures to reduce predators.

The design process involved numerous public agencies, required years of input by the public, and was reviewed by over 12 permit agencies. During that process, decisions were made on construction methodologies and timing restrictions that required that the project be constructed over a number of years, starting in 1996 and with completion in 2011. Challenges that had to met included meeting habitat distribution requirements, establishing marsh vegetation, disposal and revegetation of disposal sites, and selection of suitable substrates for nesting sites. Initial monitoring of the site has shown rapid invasion by migratory birds, native fish, and eelgrass in the subtidal basin. The presentation will discuss some of the solutions reached to resolve problems in large scale ecosystem restoration and the pleasant surprises during this 20 year process.

<u>Contact Information</u>: Michael Josselyn, WRA, Inc. 2169 E Francisco Blvd, Suite, San Rafael, CA 94901, USA, Phone: 415-454-8868 x125, Fax: 415-454-0129, Email: josselyn@wra-ca.com

EVALUATION OF ALTERNATIVES FOR WCA-3 DECOMPARTMENTALIZATION PROJECT

Fahmida Khatun[1], *Raul J. Novoa*[1], *Sashi Nair*[1], ***Veerabhadra R. Karri***[1] and *Charles Sawyer*[2]
[1] South Florida Water Management District, West Palm Beach, FL, USA
[2] US Army Corps of Engineers, Jacksonville, FL, USA

Water Conservation Area-3 (WCA-3) Decompartmentalization (DECOMP) project is part of the Comprehensive Everglades Restoration Project (CERP) where the goal is to restore the natural patterns of flow distribution, timing, continuity and volume of sheetflow in this area. The ecological target for restoration is the recovery of pre-drainage hydrologic patterns of hydroperiods. This study explores a proposed improvement to sheetflow that can be achieved by backfilling/plugging the Miami canal which is currently acting as a barrier to sheetflow. Further improvements to sheetflow can be achieved by redistributing flows southward along the northern boundary of WCA-3A. Seven alternative scenarios were evaluated using the Glades-LECSA Regional Simulation Model (RSM) to understand the effect on stage and flow dynamics within WCA-3.

The intent of each alternative simulation was to simulate future conditions in the year 2015 without any of the CERP projects that are anticipated to be in place by that year plus the specific alternative features. All non-CERP projects that are anticipated to be in place by that time were also modeled. The simulation period was from 1/1/1965 to 12/31/2000. Each of the alternatives included backfill or plugging of the Miami Canal and either the full length Hydropattern Restoration Feature (HRF) or the West of G-205 HRF. Full length HRF spanned the entire northern boundary of WCA 3A and included east, central and south components. The east HRF was located directly south of STA-3/4, the central HRF directly south of Holey Land Wildlife Management Area (HLWMA) and the west HRF directly south of Rotenberger Wildlife Management Area (RWMA). The boundary conditions along the northern boundary of WCA-3A were provided from the South Florida Water Management Model (SFWMM). Evaluations of the alternatives presented in this paper were based on the relative comparisons of average annual water budgets, flow transects, stage hydrographs and duration curves, ponding depths, hydroperiods and surface water vectors.

<u>Contact Information</u>: Fahmida Khatun, Hydrologic and Environmental Systems Modeling, South Florida Water Management District, 3301 Gun Club Road, West Palm Beach, FL 33406, USA, Phone: 561-682-2630, Fax: 561-682-2027,
Email: fkhatun@sfwmd.gov

SEDIMENT MANAGEMENT FOR COASTAL RESTORATION IN LOUISIANA - ROLES OF MISSISSIPPI & ATCHAFALAYA RIVERS

Syed Khalil
Coastal Protection and Restoration Authority, Baton Rouge, LA, USA

It is well documented that acute land loss in coastal Louisiana has resulted in ecocatastrophe as a consequence of reduced sediment supply in the coastal system/marshes. It is also well established that Coastal Louisiana is a sediment-starved system and in many areas sediment deposition is insufficient to offset relative sea level rise and other processes that contribute to land loss. Human intervention has impaired the Mississippi River's ability to deliver sediment to the adjacent wetlands to. It is the imbalance resulting from alteration of the natural environment which threatens the fragile ecosystem and requires a robust sediment management strategy to restore the natural balance. There are some great lessons to be learned as to how human intervention can complicate the ecosystem by interrupting natural process and exacerbating ecological degradation, upsetting the balance of the delicate relationship between a river system (Mississippi River) and a coastal environment (Louisiana Coast) to our detriment by excessively engineering the river system. The Mississippi River was engineered mainly for flood control and navigation purposes. But now the Mississippi River must play a multifaceted role where it is a source of sediment and a driver that not only sustains the regional wetland and coastal ocean ecosystems but also serves other vital purposes such as navigation, flood control, and water supply. Managing the Lower Mississippi River is a great challenge due to its complex sediment-water dynamics and the multiple (and often competing) uses of its resources, however, restoring a more healthy sediment budget by reconnecting the river and coastal/littoral systems would re-establish more natural, land-sustaining processes. To inform this approach, we can learn some lessons from the Atchafalaya River which is the main functioning distributary of Mississippi River. The Atchafalaya River and hydrologic basin and the expanding deltas (Atchafalaya and Wax Lake Deltas) are the only portion of Louisiana's coastal region where land mass is being created. An understanding of the Atchafalaya River basin water and sediment budgets is critical to the planning and engineering of diversions and other mechanisms to re-introduce riverine sediments into the Louisiana coastal zone from the main stem of the Mississippi River.

To re-establish a sustainable coastal environment, large quantities of various types of sediment from renewable riverine and offshore sources are needed to compensate for eroding wetlands. Therefore, a meaningful restoration program must integrate various sediment input mechanisms, including: building appropriate sediment-diversions, beneficially using the millions of cubic yards of sediment dredged annually from navigational channels, harvesting deposits of sand in the river and offshore, and related sediment management activities that are compatible with other uses of the river. This requires not only identification and delineation of potential sediment sources that could be utilized for restoration but also managing these resources wisely and in a systematic manner. To accomplish this, Louisiana is developing a comprehensive sediment management plan. The Louisiana Sediment Management Plan (LASMP) is expected to provide regional strategies for improved comprehensive management of Louisiana's limited sediment resources.

Contact Information: Syed M. Khalil, Coastal Protection and Restoration Authority, 450 Laurel Street, Baton Rouge, LA 70801, USA, Phone: 225.342.1641, Fax: 225.242.3760, Email: Syed.Khalil@la.gov

EVERGLADES ECOSYSTEM RESTORATION TARGET VALIDATION

Anwar Khan
HDR Environmental, Operations and Construction, Inc., Fort Lauderdale, FL, USA

The Comprehensive Everglades Restoration Plan (CERP) provides a framework and guide to restore, protect, and preserve the water resources of central and southern Florida, including the Everglades. The Lake Okeechobee Watershed (LOW) Project combines five of the sixty CERP elements and is directed towards achieving holistic restoration of Lake Okeechobee, which lies at the headwaters of the Everglades system.

Through a comprehensive planning process, a tentatively selected ecosystem restoration plan has been identified for the LOW Project. This plan includes construction and operation of three reservoirs, two stormwater treatment areas (STA), and one wetland restoration project. The plan has a footprint of approximately 33,000 acres and is projected to cost over $1.5 billion.

The planning team identified and used quantified planning targets of 286,000 acre-feet of storage capacity and 68 to 130 metric tons per year of phosphorus load reduction to guide formulation and evaluation of alternative plans that would provide additional storage in the watershed and improve water quality in Lake Okeechobee. After the restoration plan was identified, an independent analysis was undertaken to validate the two quantified planning targets and demonstrate that the tentatively selected plan (TSP) was not the most expensive plan; i.e. more storage and P-load reduction could be achieved by plans with a higher total cost.

This paper will discuss the restoration target validation approach, which involved establishing and analyzing relationships between ecological benefits and total M-CACES-like costs for a range of standalone reservoir storage capacities and standalone STA P-load reductions and comparing them to reservoir and STA costs and ecological benefits associated with the LOW Project TSP.

<u>Contact Information</u>: Anwar Khan, Sr. Project Manager, HDR EOC, 5310 N.W. 33rd Ave, Suite 212, Fort Lauderdale, FL 33309, USA, Phone: 954-494-2084, E-mail anwar.khan@hdrinc.com

EVERGLADES COLLABORATIVE ADAPTIVE MANAGEMENT PROGRAM PROGRESS

Sarah Bellmund[1], *Rebecca Burns*[2], *Susan Gray*[3], *Matthew Harwell*[4], *Kent Loftin*[6], ***Andrew LoSchiavo***[7], *Laura Mahoney*[7], *Ernest Marks*[8], *Agnes McLean*[9], *Jennifer Pratt-Miles*[10], *Barbara Stinson*[10], *Steve Traxler*[11], *Tom St. Clair*[2] and *Jim Vearil*[7]

[1]Biscayne Bay National Park, Homestead, FL, USA
[2]Everglades Partners Joint Venture, Jacksonville, FL, USA
[3]South Florida Water Management District, West Palm Beach, FL, USA
[4]Environmental Protection Agency, Gulf Breeze, FL, USA
[5]U.S. Army Corps of Engineers, Alexandria, VA, USA
[6]Hydroplan, LLC, Hobe Sound, FL, USA
[7]U.S. Army Corps of Engineers, Jacksonville, FL, USA
[8]Florida Department of Environmental Protection, Tallahassee, FL, USA
[9]Everglades National Park, Homestead, FL
[10]Meridian Institute, Dillon, CO
[11]U.S. Fish and Wildlife Service, Vero Beach, FL, USA

When the Comprehensive Everglades Restoration Plan (CERP) was authorized in 2000, adaptive management (AM) was recognized as a necessary tool to address uncertainty in achieving the broad goals and objectives for restoring a highly managed system. The South Florida Ecosystem covers 18,000 square miles, with 68 threatened and endangered species of flora and fauna, and many ecologically unique habitats. Much has transpired over the past 12 years to develop and implement an adaptive management (AM) program to support restoration implementation. Our presentation covers the Everglades progress in 1) restoration project implementation of the foundation, first and second increments of CERP; 2) development of restoration science, monitoring, and assessment programs; 3) adaptive management program development and implementation milestones; and 4) understanding the Everglades restoration governance model. In addition, we'll cover what we've learned and how this learning is shaping the next steps for Everglades restoration and maturation of the AM program. Many large-scale ecosystem restoration programs are employing adaptive management and will benefit from a sharing of lessons learned.

Contact Information: Andrew J. LoSchiavo, RECOVER Branch, Jacksonville District, U.S. Army Corps of Engineers, 701 San Marco Blvd, Jacksonville, FL, 32207, USA, Phone: 904-232-2077, Fax: 904-232-1434, Email: Andrew.J.LoSchiavo@usace.army.mil

HABITAT MONITORING AND ASSESSMENT IN LARGE WETLAND SYSTEMS

***Craig T. Mallison*[1]** and *Boyd Z. Thompson*[2]

[1]Florida Fish and Wildlife Conservation Commission, Lakeland, Florida, USA

[2]Florida Fish and Wildlife Conservation Commission, Eustis, Florida, USA

The Florida Fish and Wildlife Conservation Commission (FWC) assembled teams, consisting of resource biologists, to manage large wetland systems such as the Kissimmee Chain of Lakes (83,000 ha) and the Orange Creek Basin (26,000 ha). Historical management focused on a single species or group, such as fish, whereas the new team approach adopted a holistic strategy to include all fish and wildlife. Teams used scientific literature and best professional judgement to define habitat requirements for focal taxa (selected fish and wildlife species or groups), including alligators, fish, waterfowl, wading birds, and threatened or endangered species. Actual habitat conditions, based on littoral vegetation mapping and GIS analyses, were compared to habitat requirements to evaluate lake-wide habitat conditions on two Florida lakes: Lake Tohopekaliga (7,600 ha) and Orange Lake (5,100 ha).

FWC hired professional mapping contractors to produce detailed maps of vegetation occurring within lakes and adjacent wetlands. Map production included photo interpretation of color-infrared aerial photography to digitize areas dominated by distinct plant species or communities. Field surveys were completed to validate maps and to resolve classification errors or mapping difficulties. Final maps attained a classification accuracy of at least 90% based on assessment points.

Team biologists and GIS experts within FWC developed a GIS protocol to evaluate habitat conditions based on vegetation metrics (dominant vegetation, percent coverage of aquatic plants, plant species composition, and spatial distribution of plants). The amount of usable habitat within each lake basin was estimated for focal taxa. Lake-wide habitat conditions were evaluated by comparing measured habitat conditions to habitat requirements for focal taxa. Results for all focal taxa were combined to identify potential management areas for improving lake-wide habitat conditions.

Habitat evaluations indicated that 3,910 ha of area provided suitable habitat conditions for at least one of the focal taxa on Lake Tohopekaliga in 2007. Within the littoral zone, 490 ha did not meet habitat requirements for any focal taxa and were identified as potential management areas. A shortage of foraging and nesting habitat for the endangered Everglade snail kite was identified as the primary management concern relative to lake-wide habitat conditions. On Orange Lake, moderate- and high-quality habitat totaled 3,190 ha in 2007, and 770 ha were identified as potential management areas. Primary management concerns included an excess of shrub swamp habitat and a shortage of shallow marsh. Littoral vegetation mapping was repeated in 2009 and GIS analyses are in progress. This Information has helped FWC teams to locate areas that may benefit most from management to improve overall, lake-wide habitat conditions for fish and wildlife.

Contact Information: Craig Mallison, Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission, 3900 Drane Field Road, Lakeland, Florida 33811 USA, Phone: 863-648-3814, Fax: 863-701-1248, Email: craig.mallison@myfwc.com

BEST MANAGEMENT PRACTICES IN THE EVERGLADES: USING AN HERBICIDE TO REDEFINE THE LEADING EDGE OF THE NUTRIENT ENRICHED CATTAIL ZONE

***Michael Manna**, Susan Newman, LeRoy Rodgers, David Black* and *Mark Cook*
South Florida Water Management District, West Palm Beach, FL, USA

The Active Marsh Improvement Ridge and Slough project uses the herbicide, imazamox (ClearcastTM) to control Typha domingensis (cattail) along the leading edge of the nutrient impacted zone in Water Conservation Area 2A. Triplicate treatment and control plots (100x100m) were established along the nutrient front, with additional controls in unenriched areas. Specifically, the experiment is designed to assess the efficacy of two different herbicide application rates to remove cattail from partially to heavily invaded ridges and sloughs, thus re-establishing the vegetative dominance to characteristic ridge and slough species. Preliminary evaluations indicate that aerial applications of imazamox at a rate of 0.28 kg ae ha-1 resulted in substantial control of cattail with little to no damage observed on other emergent macrophytes. Selective control of cattail will have multiple benefits including halting or pushing back the cattail invasion front and restoration of wading bird foraging habitat. Unlike previous studies in this area, this project does not use fire as one of its management options, thus if successful, may provide an alternative management strategy for nutrient-enriched areas of the Everglades. Plant responses at 3 and 6 month post-herbicide application will be presented during the conference.

Contact Information: Michael Manna, Everglades Assessment Section, South Florida Water Management District, 3301 Gun Club Rd., West Palm Beach, FL 33415 USA, Phone: 561-686-8800, Email: mmanna@sfwmd.gov

THE INFLUENCE OF ABIOTIC AND BIOTIC SEED DISPERSAL VECTORS ON VEGETATION STRUCTURE IN THE EVERGLADES AND PANTANAL

Scott Markwith[1] and *Erich Fischer*[2]
[1] Florida Atlantic University, Boca Raton, FL, USA
[2] Universidade Federal de Mato Grosso do Sul, Campo Grade, MS, Brazil

Seed dispersal influences community structure, species diversity, and population dynamics of individual species. These vegetation characteristics are also influenced by the mode of dispersal, attributes of the dispersal vectors, and the interactions of the vectors with the plant propagule being dispersed. In wetlands the major modes of seed dispersal include hydrochory (dispersal by moving water), anemochory (dispersal by wind), and zoochory (dispersal by fauna). These processes and patterns have been investigated with varying intensity in the Everglades and Pantanal wetlands.

Zoochory has been examined to a much greater extent in the Pantanal, and the most important taxa of seed dispersers are birds and mammals. Among mammals, bats are regarded as important dispersers based on inferences from studies on bat feeding habits. The bat species Artibeus jamaicensis is probably the main vector linking fig species to the palm phorophytes in the Pantanal (Teixeira et al. 2009, Munin et al. submitted, Corrêa et al. 2012).

A plant-disperser network in the Pantanal (excluding bats, Donatti et al. 2011) shows modularity of interactions, partially determined by co-adapted traits of plants and animals. One module of bird-plant interactions involves phylogenetically related species, but the other three modules did not; so, phylogenetic effect on network structure is low (i.e. related taxa are represented in different modules). In addition, large animals interact with more plant species than small ones, and small-fruit species interact with more animal species than large-fruit plants.
In the Greater Everglades, Gawlik and Miao (2002) found that important tree island species are dispersed by birds. Consumption by birds also affects the length of seed dormancy and duration of the germination period differently depending on bird and plant species. Gawlik et al. (2002) found that a high fruit-use guild of birds is only found on tree islands, while the low fruit-use guild is found equally in both marsh and tree island habitat, potentially resulting is different dispersal patterns among guilds.

Research on patterns of hydrochory in intact and degraded ridge and slough communities of the Everglades found that the timing of increasing water depths and velocity, i.e. ascending flows, coincided with the dispersal phenology strategy in intact sloughs, which may assist the dispersal of slough species through the system into future physically restored areas. Ridge species in degraded sloughs, such as Cladium jamaicense and Cephalanthus occidentalis, timed their seed release with peak depths immediately before drawdown, and during negligible water velocities, i.e. descending flows. This strategy may increase the probability of these species finding and being deposited on elevated peat locations. Research on the influences of hydrochory and anemochory on community restoration in the restored Kissimmee River floodplain are also ongoing.

<u>Contact Information</u>: Scott Markwith, Department of Geosciences, Florida Atlantic University, 777 Glades Road, Boca Raton, FL 33431, USA, Phone: 561-297-2102, Email: smarkwit@fau.edu

STREAMLINING CENTRAL EVERGLADES PROJECT PLANNING (CEPP) USING CERP ADAPTIVE MANAGEMENT PROTOCOLS

John Marshall
Arthur R. Marshall Foundation/FEI

Executive Summary: Streamline CEPP using CERP ***Adaptive Management Integrated Guide*** protocols by:
Incorporating a CEPP Conceptual Ecological Model (CEM) to arrive at restoration valuation measures
Focusing on CERP 1999 Table 5-1 Goals & Objectives as the basis for top level valuation measures
Valuing ecosystem services based on measured increases in total special extent per CERP Objective 1
Assumption: CEPP Time-lines & public support mandate streamlining by synthesis all can understand.

PROGRESS: Adding CEPP to CERP using CERP Adaptive Management Protocols resulting in CERP(+).
Central Everglades Project Planning (CEPP) Positives:
The Project Delivery Team (PDT) Goes in the direction of CERP(+)
Federal Register/CEPP Workshops wording has this restoring flow, etc.:
Details at www.sfrestore.org;
See Federal Register handout (Attachment 1, A-1, next page)
Noted in Nov 30 CEPP Workshop: CEPP Federal agencies are considering ecosystem services valuation (ESV) for decision-support, per the July, 2011 White House Report – *Sustaining Natural Capital*: *Protecting Society & The Economy*
Streamline the process using the CEPP evaluation tool box with 3 E-Z evaluation tool box additions per the CERP 2011 ***Adaptive Management Integration Guide*** protocols (See protocols in Attachment 2):
CEPP Conceptual Ecological Model (CEM) (See Attachment 3 case for a CEPP CEM)
A CEPP CEM is required by Activity 4 and lead-in to other required PDT activities;
Note: Measures posted in Nov 30 CEPP Workshop were borrowed from other CEM's, but other regions do not include historical *attributes* of a pond apple forest, sawgrass plains, and 40 mi+ wide expanse of sheet flow; the *drivers* and *stressors* are also different.
CERP 1999 Table 5-1 Goals & Objectives (see attachment 4 and "posting on the wall");
Establish measures based on CERP Table 5-1 Total system goals and objectives per CEM process, e.g., what is the increase in total spatial extent of natural area in acres?
Add Ecosystem Services Valuation Approach & Methodology to the evaluation tool box
Calculate ESV of alternatives based on dollars per acre per year using Costanza Synthesis dollar values per acre, number of acres of increased spatial extent, and CERP life-cycle, e.g. economic and ecologic value for an alternative configuration looks something like:
ESV = Costanza Synthesis Biome type value per acre per year x 100,000 acres x 40 years ESV ~ $10,000 x 100,000 acres x 40 years
Compare benefits calculated by ESV to costs for a B:C ratio that provides return on investment (ROI) decision-support for decision makers.
NOTES, especially for those critical of the benefits transfer approach based on the Costanza Synthesis, the most widely referenced peer-reviewed paper on ESV:
Alternative approaches to a more ESV localized analysis are data and modeling intensive, and likely not achievable in a streamlined CEPP set time-frame
Literature that documents localized ESV modeling approaches appear to borrow data from other regions with even more benefits transfer than occurs using the Costanza Synthesis
CONCLUSION: The a.b.c. approach above has the distinct result of ***quicker, cheaper, better*** analysis of alternative and falls into the category of *close enough for government work*
Also goes in the direction of the White House Report recommending the feds apply ESV in projects like CERP as a means to get to return on investment for astute decision-support.

POSSIBLE SUPPORT by up-start orgs in the news in November, 2011, and presently: Public Comment Request to Everglades Legislative Caucus; Member request to Florida Conservation Coalition (FCC): Push Streamlined CEPP
Everglades Coalition Conference, ESV Breakout Session, Jan 7 (Push Streamlined CEPP using ESV)
Apply ESV to Proposed Everglades Headwaters National Wildlife Refuge (Push Costanza Synthesis)
Summer Intern Program Recruiting begins at EvCo Conference; project assignment = ESV Theme applied to CEPP

Contact Information: John Marshall, Arthur R. Marshall Foundation/FEI 1028 N. Federal Highway, Lake Worth, FL 33460, USA, Phone: 561-233-9004; Email: JAMinfo@aol.com

UNDERSTANDING THE INVASION AND MANAGEMENT OF *MELALEUCA QUINQUENERVIA* FROM TOP-DOWN TO BOTTOM-UP

Melissa R. Martin[1], *Philip W. Tipping*[2] and *K.R. Reddy*[3]

[1] United States Fish and Wildlife Service, A.R.M. Loxahatchee National Wildlife Refuge, Boynton Beach, FL, USA

[2] United States Department of Agriculture, Agricultural Research Service, Invasive Plant Research Laboratory, Fort Lauderdale, FL, USA

[3] University of Florida, Department of Soil and Water Science, Gainesville, FL, USA

Invasive plants can thrive in new habitats where they out-compete native plants and dominate communities and whole ecosystems. The reasons for their success are debated and have led to the creation of hypotheses that roughly break down into either top-down or bottom-up centric explanations of invasion or some combination of both. The so-called enemy release hypothesis attributes their success to reductions in top-down forces where natural enemies are left behind when plants invade into a new area. Conversely, the resource hypothesis suggests that invasion is facilitated by more bottom-up forces such as resource availability.

The enemy release hypothesis forms the cornerstone for the management practice of classical biological control of weeds whereby coevolved host specific insect herbivores from the plant's native range are reunited with the plant in its extant range thereby restoring some level of top-down regulation via herbivory. This practice has lead to the successful control of many exotic species including the floating aquatic plant Salvinia molesta Mitchell, however, bottom-up forces may affect top-down controls when the presence of excessive resources like eutrophication allows plants to compensate for herbivory. Other research suggests that both resource availability and enemy release act in concert to facilitate invasion and that fast-growing, presumably high resource plant species like Australian tree Melaleuca quinquenervia would benefit more from enemy release.

Currently, introduced, host specific, insect herbivores are controlling M. quinquenervia growth and reproduction, however, there is no Information on how this management tactic may be influenced by other ecosystem variables like resource availability. This study investigated the following question: Does resource availability affect M. quinquenervia biomass production and nutrient dynamics after introduced herbivory? Preliminary data reveal that when protected from the top-down control of herbivory M. quinquenervia trees were able to produce 2.7 times more biomass under higher nutrient conditions. In contrast, there was no difference in biomass production in trees that were not protected from the insect herbivores. The results of this study may provide significant insight into the factors that influence the invasion and management of M. quinquenervia on a landscape-level.

Contact Information: Melissa R. Martin, United States Fish and Wildlife Service, A.R.M. Loxahatchee National Wildlife Refuge, 10218 Lee Road, Boynton Beach, Florida 33473, USA, Phone: 561-735-6006, Fax: 561-735-6008,Email:melissa_martin@fws.gov

WATER QUALITY CONSTRAINS HYDROLOGIC MANAGEMENT OPTIONS FOR A NORTHERN EVERGLADES PEATLAND

***Paul V. McCormick*[1]**, *Michael G. Waldon*[2], *Rebekah E. Gibble*[2] and *Eric S. Crawford*[3]
[1]Joseph W. Jones Ecological Research Center, Newton, GA, USA
[2]Arthur R. Marshall Loxahatchee National Wildlife Refuge, Boynton Beach, FL, USA
[3]South Florida Water Management District, West Palm Beach, FL, USA

Current environmental management issues in the A.R.M. Loxahatchee National Wildlife Refuge illustrate how water-quality constraints impinge upon efforts to restore the hydrology of the Florida Everglades. Prior to human alterations, the present-day Refuge was part of an Everglades landscape that was shaped by the directional flow of water, extended hydroperiods, and a phosphorus(P)-limited and mineral-depleted chemistry indicative of a rainfall-dominated hydrology. The Refuge is now managed as an impoundment, and water levels (stages) and water quality are controlled by two water sources: 1) rainfall directly on the peatland (50% of water inputs); (2) inflows of P-rich, mineralized runoff into perimeter conveyance canals (50% of inputs). As in other parts of the Everglades, plans to improve hydrologic conditions within the Refuge must consider potential water-quality impacts resulting from a reliance on canal inflows to achieve otherwise beneficial increases in flows, depths, and hydroperiods.

Various modifications to the Refuge's hydrologic regime have been implemented or proposed in recent decades to support vegetation, wildlife, and soil conservation. Stages in the Refuge are managed in accordance with a regulation schedule that allows for increasing stages during the wet season (June-October) when rainfall and canal inflow volumes are greatest and requires a gradual decline during the ensuing dry season. During the 1990s, this schedule was modified to allow for greater water storage during the wet season to increase Refuge hydroperiods. More recent analyses indicate that further improvements in hydroperiods could be achieved by increasing the frequency and duration of wet season high stages. These improvements would require that inflows to the Refuge be increased, particularly when conditions are dry. In wet years, the Refuge often receives inflows in excess of environmental needs in order to meet regional flood-control requirements.

Protection of native vegetation (macrophyte, periphyton) communities is a key management objective for the Refuge. Field surveys and controlled experiments have established strong relationships between canal-water influences on water and soil chemistry and undesirable changes in these communities. Soil P enrichment gradients near the perimeter of this peatland have contributed to the replacement of desirable communities with dense stands of cattail (Typha domingensis) and other nuisance plant species. Characteristic vegetation in the Refuge interior has also been shown to be sensitive to increases in water and soil mineral content, which have occurred across a much larger area than that affected by P enrichment. The severity and spatial extent of these chemistry changes is controlled by the degree to which canal water is able to intrude into the Refuge interior, which in turn is determined by factors such as the relative stages of water in the canals and the peatland interior and total inflow volumes.

From a water-quality perspective, the overarching constraint to improved hydrologic management in the Refuge is to minimize the potential for canal-water intrusion and associated ecological impacts until water quality is improved. This would require that canal inflow volumes and stages be timed properly to track interior marsh stages. For example, rapid increases in canal stages early in the wet season when interior stages are still low may improve hydroperiods but promote intrusion. Inflow volumes beyond those required to achieve hydrologic objectives also increase the risk of water-quality impacts by increasing the probability of large-scale flow of canal water across the Refuge. While restoration of flow may be critical to reversing long-term landscape changes in the Refuge, this management option is currently precluded by the poor quality of source waters. The ability to achieve hydrologic objectives while minimizing water-quality impacts is further constrained by Refuge topography and limitations to existing water-management infrastructure and operational flexibility.

Contact Information: Paul V. McCormick, Joseph W. Jones Ecological Research Center, 3988 Jones Center Dr, Newton, GA 39870 USA, Phone: 229-734-4706 x248, Fax: 229-734-6650, Email: pmccomick@jonesctr.org

LARGE-SCALE SEARCH FOR TIDAL MITIGATION SITES ON THE ELIZABETH RIVER, VIRGINIA

Mark McElroy
ARCADIS-US, Inc. Newport News, VA, USA

The Norfolk District of the U.S. Army Corps of Engineers (USACE) and the Virginia Port Authority (VPA) are constructing the Craney Island Eastward Expansion (CIEE) project in Portsmouth, Virginia. This project will result in approximately 522 acres of subaqueous bottom impacts on the Elizabeth River. This expansion would extend the useful life of Craney Island by approximately nine years and would provide 500+ acres of new marine terminal space for the VPA. As mitigation for the subaqueous bottoms and a small amount of vegetated wetlands a Compensatory Mitigation Plan was approved by the Virginia Department of Environmental Quality that provided for restoration of 411 acres of contaminated river bottom, creation of 20 acres of oyster grounds, restoration/creation of 56 acres of tidal wetlands. This paper describes the methods used to search for appropriate sites to be used to conduct the tidal mitigation component of this mitigation plan.

During preparation of the Section 404/401 Joint Permit a tiered approach that systematically narrowed down the sites from a large array of potential sites (Tier I) to the currently proposed mitigation sites (Tier IV) based on specific search criteria was undertaken. The criterion which was used to evaluate properties included:

Site Development
Site Elevation (Topography)
Site Size
Existence of Jurisdictional Features on Site
Proximity to Tidal Waters (Hydrology)
Accessibility for Construction
Potential for Contamination
Utility Encumbrances on Site
Resource Protection Area (RPA) Encumbrance on Site
Site Available for Purchase

As a result, the VPA and Corps of Engineers evaluated approximately 215 parcels and 3,917 acres to find the required 56 acres of preferred tidal wetland mitigation. Candidate sites were evaluated with a desktop survey which employed the use of ArcMap® software from Environmental Systems Research Institute (ESRI) to analyze geographic Information system (GIS) and computer-aided design (CAD) Information obtained from private corporations, non-profit organizations, city, state and federal agencies. The data was either provided by land owners whose properties were evaluated, purchased, or freely obtained from their respective websites. The desktop evaluation was used to identify areas or conditions that could potentially benefit or encumber wetland creation on the evaluated site.

Using this approach we efficiently drilled down through the 215 parcels to a list of finalists, conducted on-site studies and prepared conceptual tidal wetland mitigation designs for review by the agencies. The first site (11 acres) is currently nearing the planting phase and is due to be complete mid-2012.

<u>Contact Information</u>: Mark McElroy, ARCADIS-US, Inc., 701 Town Center Drive, Suite 600, Newport News, VA 23606, USA, Phone: 757-873-4418; Fax: 757-873-757-873-8723, Email: mark.mcelroy@arcadis-us.com

WETLAND RESTORATION ON FLORIDA CATTLE RANCHES: NRCS WETLAND RESERVE PROGRAM

Shannon E. McMorrow[1], *Scott Kuipers*[2], *Jessica Mixon*[2], *Sam C. Arden*[1], *Judith L. Dudley*[1], *Jeremy M. Paris*[3], *Joy M. Ryan*[1], *Charlene A. Stroehlen*[1] and *William A. Tucker*[1]

[1]AMEC E&I, Inc., Newberry, FL, USA
[2]USDA Natural Resource Conservation Services, Okeechobee, FL, USA
[3]AMEC E&I, Inc., Miami Lakes, FL, USA

AMEC E&I, under contract to USDA's Natural Resource Conservation Service (NRCS), has prepared Wetland Reserve Plan of Operation (WRPO) documents for four easement tracts located in central and south Florida in the northern everglades region, as part of the NRCS Wetland Reserve Program (WRP). A WRPO is a conservation plan that identifies how wetland functions and values will be restored, enhanced, protected, maintained and managed to accomplish the goals of the NRCS WRP project area. The WRPO includes all required conservation practices and activities applicable to meeting the goals and long-term management requirements of the easement. For these four projects, the process of developing the WRPO was a collaborative effort with NRCS, landowners, and AMEC. The WRPO easement properties are generally characterized as improved pastureland; however, they historically consisted of a broad complex of swamps, prairies, marshes, and flatwoods. Agricultural drainage ditches have dramatically altered the natural wetland functions and ecological values of these sites.

The main goal of the WRPO is to return the conservation easement property to historic conditions; natural wetland and associated upland ecological communities (or as close as possible) that existed prior to agricultural manipulation (primarily ditching). Pre-disturbance historical aerial photography was the primary tool used to determine desired historic ecological communities, however soils data were also considered. Field assessments of the easements were completed to gather Information on: land use, vegetation, hydrology, relative "health" of the ecological communities, threatened and endangered species and wildlife habitat.

Using desktop and field gathered data, conceptual wetland restoration plans were prepared. SPAW and ICPR hydrologic models were utilized to evaluate the existing hydrology and then to develop a variety of alternatives for re-directing water at the site to achieve optimal hydrologic conditions. The restoration plans and modeling scenarios included a variety of engineering solutions to change site conditions including ditch blocks, ditch modifications, and culverts. Rough cost estimates were developed to identify the most cost-effective alternatives. The hydrologic alteration proposed in the restoration plans will result in an increase in overall acreage of wetlands on the properties compared to existing conditions. In addition to hydrologic modification, other conservation practices were recommended to achieve the goals of the WRP. Examples of these include invasive exotic plant management, range planting, tree/shrub establishment, and prescribed burning.

Landowner preferences, cultural resources, threatened and endangered species habitat, and off-site impacts were all considered during the development of the WRPO for each tract. Although, the wetland restoration is confined to these isolated tracts of land, the benefits are far reaching and significant. Together these four projects comprise over 30,000 acres of habitat. Local and "downstream" benefits include increasing groundwater recharge and improved water quality. Establishing these conservation easements also has the potential to establish, improve, and/or create contiguous wildlife habitat.

Contact Information: Shannon McMorrow, AMEC E&I, Inc., 404 SW 140th Terrace, Newberry, FL 32669, USA, Phone: 352-333-3634; Fax: 352-333-6622, Email: Shannon.mcmorrow@amec.com

ECO-HYDROLOGY MODELING IN COASTAL LOUISIANA TO ASSESS PROJECT EFFECTS ON THE LANDSCAPE

***Ehab** Meselhe*[1]*, John A. McCorquodale*[2]*, Jeff Shelden*[3]*, Mark Dortch*[3]*, Stokka Brown*[4]*, Mallory Davis*[4]*, Wang Zhanxian*[3]*, Peter Elkan*[3] and *Jennifer Schindler*[2]

[1]University of Louisiana at Lafayette, Lafayette, LA, USA
[2]University of New Orleans, New Orleans, LA, USA
[3]Moffatt and Nichol, Raleigh, NC, USA
[4]C.H. Fenstermaker & Associates, Lafayette, LA USA

The future of the Louisiana Coast is uncertain due to accumulation of natural and engineered changes that took place over time. As such, it is imperative to develop tools to better understand how this system is changing over time. These tools will be used to assess proposed measures to mitigate or eliminate adverse changes in an attempt to restore and protect the coast. A computationally efficient numerical tool has been developed to accomplish this goal. This numerical tool is a mass-balance compartment model that can be used to perform long-term eco-hydrology analyses of the Louisiana Coast.

The model consists of three sub-basin modules: Chenier Plain (CP), Atchafalaya Basin (AA), and Lake Pontchartrain/Barataria Bay (PB). The PB model was previously developed in FORTRAN and has been used as the basis for developing the AA and CP models in the Berkeley Madonna modeling environment. The models are designed to calculate hydrodynamic and water quality processes over a 25-year period. They take into account water and constituents entering and exiting the domain as well as the exchange between the compartments and the atmosphere. In addition to the hydrodynamics (stage, flow rate, and velocities), the following water quality constituents are included in the model: total suspended solids, salinity, total Kjeldahl nitrogen, water temperature, nitrate + nitrite nitrogen, ammonium nitrogen, dissolved organic nitrogen, total phosphorus, soluble phosphorus, phytoplankton as chlorophyll-a, detritus, residence time or age, nitrogen removed, and accretion. All regions are calibrated and validated to observed data.

Proposed restoration and protection projects included in the models are marsh creation, hydrologic restoration, shoreline protection, ridge restoration, diversions, channel re-alignments, and oyster reef developments. Simulations of these projects are performed to provide input values for other expert eco-system process models with a final goal of producing a comprehensive 50-year output used to assess the effects of each proposed project as compared to a 50-year output where no projects are introduced.

Contact Information: Ehab Meselhe, Department of Civil Engineering, University of Louisiana at Lafayette, P.O. Box 42291 Lafayette, LA 70504 USA, Phone: 337-739-9716, Fax:337-428-6688; Email: Meselhe@louisiana.edu

PROCESSES AND DYNAMICS OF ECOSYSTEM RECOVERY IN NUTRIENT-ENRICHED EVERGLADES AFTER PHOSPHORUS LOAD REDUCTION

ShiLi Miao[1] and *Cassondra R Thomas*[2]
[1]South Florida Water Management District, West Palm Beach, FL, USA
[2] Cardno ENTRIX, West Palm Beach, FL, USA

Processes and dynamics of ecosystem recovery have been the focus of restoration and ecosystem ecology. However, a lack of well-developed ecological theories and principals based on long-term datasets hampers our understanding and prediction of ecosystem recovery regardless of whether the wetland is created or restored. The Everglades has experienced decades of high nutrient loading and altered hydrology resulting in ecosystem shifts from the historical ridge/slough landscape to cattail monocultures and loss of topographic relief. Research was implemented to examine the processes and dynamics of ecosystem recovery after 15 years of reduced surface water phosphorus (P) concentration and loading in Water Conservation Areas (WCA 2A). As part of a large-scale ecosystem restoration study, ecosystem processes and matrix concentrations were examined over a 5- or 15-year timeframe along an existing nutrient gradient to determine if nutrient load and concentration reduction resulted in ecosystem process change. The gradient was divided into three areas: highly-enriched, moderately-enriched, and reference.

The pattern and trajectory of recovery were evaluated by each key component's P concentration and its ratio in enriched areas to the reference condition. Overall, inflow water TP concentrations, loading rates, and water depths declined since 1994, as did the TP concentration of surface water in the enriched areas of WCA 2A. Phosphorus loading rates were the main driving force behind marsh surface water TP concentration reduction, especially closer (< 3 km) to the Hillsboro Canal. Evidences of reduced P concentrations were also found for cattail tissue and near-surface soil. However, there were differences in the trajectory of decline and processes between the highly-enriched and moderately-enriched areas. Water quality in the highly-enriched area experienced a rapid initial decline in P concentration followed by a slow decline. Cattail and soil P concentrations decreased slowly but steadily over the same time period, indicating cattail stress and accumulation of new low-P sediment on the top of enriched-soil, respectively. In contrast, in the moderately-enriched area surface water P stayed stable around 20 ppb, but porewater concentration levels were similar to reference areas by the end of the study. While plant and soil P concentrations also did not demonstrate significant declines, burial of P-enriched soil below lower P-concentration soil was apparent. Overall, P concentration reductions were detected at several levels of ecosystem recovery in nutrient-enriched areas of WCA 2A. Yet the known recovery patterns seem not over a sufficient duration to predict future recovery and hence additional monitoring and ecological modeling are critically needed.

Contact Information: ShiLi Miao, Water Quality Treatment Technology Section, Applied Sciences Bureau, Water Resources Division, South Florida Water Management District, 3301 Gun Club Road, FL, USA, Phone: 561-682-6638, Fax: 561-682-5382, Email: smiao@sfwmd.gov

RESTORING ECOSYSTEM FUNCTION IN THE P-ENRICHED EVERGLADES: CREATING AN ALTERNATE REGIME

Susan Newman[1], *Scot E. Hagerthey*[2] and *Mark I. Cook*[1]
[1]South Florida Water Management District, West Palm Beach, FL, USA
[2]U.S. Environmental Protection Agency, Arlington, VA, USA

Four decades of elevated phosphorus (P) loads to the historically oligotrophic Everglades has resulted in a regime shift from the ridge (Cladium jamaicense Crantz)-and-slough landscape to large areal expanses of cattail (Typha domingensis Pers.). To accelerate the recovery of P-impacted areas, restoration requires not only a reduction in the external P concentrations and loads, but also management activities that reduce the internal resilience and resistance inherent to the cattail regime. The cattail habitat improvement project (CHIP) is a large-scale in situ study comprised of 15 6.25 ha plots to test the ability to rehabilitate cattail areas by creating an alternative submerged aquatic vegetation (SAV) regime. Using a combination of herbicides and fire, open areas were created in enriched and moderately enriched areas of the northern Everglades (Water Conservation Area-2A) in July 2006. The two primary objectives were to assess whether creating openings in dense cattail areas will sufficiently alter trophic dynamics such that wildlife diversity and abundance could be increased and, determine to what extent the ecological functions of these created open areas compared to those of the natural Everglades. Plots were monitored for four years, with no reductions in P levels in surface water or soil being observed, though given the infancy of this regime this was not surprising. However, there was strong evidence of altered ecological function within the open plots relative to controls with; 1) increased dissolved oxygen concentrations, 2) increased microbial activity and associated decomposition, 3) extensive SAV, principally Chara cover, and 4) increased fish biomass. Direct evidence of connections between altered nutrient cycling and foodweb dynamics were assessed using stoichiometric relationships. Stoichiometric relationships indicated that the quality, quantity, and diversity of primary consumers were greater in open plots relative to controls. In addition, because the active management strategy removed dense emergent macrophytes the higher quality prey were more readily accessible for consumption by wading birds. Three years post herbicide application, with the exception of one plot, cattail remained at < 30% cover, indicating that with minimal effort and cost, this altered regime could be sustained in the long-term.

<u>Contact Information</u>: Sue Newman, Everglades Systems Assessment Section, South Florida Water Management District, P.O. Box 24680, West Palm Beach, FL 33416-4680, USA, Phone: 561-682-6608, Fax: 561-682-5608, Email: snewman@sfwmd.gov

PREDICTING THE EFFECTS OF HURRICANE PROTECTION AND WETLAND RESTORATION PROJECTS ON FISH AND WILDLIFE

J. A. Nyman
School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, LA, USA

The State of Louisiana is revising its Master Plan for ecosystem restoration and hurricane protection. This effort includes the development of a prioritization tool that compares the ability of possible projects to minimize economic damage from storm surge and to maximize ecosystem services from wetlands. The prioritization tool depends upon models that simulate the effects of possible protection and restoration projects on water level and salinity, vegetation, geomorphology, fish and wildlife, storm surge, and storm damage. Here, we focus on fish and wildlife models. Restoration planners and stakeholders selected to focus on ecosystem benefits from one species group (neotropical migrant songbirds) and 14 species (American alligator, muskrat, river otter, black drum, speckled trout, brown shrimp, white shrimp, largemouth bass, gadwall, green-winged teal, mottled duck, roseate spoonbill, red swamp crawfish, and eastern oyster). A team of six modelers from four institutions developed models to predict habitat quality for those fish and wildlife. The most common input variables related to percent open water, water salinity and emergent vegetation class. The model was used to simulate changes in habitat quality for fish and wildlife for 50 years under various scenarios of restoration, sea-level rise, riverine discharge, and subsidence. Those outputs then were used as input for the prioritization tool.

Contact Information: J.A. Nyman, School of Renewable Natural Resources, LSU AgCenter, Baton Rouge, LA 70803, USA, Phone: 225 578-4220, Email: jnyman@lsu.edu

SOIL NUTRIENT STORAGE AND CYCLING IN THE RESTORED KISSIMMEE RIVER FLOODPLAIN

Todd Z. Osborne[1], *Vimala D. Nair*[1], *Larry R. Ellis*[1], *Brad Jones*[2] and *Willie Harris*[1]
[1]Soil and Water Science Department, University of Florida, Gainesville, FL, USA
[2]Lake and River Ecosystems Section, South Florida Water Management District, West Palm Beach, FL, USA

The restoration of the Kissimmee River not only returns the meandering river channel, once a natural feature of the river prior to its channelization in 1960's, but it also reestablishes the hydrologic connection to the former floodplain. This reconnection of the floodplain has allowed seasonal flooding of these lands and thus historical vegetation communities to return. River restoration is anticipated to increase the nutrient retention through deposition and biological assimilation on the floodplain. However, until the restoration project is finished and a more natural hydroperiod and stable wetland ecosystem become established, periodic inundation of the floodplain may mobilize nutrients in former cattle pastures. Phosphorus is of particular interest as it has been identified as the leading cause of eutrophication in Lake Okeechobee and the degradation of many other downstream water bodies, such as the Water Conservation Areas that make up the Northern Everglades. To determine if soils and sediments from both the restored portion of the Kissimmee River floodplain and those areas slated for restoration will retain more nutrients after restoration or export more nutrients in the short-term, an extensive spatial survey of soil biogeochemical properties was conducted in 2011 to determine the potential activity (sequestration and efflux) of soil phosphorus and nitrogen. Utilizing traditional soil analyses and new tools, such as the soil phosphorus sorption capacity (SPSC), nutrient retention and export were determined for several dominant soil types. Geostatistical analyses enabled modeling of spatial extent of soil attributes and nutrient export potentials. Key soil properties were mapped spatially to create a baseline distribution to enable interpretation of nutrient retention or export potential and to aid future evaluation of restoration success. Determination of restoration success or failure requires the ability to detect change within the system being restored. This investigation also provides a framework for future change detection at the landscape scale utilizing distribution functions of soil attributes.

Contact Information: Todd Z. Osborne, Wetland Biogeochemistry Laboratory, Soil and Water Science Department, 106 Newell Hall, Gainesville, FL 32611; Phone: (352) 392-1804; Email: Osbornet@ufl.edu

THE LOUISIANA COASTAL AREA, MISSISSIPPI RIVER HYDRODYNAMIC AND DELTA MANAGEMENT (MRHDM) STUDY

Cherie Price[1] and *Brian Vosburg*[2]

[1]U.S. Army Corps of Engineers, New Orleans, LA, USA

[2]Coastal Protection and Restoration Authority of Louisiana, Baton Rouge, LA, USA

The Mississippi River (MR) is a significant and valuable resource with the potential to support sustainable restoration in coastal Louisiana giving rise to the need for a focused and deliberate examination of its capabilities. The river possesses the largest replenishable sediment supply available to Louisiana to assist in protecting and restoring coastal areas. Although suspended sediments in river water have been significantly reduced since the 1800s the river still harbors and conveys significant quantities of sediment. Restoration experts realize that directing river water and sediments to coastal areas is a significant component of large scale restoration strategies. Issues and drivers, such as economics, surrounding the coexistence of navigational and ecological use of river resources can pose significant challenges in accessing river resources for restoration purposes. The objective is to discover solutions for ecosystem restoration, as well as long-term channel safety and stability.

The Louisiana Coastal Area, Mississippi River Hydrodynamic and Delta Management co-sponsored study between the U.S. Army Corps of Engineers, and the Coastal Protection and Restoration Authority of Louisiana, will employ a twofold approach to fulfill a long standing need to determine how much MR sediment and river capacity is available annually to support coastal restoration initiatives. Just as the previous planners and managers considered the impacts of levees and navigation on the river and the surrounding communities, this study seeks to identify and articulate the issues surrounding the removal of sediments from the river for coastal restoration and to provide solutions that work in harmony with these existing uses. The MRHDM study will seek to integrate components of Louisiana's 2012 Coastal Master Plan.

The first component of the MRHDM study is a comprehensive, system-wide, riverene hydrodynamic analysis that will capitalize on the current state of MR science while also collecting and developing additional data and tools to assess the water and sediment resources available to support coastal restoration initiatives while also sustaining current navigation and flood control. The study will support near term planned diversions and evaluate future large scale, long term, ecosystem restoration projects. The developed models will also be used to adaptively manage constructed features to optimize the execution of project objectives.

The second study component focuses on the receiving wetlands adjacent to the MR and identifying and evaluating approaches that would greatly increase the deposition of MR sediment to restore deltaic growth in the MR Delta Plain. This effort will determine methods to retrieve and apply sediments from the river in a sound, ecological context to offset the effects of relative sea level rise. In addition, investigations will assess the assimilation of excess nutrients by filtering through wetlands before leading to the annual development of a significant hypoxic zone in the northern Gulf of Mexico. It is important to note that in endeavoring to implement a multi-use approach on the MR, alternative river navigation alignments may be required. This presentation will delve more into the complexities associated with such a significant and substantial study that has major implications in Louisiana's future.

Contact Information: Cherie Price, U.S. Army Corps of Engineers, Regional Planning and Environmental Division South, P.O. Box 60267, New Orleans, LA, USA, 70160, Phone: 504-862-2737, Fax: 504-862-1892, E-mail: Cherie.Price@usace.army.mil

STATE OF THE SCIENCE FOR MULTIPURPOSE USE OF THE LOWER MISSISSIPPI RIVER TO ACHIEVE SUSTAINABILITY

Richard C. Raynie
Coastal Protection and Restoration Authority of Louisiana, Baton Rouge, LA, USA

Land loss in coastal Louisiana is linked to the separation of the river from the adjacent delta plain and estuaries. Virtually all discussions of achieving some measure of sustainability in coastal Louisiana revolve around re-connecting the Mississippi River to its delta plain. The historical management strategy has favored the river-side of the equation. Within its banks, the Mississippi River has been managed for navigation and flood control at the expense of the adjacent estuaries and deltaic wetlands which have been deprived of annual floodwaters which carry sediment and nutrients necessary to sustain the delta. The challenge is finding a balance where the river can be allowed to return to the estuary without compromising goods and services and the communities that support critical industries of national significance (e.g., commerce and navigation, oil and gas exploration, commercial fisheries, and others). In order to develop a balanced approach, maintaining navigation and flood control on the river-side, while returning flow to sustain the adjacent estuaries and wetlands, scientific and technical advances are being pursued to provide opportunities for sustainable management of the Mississippi River and Delta for the 21st century.

Louisiana's coast is a "working coast" generating billions of dollars annually for the National budget. In order to support the multiple uses of the river as well as the critical need to protect and maintain the fragile and degrading Mississippi River Delta and the communities therein, Louisiana is working with federal, state, and local partners to improve our understanding of the complexity and interdependence of the goods and services that the river and its delta provides.

There are some challenges and also some major uncertainties when developing sustainable management strategies for the lower Mississippi River, including (1) identifying the best locations for diversions and navigation channel realignments to maximize delta benefits and minimize in-river impacts, (2) determining the most appropriate size and operational strategy for controlled diversions to maximize land building and land sustaining benefits, (3) improving our understanding of the complexity of water and sediment dynamics in the river and developing water and sediment budgets, (4) balancing the water needs (flow and volume) for in-river uses with the needs of the delta, (5) improving our understanding of the linkage of water quality, wetland nutrient assimilation, and Gulf hypoxia, and (6) balancing water flowing into the estuary to maintain the high fish and wildlife productivity characteristic of Louisiana's coastal wetlands.

To address these uncertainties, the state and its partners are utilizing state-of-the-art equipment to collect empirical data in the river, develop new physical and numerical predictive models, and analyzing nearly 20 years of data from existing diversion projects to develop recommendations for diversions and their future use. This presentation will discuss current understanding of relevant scientific and technical issues as they relate to sustainable management of the lower Mississippi River.

Contact Information: Richard C. Raynie, Coastal Protection and Restoration Authority of Louisiana, Louisiana Applied Coastal Engineering and Science (LACES) Division, P.O. Box 44027, Baton Rouge, LA 70804-4027, USA, Phone: 225-342-9426, Fax: 225-242-3632, Email: Richard.Raynie@LA.gov

THE FUTURE OF COASTAL LOUISIANA: EXPECTED OUTCOMES OF IMPLEMENTING THE 2012 MASTER PLAN

Denise J. Reed *on behalf of the 2012 Louisiana Master Plan Delivery Team*
University of New Orleans, New Orleans LA, USA

The purpose of the 2012 Louisiana Coastal Master Plan is to identify projects that will make a difference for the communities and ecosystems of south Louisiana and prepare the way for action. Models were developed to estimate the effects of hundreds of projects that have the potential to make a difference to the coastal landscape and/or its c communities and industries. While the most obvious symptoms of coastal degradation are wetland loss and increased damage from coastal storms, it is important to consider the array of consequences associated with actions that are geared towards either building land or protection communities from flooding. Synergies or conflicts among projects, as well as limited funding, need to be considered in developing a holistic plan for the coast.

Results from eco-hydrology, wetland morphology and barrier morphology models were used to identify the effects of projects on the extent of coastal land, while the vegetation, upper trophic level and ecosystem service models provided additional insight on how the resulting changes in estuarine gradient and landscape would affect a number of ecosystem metrics. Predicting change over time for a 50 year period allowed the team to consider tradeoffs among restoration approaches which either build land quickly that is then subject to decay and those which build land gradually over time. A balance between near term (20 years) and long-term (50 years) land building, together with project cost, was used to select restoration projects.

Storm surge/wave models were run across the 50 year future without action landscape and its expected vegetative cover. The resultant damages to coastal assets were calculated and both 'structural' and 'non-structural' risk reduction projects were selected on the basis of their cost, ability to meet desired levels of risk reduction, and overall reduction in expected annual damages.

A draft list of restoration and protection projects was thus identified with an expected cost of $50 billion. However, the individual project modeling used to select these projects did not consider interactions among projects – either positive or negative. Consequently, additional modeling was performed on the draft list, and several additional groups of projects, to identify the net effects of both protection and restoration on the coastal ecosystem and future level of storm damages. The results of these analyses allow the State of Louisiana to move forward with implementation of the Master Plan knowing not only what it wants to do but what it expects to achieve.

Contact Information: Denise J. Reed, Dept Earth & Environmental Sciences, University of New Orleans, New Orleans, LA, USA 70148. Phone: 504-280-7395, FAX: 504-280-7396, Email: djreed@uno.edu

STORM SURGE AND WAVE MODELING FOR PRIORITIZATION OF LOUISIANA COASTAL RESTORATION AND PROTECTION PROJECTS

Hugh J. Roberts[1], *Zach Cobell*[1] and *F. Ryan Clark*[2]
[1]ARCADIS, Boulder, CO, USA
[2] ARCADIS, Baton Rouge, LA, USA

This work is being carried out by ARCADIS on behalf of the State of Louisiana Coastal Protection and Restoration Authority (CPRA). The study evaluates the surge and wave reduction potential of coastal restoration and protection projects. An environmental, social and economic assessment of each project is ultimately utilized by CPRA to prioritize funding for future projects in the Louisiana 2012 Coastal Master Plan. The storm surge and wave protection analysis as a component of the larger risk and damage assessment is the focus of this abstract.

The first phase of this project centered on optimization of a coupled hydrodynamic and wave modeling system which would meet the time and accuracy constraints of a statewide planning study by CPRA. The Advanced Circulation (ADCIRC) model coupled with the Unstructured Simulating Waves Nearshore (UnSWAN) model was selected. An initial study served to quantify runtime and relative accuracy for several levels of model resolution in order to recommend an optimal model setup. The modeling paradigm made use of the existing high-resolution SL18 ADCIRC model and strategically de-refined the SL18 mesh while maintaining critical hydraulic features. Over 80% of the computational nodes were removed from the SL18 mesh, while maintaining similar levels of accuracy when hindcasting Hurricane Gustav and Hurricane Ike.

The model was applied to investigate the impact on storm surge and waves during hurricane conditions for various coastal protection and restoration alternatives. In order to investigate current and future benefits of projects, the surge and wave models were loosely coupled with ecosystem hydrology, wetland morphology, barrier island morphology and vegetation models. Outputs from these loosely coupled models were applied in the storm surge and wave models to account for future scenarios of subsidence, accretion, coastal morphology and wetland loss.

The ensemble of ADCIRC and UnSWAN simulation results for current and future landscapes were subsequently used to inform the projected 50 year, 100 year and 500 year return periods for the various project alternatives and the State of Louisiana to prioritize funding of coastal projects.

Contact Information: Hugh J. Roberts, ARCADIS, 4999 Pearl East Circle, Suite 200, Boulder, CO 80301 USA, Phone: 303-885-4433; Email: hugh.roberts@arcadis-us.com

FLORIDA'S AQUATIC HABITAT RESTORATION AND ENHANCEMENT PROGRAM

***Stephen V. Rockwood*[1]**, *Bill Coleman*[2] and *Lawson Snyder*[3]
[1]Florida Fish and Wildlife Conservation Commission, Fellsmere, FL, USA
[2]Florida Fish and Wildlife Conservation Commission, Eustis, FL, USA
[3]Florida Fish and Wildlife Conservation Commission, Tallahassee, FL, USA

The Florida Fish and Wildlife Conservation Commission's (FWC) Aquatic Habitat Restoration and Enhancement (AHRE) Program, formally known as the Lake Restoration Program, was established in 1988 to address restoration and management of Florida lakes to improve freshwater fisheries. The program evolved over the years and in its current structure addresses all freshwater habitat types and associated fish and wildlife resources. Due to the vast acreage and diversity of publicly owned freshwater habitat types, a multi-disciplinary, team-oriented approach was developed to prioritize funding of habitat management projects.

The AHRE Team consists of eleven FWC biologists who serve as subject matter experts representing various fish and wildlife focal taxa groups. The purpose of the Team is to develop and administer the funding application process, coordinate with AHRE staff and advocate the development of project proposals on an annual basis, and prioritize a list of AHRE project proposals for funding consideration. AHRE staff coordinates with FWC biologists throughout the state and with other public and private non-profit conservation entities (i.e., local or county governments, water management districts, Department of Environmental Protection, U.S. Fish and Wildlife Service) to identify projects and forge potential partnerships. In many cases, proposals are based on priorities identified in comprehensive fish and wildlife conservation programs, research needs, recommendations from FWC partners or stakeholders, or GIS analyses developed by AHRE staff. Proposals incorporate a variety of wetland management techniques, or combinations thereof, including but not limited to water control devices for hydrologic restoration, dredging or scraping to remove excessive organic sediments, and management of aquatic habitat through control of exotic, noxious and invasive plants via mechanical implementation or herbicide application and re-establishment of native aquatic plants.

Proposals are due in the fall of each year. The application consists of questions covering a range of topics describing the resource, the need for the project, proposed activities, impacts to fish and wildlife, project objectives, monitoring and evaluation, etc. AHRE Team members independently review and score each application based on the allotted range of points established for each question. The Team then meets as a group in early winter to review and discuss each application. Based on these discussions, Team members are given a second opportunity to re-score the application taking into consideration new Information learned about the project. The application scores are then tallied to develop a prioritized list, compiled into a work plan, and reviewed by Commission senior staff in Tallahassee for final approval.

Funding for the AHRE program is generated from the Florida documentary stamp tax and averages about $5 million each year. Since 2001, over 300 restoration and enhancement projects have been completed improving thousands of acres of freshwater habitat which has benefitted numerous fish and wildlife species including many that are threatened and endangered.

Contact Information: Stephen V. Rockwood, Florida Fish and Wildlife Conservation Commission, 3200 T. M. Goodwin Road, Fellsmere, FL 32948 USA, Phone: 321-726-2862, Fax: 321-953-5033, Email: Steve.Rockwood@MyFWC.com

WETLAND LOSS AND DEGRADATION: THE HIDDEN COSTS OF ETHICAL OIL

Rebecca C. Rooney[1], *Suzanne E. Bayley*[1] and *Dustin Raab*[1]
[1] Dept of Biological Sciences, University of Alberta, Edmonton, AB, Canada

Oil sands deposits in northern Alberta, Canada have been touted as a source of ethical oil and a reliable alternative oil supply for US consumers. Currently, the majority of oil extracted from the oil sands is accessed by open pit mining, with between 0.33 and 0.63 m2 of land destroyed for every 1m3 of synthetic crude oil produced. An area larger than the state of Rhode Island will eventually be mined, leaving about 475,000 ha of land to be reclaimed. Before mining, most (65%) of this land is comprised of peatlands. Contrary to the claims made in the media, peatland habitat destroyed by open-pit mining of oil sands will not be restored. Reclamation will instead transform the mined landscape from predominantly forested fens into upland forest, tailings storage lakes, and small sub-saline marshes of relatively poor health.

According to industry baseline and closure plans, 30,000 ha of peatland will be destroyed by the ten oil sands mines with government approval to operate. Obviously, this loss will have stark ramifications for the ecosystem functions formerly provided by healthy peatlands. Companies plan to partially offset this loss through the creation of at least 4000 ha of new marsh and 5500 ha of new riparian shrubland. However, large scale wetland reclamation has not yet been attempted, and thus the success of these plans remains uncertain. Development has been permitted to outpace reclamation, leaving what we refer to as a reclamation debt in excess of 61,000 ha.

There are numerous impediments to wetland construction in the post-mining landscape, including limitations associated with water supply, water quality, substrate quality, and substrate stability. Although no large scale wetland reclamation has been attempted, about 30 small scale demonstration wetlands have been built over the last 35 years to experiment with these limitations. These demonstration wetlands are our only clues regarding the probable success of large scale reclamation. We evaluated their condition using multivariate and multi-metric plant-based tools and our results suggest that wetland reclamation to date has failed to produce healthy wetlands with plant communities resembling those found in natural wetlands of the same type. We believe that reclamation success could be greatly improved by following specific design criteria, including planting assemblages typical of natural wetlands.

Contact Information: R.C. Rooney, B217 Biological Sciences Bldg. University of Alberta, Edmonton, AB, T6G 2E9, Canada, Phone: 780-722-7633, Fax: 780-492-9234, Email: rrooney@ualberta.ca

RESTORATION OF THE EVERGLADES' SALINE WETLANDS AND FLORIDA BAY: RESPONSES DRIVEN FROM LAND AND SEA

David Rudnick[1], *Colin Saunders*[2], *Carlos Coronado*[2], *Erik Stabenau*[1], *Vic Engel*[1] and *Rene Price*[3]
[1] South Florida Natural Resources Center, Everglades National Park, Homestead, FL, USA
[2] Everglades Systems Assessment Section, South Florida Water Management District, West Palm Beach, FL, USA
[3] Dept. of Earth and Environment, Florida International University, Miami, FL, USA

The character of Florida Bay and the coastal Everglades has a strong dependence on the dynamic confluence of marine and Everglades waters. In the southeastern Everglades and eastern Florida Bay, ongoing implementation of the C-111 Spreader Canal project of the Comprehensive Everglades Restoration Plan (CERP) is expected to improve hydrologic conditions, decrease salinity levels and the rate of inland saltwater intrusion, and improve ecological status. However, understanding and forecasting how any given hydrologic restoration action will effect ecosystem restoration is problematic and further confounded by the variability and acceleration of sea level rise. Monitoring, research, and modeling conducted by CERP and the Florida Coastal Everglades Long Term Ecological Research (LTER) project are contributing Information and understanding of these complex dynamics. Analyses of sea level rise patterns have shown that sea level has risen about 3 mm/y in recent decades, but with a high degree of variability is related to multi-scale climatic fluctuations. An important finding has been that wetland surface water stages in Shark River Slough and Taylor Slough also have risen at a rate similar to or greater than sea level rise; hydrologic slopes, stages and hydropatterns in the wetland depend in part on sea level at estuarine and marine boundaries. Another important finding has been evidence indicating that subsurface saltwater intrusion has increased rates of phosphorus (P) release into groundwater and increased the flux of this P to surface waters of the coastal wetlands.

This flux, combined with modified patterns of inundation and salinity, may strongly affect rates of wetland soil elevation change, which in turn will influence future ecosystem-wide responses to sea level rise and restoration. Over the past decade, coastal wetland elevation increases have not kept pace with sea level rise, increasing from 0.9 mm/y to 2.5 mm/y. These rates not only are a function of the plant community structure and productivity and microbial decomposition processes, but also are strongly influenced by sediment deposits during storm events (e.g, Hurricane Wilma in 2005). Florida Bay's biogenic carbonate muds are a source of such deposits and their mobility and effects likewise will influence, and be influenced by, restoration and sea level rise. The bay's mud bank structure is of particular importance because these banks modify tidal and wave energy, water residence time, and salinity, all which can influence estuarine-wetland ecosystem interactions.

The ecological consequences of sea-level rise and restoration in the southern Everglades and Florida Bay are profound, affecting changes in hydropattern and water residence time, salinity, nutrient availability, landscape patterns, habitat structure, and food webs of this interactive estuarine-wetland ecosystem. Assessment of the C-111 Spreader Canal Project provides an opportunity to explore and understand these dynamics and improve future restoration efficacy.

Contact Information: David Rudnick, South Florida Natural Resources Center, Everglades National Park, 950 N. Krome Ave., Homestead, FL, 33030 USA, Phone: 305-224-4245, Email: David_Rudnick@NPS.gov

RESTORATION OF SIGNIFICANT WETLANDS IN INTERIOR NEW SOUTH WALES: CO-ORDINATING SCIENCE, ON-GROUND WORKS AND WATER DELIVERY

Neil Saintilan
Office of Environment and Heritage, NSW Department of Premier and Cabinet, Sydney South, NSW

The Rivers Environmental Restoration Program (2007 – 2010) aimed to arrest the decline of several significant rivers and wetlands in interior New South Wales. This $170 million program consisted in the integration of four subprograms: subprogram 1, the purchase of water holdings from willing sellers to create a strategic reserve of environmental water; subprogram 2, improvements to our understanding of the hydrology and water requirements of large wetland systems; subprogram 3, on-ground works to improve flooding efficiency in large wetlands; and subprogram 4, focused on improved understanding of cultural heritage and improved land management practices, including the acquisition of wetland for the reserve system.

Four wetland systems benefited principally from this focussed restoration program. Three Ramsar-listed wetlands on the tributaries of the Darling River represented high-conservation targets in the northern Murray-Darling Basin: the Macquarie Marshes, the Gwydir Wetlands and the Narran Lakes. To these were added the lower Murrumbidgee River floodplain in the southern Murray Darling Basin). Previous studies indicate that these systems have been undergoing accelerated ecological degradation since 1980s, largely as a result of water regulation in the catchment. The wetlands have exhibited declining waterbird numbers, encroaching of terrestrial species, colonization of exotic species, and deterioration of floodplain forest condition, and conversion of wetland into agricultural pastures. Although the catchment streams are relatively well gauged and modelled, the lack of hydrological records within the wetlands previously hampered any attempts to quantitatively investigate the relationship between hydrological variation and ecosystem integrity.

Floodplain hydrodynamic models were built for the Macquarie Marshes and Gwydir Wetlands based on 1m DEM derived LiDAR survey (a pre-existing hydrodynamic model was used for the Narran lakes). Hydraulic characteristics of key constituent wetlands, hydrological relationships between stream and wetlands and among wetlands were estimated using time series extracted from hydrodynamic simulations. The hydrology models were used to simulate the daily behaviour of inflow/outflow, volume, and inundated area for key wetlands within the broader wetland mosaic under natural, current, and proposed water management practices. The DEM was also used to guide on-ground works aimed at improving flooding efficiency in key rookery sites, holding water beneath nests for the fledging period.

RERP demonstrated the substantial conservation gains that can be made when water management, on-ground works and property acquisition are guided by science. As a result of this program, significant volumes of water have been returned to these wetlands, leading to significant increases in waterbird and frog breeding activity and the diversity and condition of wetland vegetation.

<u>Contact Information</u>: Neil Saintilan, NSW Office of Environment and Heritage. PO Box A290, Sydney South NSW 1232. Ph: 612 9995 5631; Email: neil.saintilan@environment.nsw.gov.au

THE ORLANDO EASTERLY WETLANDS: SEDIMENT ACCUMULATION MANAGEMENT STRATEGIES FOR PROLONGING PHOSPHORUS REMOVAL

M. D. Sees
City of Orlando, Christmas, FL, USA

In mid-1987, the Orlando Easterly Wetlands (OEW), a constructed wetlands treatment system, began receiving highly treated wastewater from the City's Iron Bridge Regional Water Pollution Control Facility (WPCF). The OEW was constructed to provide additional treatment to the Iron Bridge effluent for a design annual average daily flow of 75,700 m3/d (20 mgd) prior to the effluent being discharged to the St. Johns River. The average annual flow for the twenty two-year period (1988-2010) was 60,150 m3/d (15.9 mgd).

In part due to the sediment management undertaken, the OEW has continued to reduce phosphorus better than initial expectations. During the period of operation from 1988 through the end of 2010, the average annual total phosphorus (TP) concentration discharged from the OEW was 0.067 mg/L, below the average monthly discharge permit limit of 0.20 mg/L. One problem in maintaining the OEW's performance is the continuous deposition of organic material. In general, constructed wetlands have a finite lifespan and experience short-circuiting of flow paths, which lead to an eventual decline in treatment efficiency. Two methods that have been employed at the OEW have been the physical removal of the accumulated organic material and prescribed burning.

In the fall of 2002, after 15 years of effectively removing nutrients from reclaimed water, the OEW system had shown signs of reduced phosphorus (P) uptake performance. The accumulation of sediments and organic debris had been identified as the major factor responsible for considerable hydraulic short-circuiting, particularly near the inflow region of the wetland. In an effort to mitigate this short-circuiting and lower the phosphorus (P) concentration in the water column, the City of Orlando implemented a physical removal of the accumulated sediments. Since that first muck removal project, the City of Orlando has renovated 227 ha (561 acre) of the entire 482 ha (1,190 acre) system.

Due to the cost of physical muck removal, prescribed burning is often used as a management tool. In the OEW, prescribed burns have been used since 1994 as a mechanism to maintain the homogeneity of cattail stands and slow leaf litter deposition within the treatment cells. Prior to a burn, consideration is given to the potential release of inorganic nutrients to the water column. The effects of both sediment removal and prescribed burning on the sediment P storage and standing water P concentration will be described.

Contact Information: M.D. Sees, Orlando Easterly Wetlands, City of Orlando, 25155 Wheeler Road, Christmas, FL32709,USA, Phone 407-568-1706, Fax: 407-568-1725, Email: mark.sees@cityoforlando.net

APPLICATION OF ADAPTIVE MANAGEMENT FOR WETLAND RESTORATION: AN OVERVIEW OF A LARGE-SCALE EVERGLADES PHYSICAL MODEL

***Fred Sklar*[1]*,** *Scot E. Hagerthey*[2], *Susan Newman*[1], *Colin J. Saunders*[1], *Joel Trexler*[3], *Laurel Larson*[4], *Jud Harvey*[4], *Vic Engel*[5], *David Ho*[6], *Katie Skalak*[4], *Sue Wilcox*[7] and *Barry Rosen*[4]

[1]South Florida Water Management District, West Palm Beach, FL, USA
[2]U.S. Environmental Protection Agency, Arlington, VA, USA
[3]Florida International University, Miami, FL, USA
[4]U.S. Geological Survey, Reston, VA, USA
[5]Everglades National Park, Homestead, FL, USA
[6]University of Hawaii, Hilo, HI, USA
[7]US Army Corps of Engineers, Jacksonville, FL, USA

The Water Conservation Area 3 (WCA-3) Decompartmentalization and Sheetflow Enhancement (DECOMP) Physical Model (DPM) is a large, field-scale project that is expected to address scientific, hydrologic, and water management uncertainties specific to the Comprehensive Everglades Restoration Plan (CERP) DECOMP project. The DPM utilizes a temporary controllable water conveyance structure to test water depth, hydroperiod, sheet flow, and canal backfilling on landscape scale issues of faunal connectivity and on the health and sustainability of the ridge and slough landscape. Hydrological, ecological and water management uncertainties of DECOMP will be addressed using a before-after-control-impact (BACI) statistical design. The DPM will flows will be managed by ten large-diameter culvert barrels with a combined flow capacity of 750 cubic feet per second (21,237 liters/sec). In addition, a 900 meter gap will be created in a levee downstream of the structure, allowing water to flow from WCA-3A into WCA-3B, a part of the Everglades that has not experienced surface sheetflow for the last 50 years. Material excavated to create the gap will be used to construct backfill treatments in the adjacent canal. A 300 m section of canal will be backfilled to grade, i.e., surface land elevation,, a 300 m section of cannal will be partially backfilled, and the final 300 m will have no backfill. The DPM will produce a range of surface water velocities and "flow fields" in a marginally degraded portion of the natural system in order to verify the critical velocity threshold necessary to entrain and redistribute particles and nutrients in the landscape, and assess the hysteresis, maintenance and creation of ridge and slough microtopography. The details of the monitoring program of this fundamental adaptive management experiment will highlight how to assess the ecological importance and benefits of sheet flow for restoring the uniquely "corrugated" landscape pattern of the Everglades.

Contact Information: Fred Sklar, Everglades Systems Assessment Section, South Florida Water Management District, P.O. Box 24680, West Palm Beach, FL 33416-4680, USA, Phone: 561-682-6504; Email: fsklar@sfwmd.gov

COMPARISON OF EVERGLADES RESTORATION WITH OTHER LARGE-SCALE ECOSYSTEM RESTORATION PROGRAMS IN THE UNITED STATES

Tom St. Clair*, Eliza Blue Hines* and *Rebecca Burns*
Atkins North America Inc., Jacksonville, FL, USA

The Comprehensive Everglades Restoration Plan (CERP) is the largest ecosystem restoration program currently being undertaken in the United States. The size and complexity of the south Florida natural system makes Everglades unique, yet other systems have suffered similar degradation and are in need of restoration. Since passage of the enabling legislation for CERP other restoration programs have been conceived, authorized and several are in various stages of implementation. In fact, one restoration program has been active since the mid-1980s and offers many lessons learned for other restoration/recovery efforts. While each large-scale restoration is unique they also many common attributes, such as the uncertainty of how best to restore an impaired ecosystem to pre-existing functionality. The purpose of this presentation is to compare CERP to five other large-scale programs, including:
Missouri River Recovery
Louisiana Coastal Area
Bay Delta in California
Chesapeake Bay
Great Lakes

These restoration programs will be compared and contrasted based on a number of topics pertinent to large-scale restoration and include:
Authorization
Governance structure
Lead agency(s)
Funding
Geographical scale
Implementation strategy
Restoration objectives/targets
Indicators
Science – monitoring and assessment programs

<u>Contact Information</u>: Tom St. Clair, Atkins North America Inc., 7406 Fullerton Street, Suite #350 Jacksonville, FL 32256, USA, Phone: 904-363-8441, Fax: 904-363-8811, Email: tom.stclair@atkinsglobal.com

SPATIAL MODELING OF LAND CHANGE AND RELATIVE ELEVATION TO ASSESS RESTORATION PRIORITIES IN COASTAL LOUISIANA

Gregory D. Steyer[1], *Brady R. Couvillion*[1], *Hongqing Wang*[1], *John Rybczyk*[2], *William Sleavin*[1], *Holly Beck*[1], *Guerry O. Holm, Jr.*[3], *Yvonne Allen*[4], *Craig J. Fischenich*[5] and *Ronald G. Boustany*[6]

[1]U.S. Geological Survey, Baton Rouge, LA, USA
[2]Western Washington University, Bellingham, WA, USA
[3]CH2M HILL, Baton Rouge, LA, USA
[4]U.S. Army Corps of Engineers, Baton Rouge, LA, USA
[5]U.S. Army Corps of Engineers, Vicksburg, MS, USA
6U.S. Department of Agriculture, Lafayette, LA, USA

Louisiana is experiencing the most critical coastal wetland erosion and land loss problem in the United States. Although there are many causes for this loss, reductions in freshwater and sediment inputs coupled with high subsidence rates are key factors. In order to develop priorities for restoration and protection efforts, Louisiana's 2012 Coastal Master Plan utilized a suite of models to assess landscape response under future conditions with and without further restoration and protection investments. We developed a land change and relative elevation model that was used to predict changes in coast-wide wetland and water acreage, landscape configuration, vertical accretion and elevation under varying scenarios of accelerated sea-level rise (SLR), subsidence and restoration projects from 2010-2060. The landscape change sub-model predicts wetland morphologic dynamics by incorporating decadal land change trends with probabilities of marsh collapse based on given changes in inundation depth and salinity regimes. The relative elevation sub-model calculates vertical accretion and organic matter accumulation from simulated mineral sedimentation rates and site-specific soil bulk density and organic matter data. Mineral sediment accumulation was derived from a coast-wide compartment-based hydrodynamic model and then spatially redistributed using a weight surface.

Bulk density and percent organic matter was calibrated among hydrologic basins and vegetation types using soil core data from Louisiana's Coastwide Reference Monitoring System (CRMS) and the Louisiana Coastal Area Science & Technology Program. Using the empirical relative elevation model, coast-wide changes in bathymetry and topography were assessed under natural and anthropogenic factors. Spatial modeling results indicated that a substantial portion of the Mississippi River Delta wetlands, under future without project scenarios, would be submerged in the next half-century under high SLR and subsidence rates. The magnitude of wetland loss varies substantially by hydrologic basin and vegetation types and is highly dependent upon the rate of subsidence. Model outputs suggest that comprehensive restoration project investments such as marsh creation, shoreline protection, ridge restoration, and freshwater diversion projects are capable of maintaining soil elevation and reducing associated land loss rates. We will provide an overview of the modeling effort including limitations and assumptions of the models and future steps for model improvements.

Contact Information: Gregory D. Steyer, USGS, National Wetlands Research Center, Coastal Restoration Assessment Branch, c/o Livestock Show Office, LSU, Baton Rouge, LA 70803 USA, Phone: 225-578-7201, Fax: 225-578-7927, Email: steyerg@usgs.gov

MANAGING ENVIRONMENTAL FLOWS TO AN AUSTRALIAN RAMSAR WETLAND, THE MACQUARIE MARSHES: FLOODING REGIMES FOR WETLAND VEGETATION

Rachael F. Thomas[1,2], *Yi Lu*[3], *Steve Cox*[2], *Sharon Bowen*[2], *Shannon Simpson*[2] and *Shiquan Ren*[1]
[1]Australian Wetlands and Rivers Centre, University of New South Wales, Kensington, NSW, Australia
[2]Office of Environment and Heritage, Sydney, NSW, Australia
[3]NSW Office of Water, Parramatta, NSW, Australia

Flood dependent vegetation of wetlands in semi- arid regions of Australia (e.g the Ramsar listed Macquarie Marshes), rely on highly variable river flows for flooding. Spatial and temporal variations of flooding maintain the health of the heterogeneous mosaic of vegetation types. In the Macquarie Marshes these broad communities include semi-permanent wetland vegetation (e.g. common reed; water couch; cumbungi), river red gum, floodplain wetland vegetation (lignum; river cooba) and coolibah–black box. Floodplain vegetation (e.g. chenopodiaceous shrubs) is terrestrial, at higher elevations surrounding the wetland.

Rivers in many semi-arid regions are regulated by dams altering flow regimes and impacting the ecological integrity of floodplain wetlands. Australia is engaged in one of the world's most ambitious river restoration programs with the restoration of environmental flows in the Murray-Darling Basin (A$12 billion), including A$3.1 billion to buy back water from the irrigation industry. Resulting environmental flows are targeted to restore ecological health. A quantitative understanding of flood dependent vegetation water requirements, such as flood frequency and inter-flood interval, is essential for successful environmental flow management. We spatially determined the flood frequencies of the mapped vegetation communities and the inter-flood interval for health categories of semi-permanent wetland (terrestrial species dominance) and river red gum (% canopy dead).

Flooding in the Macquarie Marshes was mapped from 79 Landsat Thematic Mapper satellite images between 1989-2008. Maps were spatially stacked. For flood frequency flooded pixels in each flood map were coded to one and the probability of inundation occurrence (0.01-1.00) was calculated. To determine the dry interval, flooded pixels in each map were coded to its temporal sequence (1-79) and the maximum value for each pixel was calculated and then converted to the time of no flooding prior to vegetation mapping. Using spatial analyses median flood frequencies of vegetation communities and median dry intervals for vegetation health categories were calculated. Flood variable significance among vegetation groups was determined using the Kruskal-Wallis test.

Inundation frequencies were significantly different (p value<0.0001) among vegetation communities explaining their distribution along the wet-dry gradient. Terrestrial shrubs increasingly dominated areas that were once semi-permanent wetland vegetation, indicating that their flooding requirements were not met. These areas were dry for a long time (7 years, p value < 0.0001). River red gum canopies in poor condition (>40% canopy dead) had significantly long dry intervals (7 years, p value < 0.0001). These data indicate long-term impacts of reduced flood frequency and extended dry intervals. Results can be used to develop targets for environmental flow management and restoration.

Contact Information: Rachael Thomas, Australian Wetlands and Rivers Centre, School of Biological, Earth and Environmental Sciences, University of New South Wales Sydney NSW 2052, Phone: +61 2 425260223, Email: rachael.thomas@environment.nsw.gov.au

TWENTY-SIX YEARS OF CHANGING VEGETATIVE COVER AND MARSH AREA

Michael S. Kearney[1] and *J. C. Alexis Riter*[1] and ***R. Eugene Turner***[2]
[1]University of Maryland, College Park, MD, USA
[2]Louisiana State University, Baton Rouge, LA, USA

The State of Louisiana is committed to building diversions as the best way to “reconnect the river to the deltaic plain”, reasoning that the greater freshwater influx would lower salinity, and increase accretion and plant vigor because of the higher suspended sediment and nutrient inputs. A modeling study, however, suggests that the collapse of weakened marsh plants during Hurricane Katrina compromised their ability to mitigate storm surge flooding of New, implying that storm damages will be worse if a projected increase in intense hurricanes from climate change is realized.

The effectiveness of river diversions to mitigate marsh loss has not been quantitatively evaluated. Three major diversions, Caernarvon, West Point a la Hache, and Naomi, were in operation since the early 1990s, however, and provide an opportunity to assess trends in plant condition and total marsh area before and after diversions began. The Caenarvon diversion is more directly influenced by the Gulf of Mexico through Breton Sound than are the smaller Naomi and West Point a la Hache diversions, and has a substantially greater river freshwater inputs. We used Landsat Thematic Mapper imagery in a spectral mixture model developed in studies of low salinity, microtidal marshes, which was cross-referenced with comparisons from aerial photography, to analyze changes in marsh vegetation cover and total marsh area since 1984 for these three diversions. The inherently wide geographic capture of changes afforded by high resolution satellite imagery provide a spatial and temporal perspective on the conflicting ideas about the efficacy of diversions to restore marsh.

The evidence indicates that diversions not only fail to conserve mature brackish and tidal freshwater marshes, but disrupt plant physiology in ways that endanger individual plant vigor and overall marsh survival. We believe that the three freshwater diversions failed to increase vegetation health or area because of the physiological consequences of high nutrient flux and greater flooding of marsh plants. The agricultural literature has established that N loadings of as little as 30 kg ha-1 can cause severe lodging (stem collapse) and low root growth in cereals (i.e., graminoids. Recent (2002) estimates of the annual nitrate and total N inputs at the Caernarvon diversion range from 2-5 million kg (45-114 kg ha-1), and 3-7 million kg (~68-159 kg ha-1), respectively. Fertilization of brackish marshes would promote lower rhizome and root biomass, accelerated decomposition rates, and stems vulnerable to collapse (lodging) from high winds [Resio and Westerink, 2008]. In fact, research on Louisiana wetland vegetation documented shallow and limited rooting in Spartina alterniflora, resulting in weak substrate structure and shear strength. Moreover, nitrogen additions to freshwater wetlands enhance carbon losses.

Ultimately, the scientific basis for river diversions needs to be more convincing before embarking on a strategy that may result in marshes even less able to survive hurricanes.

<u>Contact Information</u>: R. Eugene Turner, Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, LA 70803, USA, Phone: 225-578-6454; Fax: 225-578-6326; Email: euturne@lsu.edu

ANALYSIS OF LAND USE, HYDROLOGY, AND WATER QUALITY OF BENEFICIAL REUSE FOR NATURAL SYSTEMS RESTORATION

R. Vazquez-Burney[1], *J. Bays*[1], *M. Hancock*[2], *K. Kenty*[1], *J. Harris*[3]
[1]CH2MHILL, Tampa, FL, USA
[2]Southwest Florida Water Management District, Brooksville, FL, USA
[3]Pasco County, FL, USA

The Southwest Florida Water Management District (SWFWMD) and Pasco County, FL are investigating the use of reclaimed water from the Pasco County Master Reuse System (PCMRS) to recover and enhance water resources in Pasco County. The feasibility of using constructed wetlands, natural wetlands, infiltration basins, and upland application systems to enhance hydrologic systems has been investigated. Implementation of these projects could provide benefits to hydrologically altered water resources, create habitat and recreational facilities, and increase water reuse opportunities within the region.

These efforts included innovative applications of the United States Department of Agriculture (USDA) Soil-Plant-Air-Water (SPAW) model combined with the use of Kadlec and Wallace's pkC* wetland treatment model to establish expected ranges of water level restoration to both constructed wetland and natural wetland systems while ensuring that water quality would not be adversely affected. Two main projects were evaluated.

The Central Pasco County Beneficial Water Reuse Project considered the construction of approximately 1,000 acres of treatment/infiltration wetlands sized to: 1) reduce nitrogen to background concentrations; 2) maximize the area of recharge; 3) maximize wetland habitat diversity; and 4) minimize disposal facilities. Any outflow produced from the constructed wetland system would be conveyed to either land application systems or to hydrologically-altered natural wetlands. Detailed screening analysis using Geographical Information System (GIS) data was conducted to identify areas comprised of single or multiple large properties with the most suitable physical and hydrological characteristics for the implementation of constructed wetlands and land application systems. Infiltration from the constructed wetlands would be designed to balance the need to sustain wetland communities while contributing to the recharge of surficial and Floridan aquifers. Any alternative would be required to meet the County's proposed total maximum daily load (TMDL) requirements, a critical project constraint.

The Crews Lake Natural Systems Restoration (CLNSR) project involves the use of reclaimed water from the PCMRS to recover and enhance natural aquatic ecosystems and increase water reuse capacity for Pasco County. Crews Lake was included on the SWFWMD list of stressed lakes in 1991 because of its chronically low water levels. Earthen berms constructed decades ago functionally subdivide this shallow lake into North and South Basins and alter the lake's hydrology. Planning-level results of a feasibility study of the use of natural wetlands in the North Basin of Crews Lake as treatment or receiving wetlands singly or in combination with constructed infiltration wetlands for the reuse of reclaimed water and restoration of lake water levels were developed. Predicted wetland outflow concentrations were compared to existing and proposed numeric water quality. Restoration of dehydrated wetlands within the hydrologically altered lake provides a solution that balances the critical need for treatment and disposal of excess reclaimed water, a rejuvenation of water levels and public use of the lake and an assurance of continued lake water quality.

Contact Information: Rafael Vazquez-Burney, CH2MHILL, 4350 W. Cypress St, Tampa, FL 33607, USA. Phone: 813- 281-7766, Fax: 813-374-3056. Email: Rafael.Vazquez-Burney@ch2m.com

FORECASTING VEGETATION CHANGES IN COASTAL LOUISIANA

Jenneke M. Visser[1]*, Scott Duke-Sylvester*[1]*, Jacoby Carter*[2] and *Whitney Broussard*[1]
[1]University of Louisiana at Lafayette, Lafayette, LA, USA
[2]U.S. Geological Survey, Lafayette, LA, USA

As part of the planning effort for coastal restoration and protection by the Coastal Protection and Restoration Authority of Louisiana, a vegetation model (LaVegMod) was developed to forecast vegetation changes resulting from restoration and protection actions for three uncertainty scenarios over a 50 year period. LaVegMod takes input on water-level and salinity forecasted by a hydrology model as well as changes in the area of land and elevation forecasted by a morphology model. Based on these inputs and the environmental niche for each vegetation type, LaVegMod forecasts changes in vegetation composition over time. There is a feedback between these models at 25 year intervals. LAVegMod output is used by the storm surge model to incorporate a surface roughness parameter and by higher trophic level models to estimate the changes in ecosystem services derived from the coastal zone. Instead of the four salinity zone model used in previous planning efforts, LaVegMod uses 17 vegetation classes that show the different height and habitat characteristics needed as inputs for subsequent models. In addition the model forecasts the presence of submerged aquatic vegetation (SAV) based on water depth, salinity and temperature during the summer months. The emergent vegetation model is informed by an analysis of the Coastwide Reference Monitoring System and the SAV model is informed by a previous survey of SAV presence and environmental data. Based on water level variability and salinity that occurred during a year, the model predicts a mortality percentage of the existing emergent vegetation types and the hydrology in the subsequent year determines which new vegetation type will establish. Changes in vegetation from the future without action results are compared with projects and alternatives evaluated for Louisiana's 2012 Coastal Master Plan.

Contact Information: Jenneke M. Visser, School of Geoscience, University of Louisiana at Lafayette, PO Box 44650, Lafayette, LA 70504 USA, Phone: 337-482-6966, Fax 337-482-5395, Email: jvisser@louisiana.edu

SHORT-TERM MODELING OF COASTAL RESPONSE TO WAVE CLIMATE AND RELATIVE SEA LEVEL RISE

Ioannis Georgiou[1], *Zoe Hughes*[2], ***Dallon Weathers***[1], *Mark Kulp*[1] and *Duncan FitzGerald*[2]

[1] Dept. of Earth and Environmental Sciences, and Pontchartrain Institute for Environmental Sciences, University of New Orleans, New Orleans LA, USA

[2] Dept. of Earth Sciences, Boston University, Bostom, MA, USA

Coastlines in southwest Louisiana have been eroding at an alarming rate in response to tropical storms (Martinez et al. 2009; Howes et al. 2010), interior wetland loss (Barras et al. 2006; Couvillion et al. 2011) and resulting enlargement of the tidal prism (Howes, 2009; FitzGerald et al. 2007), and due to high rates of relative sea level rise (cite). To aid the State of Louisiana in efforts to address coastal restoration at a coast wide level, we developed modeling tools to help determine the future morphology of barrier islands and coastlines throughout southeast Louisiana. The effort was focused on barrier shorelines. We used a hybrid method utilizing a one-dimensional cross-shore shoreline modeling and profile evolution, coupled with a plan-form evolution of the coast wide shoreline. The model was driven with offshore wave climate, transformed through breaking near the shoreline. We used a losngshore transport formula and subsequently a sediment continuity approach to determine local fluxes and resulting erosion. The plan-form resolution is of the order of 100 m and the cross-shore resolution is significantly less. In addition to offshore wave climate, the model was driven with relative sea level rise. After calibration using historic shorelines of 1989 through 2009, the model was used to simulate the barrier islands and adjacent shorelines response to a series of scenarios of eustatic sea level rise, subsidence, and a variety of restoration projects pre-selected by the State. Results show that erosion rates without restoration can vary throughout the coast both spatially and temporally, as well as a function of relative seal level rise. Erosion rates for the central coast are of the order of 3 m/year, while near headlands and towards the Mississippi river delta, can reach up to 9 m/year. The predicted rates for more extreme sea level rise scenarios reveal at least a 10 - 15 % increase of the erosion rate per annum, but more importantly, barrier erosion truncates the entire back-barrier platform. This takes place at 35 – 40 years under normal conditions, but is reduced to 25 – 30 years under more extreme sea level rise scenarios, suggesting first that a new transport regime or threshold maybe present, and suggesting that restoration to keep up with sea level rise is critical.

Contact Information: Ioannis Georgiou, Dept. of Earth and Environmental Sciences, 2000 Lakeshore Dr., 1065 GP, University of New Orleans, New Orleans, LA, 70148, USA, Phone: 504-280-1373, Fax: 504-280-7396, Email: igeorgio@uno.edu

IS A PARTNERSHIP ENOUGH? A LOOK BACK AND LOOK AHEAD FOR A SW FLORIDA BARRIER ISLAND

Tara L. Wertz[1], *Eric C. Milbrandt*[2] and *James T. Evans*[3]

[1] J.N. "Ding" Darling National Wildlife Refuge, 1 Wildlife Dr. Sanibel, FL, USA
[2] Sanibel-Captiva Conservation Foundation, 900A Tarpon Bay Road, Sanibel, FL, USA
[3] City of Sanibel, 800 Dunlop Road, Sanibel, FL, USA

Sanibel Island, a barrier island in Southwest Florida, faces challenges common to all barrier islands, such as development pressure, hurricanes and habitat degradation. Through a progressive and comprehensive land use code and strong community support, our partnership has planned, coordinated, researched, and completed several restoration projects. Early partnership efforts begun in the 1980s focused on exotic removal and fire management, while more recent efforts included mangrove shoreline, oyster reef, and hydrologic restoration projects. Through the establishment of restoration success benchmarks and monitoring, we have demonstrated the sustainable recovery of ecological structure and function that translates into ecosystem services. These principles are exchangeable regardless of habitat type (e.g. marine, marsh), and we will present several examples. The federal, nonprofit, and city partnership has many advantages including pooling of local resources, translating the science and restoration practices to island residents through different venues, and bringing expertise and flexibility to our projects. We will also provide examples of how the social fabric, value system and the island's tourism-based economy reacts to functional or structural changes to the landscape and seascape. These lessons learned will be demonstrated through several examples specific to Sanibel Island, but are widely applicable to other barrier islands in Florida and throughout the Gulf of Mexico. The hurricane seasons of 2004-5 presented many difficult challenges for the island, including poor water quality, habitat degradation, and much controversy on the best course for post-hurricane restoration. For example, the general public adamantly supported the removal of woody debris from fringing mangrove ecosystems despite research which overwhelmingly demonstrated that woody debris benefits mangrove seedling recruitment and soil stability . Water quality has generally improved due to a better understanding of pollutant sources from the monitoring activities associated with hydrological and habitat restoration projects. Despite these accomplishments toward a self-replicating, fully functional landscape and seascape, we still have many current and future projects identified and prioritized for 2012 and beyond.

Contact Information: Tara Wertz, US Fish and Wildlife Service, 1 Wildlife Dr, Sanibel, FL 33957, USA, Phone: 239-472-1100, Email: tara_wertz@fws.gov

IF YOU RESTORE IT, WILL THEY COME? FUNCTIONAL RESTORATION TRAJECTORIES IN A SOUTHERN CALIFORNIA WETLAND

C.R. Whitcraft, *B.J. Allen* and *T. Champieux*
Biological Sciences Department, California State University Long Beach, Long Beach, CA USA

In an effort to reclaim degraded wetland habitat, the Huntington Beach Wetlands Conservancy restored tidal influence to three marshes (Talbert, Brookhurst, and Magnolia) that had been isolated from tides for almost 100 years. Talbert Marsh was restored in 1989; Brookhurst Marsh in 2009, and Magnolia Marsh in 2010. One portion of our research in these systems evaluates whether the benthic macroinvertebrate communities and trophic structure will return to a pre-disturbance state (as compared to a reference marsh). Twenty years post-restoration, Talbert Marsh resembles other natural marshes in southern California. One commonly accepted theory of marsh community succession is a trajectory from an unvegetated, microalgae and insect-dominated system to a vegetated system with a diverse invertebrate community of detritivores and insects. Given that Brookhurst and Magnolia were restored as a vegetated marsh while Talbert was largely unvegetated pre-restoration, will Brookhurst and Magnolia develop in similar ways and over similar time-scales to Talbert? Within two months of tidal reintroduction, there was increased microalgal biomass and a similar invertebrate community in Brookhurst relative to Talbert, our reference marsh. Our study demonstrates the potential effectiveness of tidal restoration for California wetlands and provides Information about efficient and effective methods by which to evaluate the restoration of important marsh ecosystem functions, such as trophic support.

<u>Contact Information</u>: C.R. Whitcraft, Biological Sciences Department, California State University Long Beach, 1250 Bellflower Blvd, Long Beach, CA 90840-9502 USA, Phone: 562-985-4820; Fax: 562-985-8878, Email: Christine.whitcraft@csulb.edu

TOOLS FOR BROADER-SCALE EVERGLADES HYDROLOGIC ANALYSIS AND PLANNING

***Walter M Wilcox**, Calvin J. Neidrauer* and *Christopher W. McVoy*
South Florida Water Management District, West Palm Beach, FL, USA

The use of screening level models and aggregated basin scale performance indicators as a compliment to more traditionally used detailed modeling and evaluation tools can assist in helping to convey complex planning Information and facilitate stakeholder participation and project decision making. In south Florida, the REservoir Sizing and OPerations Screening (RESOPS) model and the Everglades Viewing Window (EVER-VIEWs) suite of evaluation tools were developed with these goals in mind.

While detailed regional hydrologic simulation models have been historically used for the analysis and planning of south Florida's water resources, these models are not appropriate for rapid testing of a broad range of alternative project sizes and operational configurations. The RESOPS model, written in Microsoft® Excel 2003, performs monthly time-step, 41-year continuous simulations of the hydrology and operations of south Florida's regional water management system. It simulates proposed reservoirs and wetland treatment areas in the general vicinity of Lake Okeechobee, but not the spatial complexity of flows and stages within the Everglades. Within one second, the RESOPS Model executes a simulation and automatically produces a wide variety of graphical and statistical summary measures of performance that can be used to quickly compare up to four test scenarios. The model also contains an optimization routine that enables selection of superior operating rules for Lake Okeechobee.

The Everglades Viewing Windows were developed based on ideas from Everglades hydrologists cooperating across a number of south Florida resource agencies with the goal of creating intuitive, dynamic visualizations of regional Everglades hydrology. The suite of windows provides visualizations of detailed hydrologic model simulations, including longitudinal and transverse transects of water depth and duration as well as measures of discharge, seepage, flow directionality and spatial variability. As model-independent tools, they facilitate direct comparison of multiple models, clearly showing the differences between the pre-development Everglades and the currently managed Everglades, as well as allowing comparisons of different restoration scenarios.

The RESOPS and EVER-VIEWs tools have proven successful in two highly interactive public planning processes: the "River of Grass" and the "Central Everglades Planning Project" efforts, allowing for greatly increased public understanding of key differences between original and current Everglades conditions and the ability to quickly and meaningfully visualize potential planning scenario outcomes. Short simulation times facilitated rapid response to planner, stakeholder and public input and built trust in agency efforts. In combination with other, more traditional and detailed assessment tools, the RESOPS and EVER-VIEWs tools allowed projects to be planned with strong and real stakeholder and public engagement, yet without sacrificing overall planning objectives and timelines.

Contact Information: Walter M Wilcox, South Florida Water Management District, 3301 Gun Club Road, West Palm Beach, FL, 33406 USA, Phone: 561-682-2527, Fax:561-682-2027, Email: lwingard@usgs.gov

ENGINEERING-ORIENTED PLANTATION AND MECHANICAL HARVESTING OF AQUATIC PLANTS IN WATER BODY RESTORATION ENGINEERING

Fuxing Zou and *Jianping Li*
Biosystem Engineering and Food Science School, Zhejiang University, Hangzhou, China

Aquatic plants have significant effects in water purification and restoring polluted water body. In water body restoration engineering, to select and cultivate several kinds of aquatic plants those are highly effective in water body restoration and plant them in polluted water or artifical wetlands to absorb nitrogen and phosphorus to purify water, has been proved to be a feasible way. Aquatic plants grow very fast, so special harvesting machines for regular harvesting are necessary. However, aquatic plants need to be reused for years, and it's living environment is special, so plants can't be planted disorderly and cut destructively like that in natural water bodies. Engineering-oriented plantation of aquatic plants is important for promoting overall management and mechanical harvesting to support the water body restoration function of aquatic plants. Utilization of aquatic plants, together with specially made harvesting machines–as an effective method for water pollution treatment, is being carried out in several cities in Zhejiang province, China.

Contact Information: Fuxing Zou, D753, Biosystem Engineering and Food Science School, Zhejiang University, Hangzhou, China, Phone: 86-571-88982939, Email: fuxing_zou@yahoo.com.cn

ECOSYSTEM RESTORATION - MONITORING AND ASSESSMENT

MANGROVE RESTORATION EXPERIENCE IN YUCATAN PENINSULA: THE APPROACH AND RESULTS

J. A. Herrera-Silveira[1], [1]Arturo Zaldívar Jiménez, [1]Claudia Teutli Hernández, [1]Rosela Pérez Ceballos, [1]Juan P. Caamal-Sosa, [1]Teresa Andueza Briceño, [1]Tomas Zaldívar Jiménez, [1]Ricardo Ortegón, [2]Adriana Hernández, [2]Mario Méndez, [2]Gabriel Benavides, [3]Jose Luis Andrade, [3] and *Isaac Castillo*
Presented by: ***Maria Fernanda Adame***
[1]CINVESTAV-IPN Unidad Mérida, Km 6 Antigua Carretera a Progreso, Mérida, Yucatán, Mexico.
[2]SEMARNAT-Delegación Yucatán, Mexico
[3]Centro de Investigación Científica de Yucatán, Mexico

Yucatán's mangroves have been object of different kind of impacts, highlighting the land use changes for urban and tourist developments, where highways and ports have been the major causes of loss coverage. That is why many attempts to recover mangrove were carried out since 90´s, however, this were done without the ecological and technical basis. Therefore, a multidisciplinary group is developing a program of ecological restoration in 9 locations in the state of Yucatan (SE, Mexico). This program is based on the following steps: 1) Forensic Ecology (determination of the causes of mangroves death; 2) characterization of hydrological, sediment and vegetation of the site to be restored; 3) proposal and implementation of specific actions as: hydrological rehabilitation, dredging or construction of wells, removal of sediment, dispersal centers, construction and maintenance of flow channels; 4) establishment and monitoring of success indicators at different temporal scales, 5) binding and socialization of restoration project to the local groups. In all locations has been observed recovery symptoms as salinity interstitial reduction, hydroperiod restored, seedling establishment and growth, recovery vegetation cover without being required reforestation. The success of social and environmental benefits of this program is serving as a model to adapt in other states of the Gulf of Mexico.

Contact Information: J.A. Herrera-Silveira [1]CINVESTAV-IPN Unidad Mérida, Km 6 Antigua Carretera a Progreso, Mérida, Yucatán, Mexico. Phone: 52-999-9429462,Email:jherrera@mda.cinvestav.mx

INNOVATIVE RESTORATION METHODS FOR DITCHED SALT MARSHES: TECHNIQUES AND PERFORMANCE MEASURES

Susan C. Adamowicz[1], *Geoff Wilson*[2], *Jonathan Franklin*[3], *Britt Argow*[4] and *Zoe Hughes*[4]
[1]Rachel Carson National Wildlife Refuge
[2]Northeast Wetland Restoration
[3]Dalhousie University
[4]Boston University

Most East Coast salt marshes have been ditched since Colonial times either for salt haying or mosquito control. These ditches drain both surface and subsurface water from the marsh in order to increase salt hay production or reduce mosquito-breeding areas. One consequence of ditching is the loss of surface water habitat suitable for waterfowl, wading birds and shore birds as well as fish and crustaceans. Other consequences include changes in vegetation community structure.

Previously used techniques such as ditch plugging and OMWM have not reduced sediment sinks or other attributes that can decrease salt marsh resilience to sea level rise. Waters impounded by ditch plugging further degrade marshes through increased pore water sulfides, reduced soil bulk density and increased soil percent organic matter. Sites with natural tidal creek hydrology more closely resemble open ditch sites or are intermediate between open ditch and plugged sites.

We developed an innovative approach to restore ditched salt marshes. “Ditch remediation” uses local materials to build peat within the ditch itself. Preliminary findings of changes in groundwater table levels, marsh surface and in-ditch vegetation from 2010 – 2011 will be presented. Closing ditches through peat formation is a longer-term process aimed at restoring sheet flow conditions, i.e. the marsh platform.

Removing ditch hydrology, however, does not restore a site to a natural condition. Redfield (1972) aptly noted that ditch hydrology replaced natural tidal channel hydrology. Here we discuss modeling efforts aimed at providing restoration professionals with a design template for creating channels that will mimic tidal creeks found in the vicinity of a potential restoration site.

Climate change and accelerated sea level rise have been “game changers” for salt marsh management and restoration. Previously, performance criteria concerned only narrow goals (invasive species control, mosquito production). Now, long-term success must also be measured according to a site’s ability to maintain or increase its resilience to sea level rise and other climate change stressors. We review some metrics that may be used in such performance criteria.

Contact Information: Susan Adamowicz, US FWS, 321 Port Rd, Wells, ME, USA 04090; PH: 207-646-9226, Email: susan_adamowicz@fws.gov

NORTHERN PRAIRIE WETLAND ASSESSMENT AT MULTIPLE SPATIAL SCALES.

Suzanne Bayley[1], *Irena Creed*[2], *Matt Wilson*[1] and *Rebecca Rooney*[1]
[1]University of Alberta, Edmonton, AB, T6G 2E9, Canada

Over 70% of the wetlands in the northern edge of the prairies have been lost to agricultural development and urban development is destroying the remnants. The province of Alberta lags far behind US jurisdictions in the protection and management of wetlands. This has enabled us to build from the ground up on the three-tiered foundation developed in US jurisdictions and to implement a more advanced policy. We created a comprehensive monitoring and assessment framework that can yield highly accurate intensive estimates of health from site-visits as well as coarser resolution regional estimates of health, useful for land use planning and the identification of restoration and conservation priorities.

We began at a site specific intensive level, using 81 wetlands that spanned a gradient of human disturbance to develop a physical/chemical disturbance gradient and an index of biotic integrity (IBI) based on vegetation and song birds that responded closely to the disturbance gradient. The plant-IBI was developed in the wet meadow zone of natural permanent and semi-permanent prairie wetlands and constructed wetlands. After assessing numerous plant-based metrics, 4 responded most closely to the physical/chemical disturbance gradient (r2=.68) and were non-redundant. Wetland dependent songbirds were also significantly correlated to the disturbance gradient (r2=.59). The songbird-IBI was also significantly correlated to the plant-IBI (r2=.57) suggesting that the wet meadow zone plants can also be used to predict the health of the breeding songbird community.

Although intensive IBI assessments provide reliable and accurate estimates of wetland health, they are too expensive to implement at the regional scales necessary to inform land-use planning. We therefore scaled our plant-IBI up by converting its component metrics into variables that could be measured using remotely sensed data. For example, one of the most important metrics in the IBI was the width of the wet meadow vegetation zone. Using aerial photographs and remote sensing (SPOT imagery) we found a strong correlation between the width of the wet meadow zone measured in the field and its estimate by remote sensing (r2= .83). Extrapolation to the broader sub watershed permitted us to estimate wetland health across the entire sub-watershed.

We also contrasted the IBI scores derived from the 81 sites with landscape composition metrics derived from surrounding land use. We tested a suite of GIS based landscape metrics (11 land covers and road density) in buffers around each wetland ranging from 100m to 3 km in radius. Using backwards stepwise selection, we found a very good correlation (r2= .82) between disturbance in the 100m buffer (as based on road density, % undisturbed land, % built up area) and the plant-IBI. Similarly, we found a good relationship (r2=.70) between the songbird IBI and the landscape disturbance metrics within a 500 meter buffer.

Together these provide a comprehensive suite of tools that can be implemented at local and regional scales to assess health of natural and constructed wetlands for land use planning and to assess restored and constructed wetlands for compensation.

<u>Contact Information</u>: S.E. Bayley, B217 Biological Sciences Bldg. University of Alberta, Edmonton, AB, T6G 2E9, Canada, Phone: 780-492-4615, Fax: 780-492-9234, Email: sbayley@ualberta.ca

SCALE IN THE USE OF CONTINUOUS RECORDING DATA AND THE EFFECTS OF GROUNDWATER ON THE COASTAL WETLANDS AND BISCAYNE BAY

***Sarah Bellmund*[1]**, *Herve Jobert*[2], *Gregory Garis*[1] and *Diana Aranda*[1]

1Biscayne National Park, Homestead Florida, USA

2 Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami Florida, USA

Biscayne National Park has been collecting continuous conductivity, temperature, and depth data in fifteen minute intervals for the last 7 years at 34 sites. The Miami-Dade County Department of Environmental Resources Management (MDDERM) has been collecting the same data along with additional water quality parameters monthly for more than thirty years. When these data sets are compared it is possible to determine the relative effects of aggregation of data on the resulting statistics. As data is aggregated to longer periods, resolution and variability are lost. Variability is important to the biota both in a positive and negative way. In the current Biscayne Bay restoration it is some of these isolated or unusual events that are targeted to be increased as an ecological benefit. However, when data is aggregated to longer intervals, these unusual events become difficult to see or are lost in the analysis. Using the intensive National Park Service data set it is clear that when salinity is variable this is generally not captured in the longer term monthly synoptic data. In reviewing the highly variable salinity data of Biscayne Bay, salinity changes that happen over a period of hours or days are lost in the longer term monthly data set. This is especially important in applying the salinity data to the coastal wetlands to understand the necessary freshwater inflows that result in these salinity patterns. Groundwater is important to both the coastal wetlands and the coastal estuarine areas. The effects of groundwater are best seen with the intensive data set.

Contact Information: Sarah Bellmund, Biscayne National Park, 9700 SW 328th St. Homestead, FL 33033 USA; Phone (786) 335-3624; Fax (305) 230-1190; email: sarah_bellmund@nps.gov

ECOLOGICAL VALUE OF RESTORED WETLANDS IN NORTHERN NY: AN ASSESSMENT OF WETLAND QUALITY USING BIOLOGICAL INDICATORS

Tom A. Langen and ***Catherine E. Benson***
Clarkson University, Potsdam, NY, USA

Wetland restoration is a conservation tool used by government agencies and non-profit organizations to compensate for past and present losses of wetland habitats. There are 2 federal programs that restore wetlands on private property: the U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program (PFWP) and the National Resource Conservation Service Wetlands Reserve Program (WRP). These programs provide landowners with incentives to restore and protect wetland habitats. Currently, the largest number of public-private partnership wetland restorations in the nation is found in the St. Lawrence Valley of New York. While PFWP and WRP restorations can be considered successful in terms of area of wetland restored, uncertainties exist regarding the long-term sustainability and ecological value of these programs.

The objective of our research is to assess whether PFWP and WRP wetland restorations are meeting their goals of providing habitat for wetland-dependent species, using animal and plant communities as biological indicators of wetland quality. We have evaluated the species richness and composition of amphibian, bird, fish, reptile, and plant taxa at 34 PFWP and WRP restorations and 16 natural reference sites. The richness and abundance of amphibians and fish did not differ between restored and natural wetlands. However, turtle abundance and the richness of snakes and wetland-dependent birds were higher at natural reference sites. We observed a greater coverage of wetland plants at natural wetlands, although coverage by invasive plants did not differ between wetland types. We conclude that while restorations provide valuable habitat for wetland-dependent species, richness and abundance of biological indicators are often higher at natural reference sites. We are currently examining how method of restoration, age, and surrounding landscape features (land-use, wetland connectivity) affect wetland community structure; this research has direct management implications for wetland restoration policy and practice.

Contact Information: Catherine E. Benson, Department of Biology, Clarkson University, Box 5805, Potsdam, NY 13676, Phone: 315-268-7933, Fax: 315-268-7118, Email: bensonce@clarkson.edu

SITE OCCUPANCY OF ANURANS IN THE ARTHUR R. MARSHALL LOXAHATCHEE NATIONAL WILDLIFE REFUGE: DEVELOPMENT OF A MONITORING PROTOCOL

Ryan L. Lynch[1], *Frank J. Mazzotti*[1], ***Laura A. Brandt***[2], *Wiley Kitchens*[3], *J. Hardin Waddle*[4] and *Ikuko Fujisaki*[1]

[1] University of Florida, Ft. Lauderdale Research & Education Center, Davie, FL, USA
[2] U.S. Fish and Wildlife Service, Ft. Lauderdale Research & Education Center, Davie, FL, USA
[3] University of Florida, Department of Wildlife Ecology, Gainesville, FL, USA
[4] U.S. Geological Surveys, National Wetlands Research Center, Lafayette, LA, USA

In attempt to reverse recent and widespread negative trends observed in plant and animal communities of the Everglades, one of the world's largest ecosystem restoration efforts is now underway in south Florida. Known as the Comprehensive Everglades Restoration Plan, the effort comprises of more than 60 components across 16 counties, and is scheduled to span 30 years and cost over $10 billion dollars. An important component of the plan is an adaptive management process that is used to document and assess the success of the restoration efforts. The monitoring of ecological indicator species is one method currently being utilized as part of the assessment process. Because of their high sensitivity to environmental stressors, particularly those relating to hydrological life history requirements, amphibians have been selected as a group of particular interest for use as indicators of ecological health in the Everglades.

In the present study I developed a monitoring protocol for anurans based on recent advances in site occupancy models, and conducted the first large-scale survey of anuran species in the Arthur R. Marshall Loxahatchee National Wildlife Refuge. The Refuge provides habitat for a diversity of anuran species, and occupancy rates of modeled species were extremely high across the entire center of the Refuge interior. Little evidence was found for the importance of either hydroperiod or the time since last herbicide application in effecting site occupancy of the modeled species in the sampling frame, however, further research is needed to confirm these findings on a larger scale. Detection probabilities for two of the species modeled were relatively low, suggesting that minor adjustments to the study design are necessary in order to improve parameter estimates during future surveys. The results of this research support the use of amphibians as indicators of ecosystem health, and provide a framework for future monitoring efforts in the Refuge. The continued monitoring of anurans across the Refuge landscape, and across the Everglades as a whole, will ensure that the goals and objectives of the Comprehensive Everglades Restoration Plan are being met as a result of the management practices enacted.

Contact Information: Laura A. Brandt, U.S Fish and Wildlife Service, Ft. Lauderdale Research & Education Center, 3205 College Ave., Davie, FL, USA 33314, Email: Laura_Brandt@fws.gov

SPATIAL ECOLOGY OF THE AMERICAN ALLIGATOR (*ALLIGATOR MISSISSIPPIENSIS*) AND AMERICAN CROCODILE (*CROCODYLUSACUTUS*) IN ESTUARINE AREAS OF EVERGLADES NATIONAL PARK

S. Michael Cherkiss[1]*, Kristen M. Hart*[1]*, Frank J. Mazzotti*[2]*, Brian M. Jeffery*[2]*, Jeff Beauchamp*[2] and *Edward J. Larrivee*[2]

[1]U.S. Geological Survey, Southeast Ecological Science Center, Fort Lauderdale, FL, USA
[2]University of Florida, Fort Lauderdale, FL, USA

Florida Bay has undergone a number of changes that have caused a greatdeal of concern for the health of this ecosystem. Efforts are underway to improve Florida Bay and adjacent estuaries. Alternatives for improving water delivery into South Florida estuaries may change salinities, water levels, and availability of nesting habitat in receiving bodies of water.Alligators and crocodiles are among top predators within the Greater Everglades ecosystem; these speciesintegrate biological impacts of hydrological operations, which affectthem at all life stages through (1) food webs, (2)diversity and productivity, and (3) freshwater flow. Responses of crocodilians are directly related to suitability of environmental conditions and hydrologic change. Correlations between biological responses and environmental conditions contribute to an understandingof species' status and trends over time and how they utilize available habitats. Studies of movements that quantify home ranges are vital to understand spatial requirements for individuals within the population. The purpose of our study was to determine home range and core-use areas for crocodiles in Northeast Florida Bay and Cape Sable, and for alligators in the Shark River. We used kernel density estimation with site-fidelity tests to quantify spatial habitat-use patterns over time. This Information is important for understanding population processes and life history characteristics, and for designingeffective conservation and management strategies. This study complements our long-term mark-recapture data-set on both species. With mean tracking periods >106 days for 9 adult crocodiles, we found habitat-use patterns of several individuals included areas not surveyed during our regular capture activities. Individuals traveled relatively low distances from capture and tagging sites, with 5.3 km mean displacement values. Core-use areas (i.e., 50% kernel density estimate) for six crocodiles with long-term data ranged from 51.6 to 155.2 km2 (mean ± 1SD = 86.8 ± 40.0 km2) and were located within the boundaries of Everglades National Park. Tracking of both species is on-going, and will result in a better understanding of areas used intensively by crocodilians in the Greater Everglades.

Contact Information: S. Michael Cherkiss, US Geological Survey, Southeast Ecological Science Center, Fort Lauderdale, FL 33314, USA, Phone: 786-258-1409, Fax:954-475-4125, Email: Mcherkiss@usgs.gov

DETERMINING CHANGES IN HYDROLOGIC BEHAVIORS IN THE FLORIDA EVERGLADES

Paul A. Conrads[1] and *Stephen T. Benedict*[2]
[1]USGS South Carolina Water Science Center, Columbia, SC, USA
[2]USGS South Carolina Water Science Center, Clemson, SC, USA

The ecological community structure of the Florida Everglades is an expression of present and historic hydrologic conditions. The restoration of the Everglades is dependent on understanding how the ecological communities respond to temporal and spatial changes in hydrology. Small changes in seasonal and annual water levels (0.5 foot) in the Florida Everglades can have substantial changes to the ecology of the area including vegetation and water quality. The Everglades were originally a precipitation driven hydrologic system; current (2012) water levels in the Everglades respond to precipitation and the regulated flow of water through canals and marshes. There is a need by ecologists to determine periods of similar hydrologic behaviors and quantify generalized differences in water levels between these periods of different regulation and climate conditions.

Cumulative Z-scores are a useful technique to find subtle changes, or break points, in time-series data. For a given set of data, a Z-score is the measured value minus the mean value divided by the standard deviation and defines how many standard deviations the measured value is above or below the mean. Changes in the slope of the cumulative Z-scores indicate a change in the behavior, or dynamics, of the time-series data. Analysis of water levels back to 1971 in Water Conservation Area 3A (WCA3A) showed five periods where the changes in average water levels varied from -1.0 to 1.8 feet. The timing of these changes was independently confirmed through histories of the regulation schedules for operating the canal system. These results support a hypothesis that the decreases in methyl mercury are attributable to decreased availability of sulfate resulting from decreased water volumes rather than a decrease in atmospheric deposition. The technique was applied to long-term (greater than 20 years) water-level data in the Water Conservation Areas (WCAs) and the Everglades National Park (ENP). This presentation will use examples of break point analysis and compare hydrologic changes between the WCAs and ENP.

Contact Information: Paul A. Conrads, USGS South Carolina Water Science Center, Stephenson Center – Suite 129, 720 Gracern Road, Columbia SC, 29210 USA, Phone: 803.750.6140, Fax: 803.750.6181, Email: pconrads@usgs.gov

DEVELOPMENT OF A SYNTHETIC HYDROGRAPH APPLICATION TO GENERATE INPUTS TO THE EVERGLADES DEPTH ESTIMATION NETWORK (EDEN) WATER-SURFACE MODEL

Paul A. Conrads[1] and *Edwin A. Roehl, Jr.*[2]
[1]USGS South Carolina Water Science Center, Columbia, SC, USA
[2]Advanced Data Mining International, Greenville, SC, USA

The Everglades Depth Estimation Network (EDEN) has provided principal investigators and other water-resources managers with quality-assured water-surface maps for the period January 1, 1991 to the present (2012). There is interest among principal investigators and water-resource managers to use the EDEN water-surface model to generate water-surface maps for hypothetical hydrologic conditions. The use of the EDEN water-surface model for hypothetical hydrologic conditions is challenging due to the need for model inputs for over 240 monitoring sites within the freshwater domain of the Everglades. The synthetic input hydrographs must also reflect the dynamic relations of timing and magnitude between sites for the water-surface model to execute successfully. This limitation was addressed by using a sub-domain (subarea) model of the EDEN model domain and thereby limiting the number of gages for the subarea.

This approach was applied to Water Conservation Area 3A South (WCA3AS). An experimental subarea water-surface model was developed that uses 31 stations from the EDEN network to generate water-surface elevation maps for WCA3AS. A dynamic time-series clustering technique was used to group stations with similar behaviors. The results of the dynamic clustering showed three classes of water-level behaviors. For each class (or group), one monitoring station was selected as an index site and used to estimate the water-level hydrographs for the other sites in the group using linear regression and(or) artificial neural network models. These correlation models maintain the dynamic relations between the sites. To generate synthetic input hydrographs for the WCA3AS water-surface model, a user specifies the hydrographs for the three index sites and the application generates the hydrographs for the other 28 sites using the hydrograph estimation models. The synthetic hydrograph application facilitates using the EDEN water-surface model by managing the number of input hydrographs a user must compute and ensures that the dynamic relations between input stations are maintained.

<u>Contact Information</u>: Paul A. Conrads, USGS South Carolina Water Science Center, Stephenson Center – Suite 129, 720 Gracern Road, Columbia SC, 29210 USA, Phone: 803.750.6140, Fax: 803.750.6181, Email: pconrads@usgs.gov

EVERGLADES DEPTH ESTIMATION NETWORK (EDEN) PERFORMANCE-MEASURE PRODUCTS FOR THE EVALUATION OF EVERGLADES RESTORATION

***Paul A. Conrads*[1]**, *Bryan J. McCloskey*[2] and *Pamela Telis*[3]
[1]USGS South Carolina Water Science Center, Columbia, SC, USA
[2]USGS St. Petersburg Science Center, St. Petersburg, FL, USA
[3]USGS Florida Water Science Center, Jacksonville, FL, USA

Performance measures are being developed to determine conditions that are characteristic of a healthy ecosystem for use in evaluating the restoration of the Everglades. Two potential targets of a performance measure are improved sheetflow patterns and restoration of surface-water depths and duration to pre-drainage levels and the reduction of salinity fluctuations from freshwater pulses. The Everglades Depth Estimation Network (EDEN) has provided principal investigators and water-resources managers with quality-assured water levels for 300 stations for the period January 1, 1991 to the present (2012). The EDEN-derived products can provide tools for evaluating current conditions and for evaluating restoration performance measures.

One product is daily water-level duration hydrographs: a plot of water-level percentiles (based on historic daily average water level for each day of the year) against the days of a calendar year. A daily duration hydrograph can be used to statistically quantify the water level typically observed at a gaging station. In addition to the historic distribution of water level a trace of daily water level for the current year and the preceding year also are plotted on the duration hydrograph. The severity and trends of dry or wet periods at a gaging station can be determined by comparison of the current daily water-level trace on the hydrograph with the lines depicting the water-level ranges of selected historic percentiles. In addition, traces of the performance measure of restoration-targeted water level can be shown. In one plot, the current water-level condition can be evaluated with respect to the historical water-level distribution and the restoration performance measure.

A second product is current and recent salinity conditions maps and plots. Salinity data are spatially displayed with color codes for ranges of conditions for current real-time conditions or average conditions over the recent past (for example, 7-, 14-, 28-days) and the change in salinity conditions over the same time intervals. The map presentation quickly shows current salinity conditions and salinity fluctuations over the previous month at salinity monitoring sites. For individual sites, the data also is displayed in graphical and tabular formats.

Contact Information: Paul A. Conrads, USGS South Carolina Water Science Center, Stephenson Center – Suite 129, 720 Gracern Road, Columbia SC, 29210 USA, Phone: 803.750.6140, Fax: 803.750.6181, Email: pconrads@usgs.gov

WATER-LEVEL RECORD EXTENSION OF THE EVERGLADES DEPTH ESTIMATION NETWORK (EDEN)

***Paul A. Conrads*[1]**, *Bryan J. McCloskey*[2] and *Andrew M. O'Reilly*[3]
[1]USGS South Carolina Water Science Center, Columbia, SC, USA
[2]USGS St. Petersburg Science Center, St. Petersburg, FL, USA
[3]USGS Florida Water Science Center, Orlando, FL, USA

The real-time Everglades Depth Estimation Network (EDEN) has been established to support a variety of scientific and water management purposes. The expansiveness of the Everglades, limited number of gaging stations, and extreme sensitivity of the ecosystem to small changes in water depth has created a need for accurate water-level and water-depth maps. The EDEN water-surface elevation model uses data from approximately 240 gages in the Everglades to create daily continuous interpolations of the water-surface elevation for the freshwater portion of the Everglades from 2000 to the present. These maps provide hydrologic data previously unavailable for assessing biological and ecological impacts.

A need was expressed to the EDEN project team for daily EDEN water surfaces from 1990 to 2000. The additional 10 years of surfaces will provide ecologists and resources managers with two decades (1990-2011) of surfaces to analyze hydrologic dynamics. As one moves back in time from 2000, many of the EDEN gages used to generate water surfaces were not in operation. These datasets were extended to provide estimations of hydrologic time-series histories. The general approach to the record extension (hindcasts) was to 1) create a database of available data from 1990 to the present, 2) perform dynamic cluster analysis to group stations with similar hydrologic behaviors, 3) use results from the cluster analysis to select candidate explanatory variables, 4) develop linear regression and(or) artificial neural network models to extend water-level records, and 5) evaluate record extensions with model performance statistics and comparison of water-surface maps for similar hydrologic conditions from the hindcasted period (1990-1999) and measured period (2000-2011).

Contact Information: Paul A. Conrads, USGS South Carolina Water Science Center, Stephenson Center – Suite 129, 720 Gracern Road, Columbia SC, 29210 USA, Phone: 803.750.6140, Fax: 803.750.6181, Email: pconrads@usgs.gov

SUCCESSES OF RESTORATION IN GUNSTON COVE, AN EMBAYMENT OF THE TIDAL FRESHWATER POTOMAC RIVER

Kim de Mutsert and *R. Christian Jones*
George Mason University, Fairfax, VA, USA

Gunston Cove receives treated wastewater from the Noman M. Cole, Jr. Pollution Control Plant and inflow from Pohick and Accotink Creeks, which drain much of central and southern Fairfax County. As a major discharger of treated wastewater into the tidal Potomac River, particularly Gunston Cove, Fairfax County has been proactive in decreasing nutrient loading since the late 1970's. Since 1984, scientists from George Mason University have been monitoring water quality and biological communities in the Gunston Cove area. Phosphorus loadings were dramatically reduced in the early 1980's. Nitrogen loadings have also been greatly reduced in the last several years. Phytoplankton populations in Gunston Cove have shown a clear pattern of decline since 1989. The increased water clarity has brought the rebound of SAV, which provides increased habitat value for fish and fish food organisms. A lag period of 10-15 years between phosphorus control and phytoplankton decline was observed, like in many other freshwater systems, resulting at least partially from continued loading of P from enriched sediments to the water column. Another significant change in water quality has been the removal of chlorine and ammonia from the pollution control plant effluent. A decline of over an order of magnitude in ammonia nitrogen has been observed in the cove as compared to earlier years. The declines in ammonia and chlorine have allowed fish to recolonize tidal Pohick Creek. Monitoring of creek fish allowed us to observe recovery of this habitat, which is very important for spawning species such as shad. Another trend of significance to managers is changes in the relative abundance of fish species in the cove. Recent increases in SAV provide refuge and additional spawning substrate for the adhesive eggs of banded killifish (Fundulus diaphanus), which is now the most abundant species in the cove. Overall, the fish assemblage in Gunston Cove is dynamic and supports a diversity of commercial and recreational fishing activities. The onset of larger areas of SAV coverage in Gunston Cove will have further effects on the biological resources and water quality of this part of the tidal Potomac River. The nearly 30 year record of data from Gunston Cove and the nearby Potomac River has revealed many important long-term trends that validate the effectiveness of County initiatives to improve treatment and will aid in the continued management of the watershed and point source inputs.

Contact Information: Kim de Mutsert, Environmental Science and Policy, George Mason University. 4400 University Drive MSN 5F2, Fairfax, VA 22030, USA. Phone 703-993-4480, Fax: 703-993-1066, Email: kdemutse@gmu.edu

WETLAND PLANT COMMUNITY RESPONSES TO SEDIMENT REMOVAL IN THE PRAIRIE POTHOLE REGION

Shawn DeKeyser[1], *Caitlin Smith*[2] and *Cami Dixon*[3]
[1]North Dakota State University, Fargo, ND USA
[2]U.S. Fish & Wildlife Service, New Richmond, WI USA
[3]U.S. Fish & Wildlife Service, Woodworth, ND USA

We assessed the effects of sediment removal as a restoration practice on plant communities in Prairie Pothole Region wetlands to determine if this management technique is providing desired results to create conditions for ideal vegetation communities in wetlands that will benefit wildlife. The desire is to move away from basins dominated by hybrid cattail (Typha X glauca) to basins supporting species and structure found in natural wetlands of the region. Three types of wetlands were surveyed; natural (reference), excavated (treatment), and converted cropland (cattail choked). Plant community surveys were completed in the shallow marsh and wet meadow zones of seasonal wetlands. Sites were sampled using a modified Daubenmire method. Aerial photos were assessed to determine the occurrence of drawdown cycles in wetland sites. Plant community data were analyzed using non-metric multidimensional scaling and multi-response permutation procedure to make comparisons between sites. The wet meadow zones and shallow marsh zones of the three types of wetlands were all significantly different ($p<0.016$). In general, restored wetlands show vegetation trends that resemble natural wetlands, while those that have been allowed to recover without restoration tend to be cattail choked. When examining hybrid cattail specifically, visual obstruction scores were approximately four times greater in converted cropland sites versus treatment or reference sites. Vegetation composition indicates hydrologic conditions (fresh to brackish conditions) of specific sites and regional distribution are likely influential factors in wetland plant establishment.

Contact Information: Shawn DeKeyser, North Dakota State University, School of Natural Resource Sciences, NDSU Dept. 7680, P.O. Box 6050, Fargo, ND 58108-6050, USA, Phone: 701-231-7868, Fax: 701-231-7861, Email: edward.dekeyser@ndsu.edu

LINKING ECOSYSTEM METABOLISM AND PLANT SPECIES COMPOSITION THROUGH ECOLOGICAL STOICHIOMETRY

Matthew J. Cohen and ***Rachel L. Douglass***
University of Florida, Gainesville, FL USA

Ecosystem metabolism is an integrative metric of ecosystem functioning, synthesizing the relative contributions of multiple inputs, processes, and interactions; factors affecting ecosystem metabolism have been found to include light availability, temperature, and supply of available nutrients as well as organic matter supply, yet no one factor has been found to be applicable across sites. Ecological stoichiometry is a conceptual framework for unifying organisms as well as their interactions within the biotic and abiotic world through chemistry. Traditionally, ecosystem metabolism and ecological stoichiometry present two distinct lines of scientific investigation; yet merged together they have the potential to create novel insight concerning the characterization and assessment of ecosystem metabolism across systems. The development of a method to assess ecosystem function across systems will be an invaluable aid to restoration efforts. Despite extensive studies of ecosystem metabolism, to date, no studies have addressed ecosystem metabolism research from a stoichiometric perspective.

Primary producers represent the interface between the living and nonliving components of the environment. They form the base of ecosystems and perform key functions including the cycling nutrients, provision of habitat structure, and protection from erosion, as well as the supply of energy to higher trophic levels; additionally, they control ecosystem metabolism. This study sets out to address the question: what is the relationship between ecosystem metabolic stoichiometry and the dominant primary producers? First, to assess the relationship between overall ecosystem metabolic stoichiometry and that of dominant primary producers, we employed the use of high resolution, real time nutrient sensors; composite sampling of vegetative tissue; and discrete sampling of water and sediment at five sites of varying autotrophic species composition. The sites range from pristine reference condition sites to sites with only undesirable species. Next, to provide predictions regarding the relationship between ecosystem metabolic stoichiometry and the dominant primary producers in the system, a simulation model was developed which partitions ecosystem metabolism into the relative contribution of separate guilds. By illuminating how sites with differing species compositions vary in ecosystem metabolic stoichiometry and ecosystem function, this research has the potential to forge a template for stoichiometric metabolic analysis in aquatic ecosystems. This research links organismal nutrient content to the stoichiometry of ecosystem metabolism and aims to determine the effect of this link not only on the organisms themselves but on the function of the ecosystem as a whole. This synthesis of ecological stoichiometry and ecosystem metabolism will significantly contribute to the field of restoration ecology by allowing for direct comparison of function via stoichiometry across ecosystems and ecosystem types.

Contact Information: Rachel L. Douglass, University of Florida, 327 Newins-Ziegler Hall, Gainesville, FL 32611 USA, Phone: 352-846-0359, Fax: 352-846-1277, Email: rldouglass@ufl.edu

LONG-TERM DYNAMICS OF NITROGEN AND PHOSPHORUS CONCENTRATIONS IN WATERS OF A RESTORED FORESTED WETLAND

Craig Duxbury[1], Scott Davidson[2], Terry Auter[3] and Tom DeBusk[3]
[1] Walt Disney Imagineering, Research and Development, Lake Buena Vista, FL USA
[2] Thermo Fisher Scientific, Sanford, FL USA
[3] Azurea, Inc., Rockledge, FL USA

Nutrient dynamics in a hydrologically-restored forested wetland in central Florida were evaluated prior to and one year after rehydration and again after 18 years of flooding. Channelization and impoundment of an adjacent stream in the late 1960's resulted in a substantial decrease in the hydroperiod of the wetland and desiccation of the organic soils. Prior to restoration of surface water flows, we conducted laboratory incubations of flooded soil cores from the wetland in order to predict net flux of N and P from the wetland soil under flooded conditions. Results of this 32-day incubation study demonstrated an initial net flux of N, P and TOC from the soil to water column, with a subsequent decrease in fluxes by the end of the study period. These results alluded to an initial flush of nutrients of relatively short duration, from the wetland soil following rehydration.

To confirm the laboratory results, we also collected water samples for N and P along a transect across the wetland. Water samples were collected in groundwater prior to hydrologic restoration, one year after reflooding, and again 18 years after restoration. Concentrations of N and P in ground and surface waters greatly exceeded inflow concentrations. This trend was still evident in surface water samples collected 18 years after restoration. This indicates that the soils in the wetland continued to serve as a net source, rather than sink, of nutrients. This result was due to, in large part, to the hydrology of the system which was driven by limited flushing. Our study results demonstrate the potential for long-term export of nutrients from hydrologically-restored wetlands that have experienced significant oxidation of organic soils.

Contact Information: Craig Duxbury, Walt Disney Imagineering, 1365 Avenue of the Stars, Lake Buena Vista, FL 32830 USA, Phone: 407-560-6519, Email: craig.v.duxbury@disney.com

INNOVATIVE SOLUTION FOR STORING AND RETRIEVING EVERGLADES MONITORING DATA

Maria Asencio[1], *Deborah Scerno*[2], *Susan Kemp*[2], *Greg Graves*[1], *Bill Hall*[1], *Barbara Burch*[2], *Al Yonick*[2], *Heather Kostura*[2] and *Liz Darling*[2] -- Presented by: ***Gretchen Ehlinger***[2]
[1]South Florida Water Management District, West Palm Beach, FL, USA
[2]United States Corps of Engineers, Jacksonville, FL, USA

In order to implement adaptive management for the Comprehensive Everglades Restoration Plan (CERP) and to measure progress towards ecosystem restoration, a significant amount of sampling is performed - from water quality and quantity sampling to that which is more biological in nature. Although there is a database for the water quality and quantity measurements, one did not exist for biological/ecological data. Thus in order to determine how the water quality and/or quantity and the biological data were related or how the biological data was related to each other, several spreadsheets worth of data had to be located and either manipulated (re-arranged) by hand or a specific script had to be written to formulate each combination of data. This proved to be very time consuming and concerns were raised as to whether unanticipated correlations were being missed or if data itself was being missed.

A SQL-based database was created for the storage and retrieval of biological and ecological data collected in support of CERP. The CERP Integrated Database (CID) was designed based on input from the scientists who analyze the data as well as those who collect it. The input process allows for quality assurance by contract managers before final acceptance into the database. Data from the following sampling activities can be stored: Algae; Bacteria; Bird; Climate Conditions; Fish; Ground Water; Herpetofauna; Invertebrates; Location (physical); Mammal; Nekton; Periphyton; Plant; SAV; Soil / Chemistry; Surface Water. This database contains a spatial component - connection to a GIS/SDE oracle based geospatial database. This feature allows the biological and ecological data collected for CERP to be easily located through a point and click web interface. Data can be queried and extracted either spatially or by station and allows for simple combination with other sampling data. Since the database is based on industry standards, it can also be connected to other biological databases.

Contact Information: Maria Asencio, South Florida Water Management District, 3301 Gun Club Road, West Palm Beach, Florida 33406, USA, Telephone: 561-682-2128, Email: masencio@sfwmd.gov

SUSTAINABILITY OF LONG-TERM MONITORING FOR LARGE SCALE ECOSYSTEM RESTORATION

Gretchen Ehlinger[1], *Eliza Hines*[2], *Tom St Clair*[2] and *Dave Tipple*[1]
[1]U.S. Army Corps of Engineers, Jacksonville District, Jacksonville, FL, USA
[2] Atkins Global, Jacksonville, FL, USA

Long-term system-wide monitoring is a critical facet of ecosystem restoration. It not only provides an avenue to detect changes in the ecosystem as restoration is implemented, but also supplies Information about the current status of the natural system and addresses key questions about how the system might respond to restoration actions. The Comprehensive Everglades Restoration Plan (CERP) Monitoring and Assessment Plan (MAP) is a long-term system-wide monitoring and assessment program for the Everglades and south Florida. Initiated in 2001 (as authorized by the Water Resources Development Act of 2000), the overarching goal for implementation of the MAP is to have a single, integrated, system-wide monitoring and assessment plan that will be used and supported by all participating agencies and tribal governments as the means of tracking and measuring CERP performance. Ten years into its implementation, the sustainability of the MAP for a large-scale ecosystem restoration program like CERP is tenuous. Given the slower than anticipated pace of implementation of CERP projects, restoration of the natural system remains slow and creates additional challenges in justifying the need for long-term monitoring. These challenges include dynamic implementation and construction schedules, aligning changing interagency monitoring priorities, funding constraints given budget reductions, and the everyday challenges associated with a administering a multi-million dollar monitoring program each year. The results of these factors are that management decisions focus limited dollars on project-scale effects at the risk of sacrificing monitoring at the system-scale. The risk of reducing system-wide monitoring is not being able to separate out project restoration success from natural system variability and the reduction in the ability to capture potential unknown changes across the system in the future. The key to continued support of long-term monitoring is to link the science with policy and management questions and decisions, as they relate to achievement of restoration goals. It is imperative that the long-term monitoring programs communicate the need to identify and evaluate environmental change that occurs across spatial and temporal scales in order to document restoration progress and gain new Information to ensure restoration efforts can be improved to achieve restoration success. After all, maintaining political and public support for restoration will require demonstration of environmental benefits that will only be evidenced through the long-term monitoring programs of large scale ecosystem restoration projects.

Contact Information: Gretchen Ehlinger, RECOVER & System-wide Analysis Branch, Planning and Policy Division, U.S. Army Corps of Engineers, Jacksonville District, 701 San Marco Blvd., Jacksonville, FL 32207, USA, Phone: 904-232-1682, Fax: 904-232-3442, Email: gretchen.s.ehlinger@usace.army.mil

THE POTENTIAL EFFECT OF THE NOVEL ECOSYSTEM CONCEPT ON WETLAND RESTORATION PLANNING AND EVALUATION

Susan Galatowitsch
University of Minnesota, Saint Paul, MN, USA

The concept of novel ecosystems has recently emerged as reaction to increasing human-caused transformation of landscapes caused by irreversible drivers such as introduced species. Use of historical ecosystem condition as a template for restoration planning is widely regarded as inadequate given anticipated climate changes; however, the concept of novel ecosystems is not a robust approach either. The paleoecological record provides strong evidence that the combinations of dominant species in modern ecosystems are the latest manifestation of species distributions that continually change in response to climate. Certainly, the rates of biotic and abiotic changes have accelerated, but novel ecosystems are defined by the existence of new combinations of species, and so rooted in the same static notion of plant communities as historical standards. In novel ecosystems, these combinations are said to arise through human impacts – but not all human impacts affect ecological resilience in the same way. This is a particularly challenging problem for restoration: restoration sites are human-impacted, so someone must decide whether the evaluation standard should be a relatively intact reference ecosystem or one that is “novel”. While restoration ecology researchers will undoubtedly be nuanced in what should be considered novel or not (and will likely debate this for years), ecological restoration practitioners will use ‘best professional judgment’ to make this determination in a sociopolitical context that usually rewards low-cost solutions. Establishing wetland restoration completion criteria based on a novel ecosystem dominated by a few introduced species is a much lower and easier-to-achieve standard than one based on restoring the ecosystem attributes of a modern, but relatively intact example of a particular kind of wetland. Recent efforts to apply concepts of ecological resilience and ecological services to wetland restoration planning and evaluation have greater potential to serve as sound basis for decision-making.

Contact Information: Susan Galatowitsch, University of Minnesota, 1970 Folwell Avenue, Saint Paul, MN 55108, USA, Phone: 612-624-3242, Fax: 612-624-4941, Email: galat001@umn.edu

HYDRILLA MANAGEMENT POSITION STATEMENT

Ed Harris
Florida Fish and Wildlife Conservation Commission, Orlando, FL, USA

Hydrilla (Hydrilla verticillata) was probably introduced to Florida in the late 1950s. By the 1970s, it was established throughout Florida. When hydrilla invades, ecologically-important native submersed plants such as pondweeds (Potamogeton spp.), eelgrass (Vallisneria americana), and coontail (Ceratophyllum demersum) are shaded out by hydrilla's thick mats, or are simply outcompeted, and eliminated. Millions of dollars are spent each year on herbicides and mechanical harvesters in an effort to place hydrilla under "maintenance control". Hydrilla greatly slows water flow and clogs irrigation and flood-control canals; in Florida, large mats of fragments collect at culverts and clog essential water control pumping stations. Hydrilla seriously interferes with boating, both recreational and commercial, and prevents swimming and fishing; major infestations can limit sportfish weight and size. Dense hydrilla infestations can also change water chemistry and oxygen levels.

The management objectives for hydrilla have for many years been a point of disagreement and contention among many user groups and managers of the State's freshwater lakes and rivers. The purpose of the development of an agency position statement for hydrilla management is to establish guidance on how this nonindigenous invasive aquatic plant should be managed and what process will be employed to determine hydrilla management prescriptions for specific waterbodies. The Fish and Wildlife Conservation Commission (FWC) opposes the deliberate introduction of hydrilla into waterbodies where it is not currently present. Although the FWC prefers to manage for native aquatic plants, it recognizes that in waterbodies where native submersed aquatic plants are absent or limited, hydrilla at low to moderate densities can be beneficial to fish and wildlife. With input from resource management partners and local stakeholders, the FWC is in the process of determining hydrilla management prescriptions on each public waterbody in Florida using a risk-based analysis that considers human safety issues, economic concerns, budgetary constraints, fish and wildlife values and recreational use.

The use of FWC's position statement and the process of developing a management prescription for an individual waterbody will be discussed in detail.

Contact Information: Ed Harris, FFWCC, 6830 Shadowridge Drive, Suite 201, Orlando, FL 32812 USA, Phone: 407-858-6170, Fax: 407-858-6176, Email: ed.harris@myfwc.com

DOES REMOVAL OF DEGRADED PEAT HELP TO RESTORE MIRE ECOSYSTEM SERVICES? RESULTS OF A FIELD EXPERIMENT

Łukasz Kozub[1,2] *, Wiktor Kotowski*[1,2] and ***Petter Hedberg***[1]
[1]Department of Plant Ecology and Environmental Conservation, University of Warsaw, Poland
[2]Wetland Conservation Center, Warsaw, Poland

Mires and peatlands provide ecosystem services of crucial importance to economy and environmental homeostasis, the most important ones being carbon sequestration and nutrient storage, while at the same time providing shelter for endangered species. Drainage of mires leads to the loss of these services or even causes negative impact on the environment, e.g. due to the emission of GHG and nutrients, and subsequent loss of biodiversity due to internal eutrophication. In Central and Western Europe, where majority of peatlands have been drained for agriculture, their negative effects on the environment urge for extensive restoration measures aiming at the reestablishment of their primary ecosystem services. A commonly used method of peatland restoration is rewetting. It has low cost per area unit but its potential to rapidly restore ecosystem services is limited. A less common method of fen restoration, intended to give more rapid effects in terms of biodiversity and nutrient status, is the removal of degraded topsoil. Though applied already in a number of peatland restoration projects, the method of topsoil removal has not been quantitatively assessed yet in terms of its potential to reduce nutrient and GHG losses from peat.

We carried out an experimental peatland restoration project, where topsoil removal was applied on 2 ha of severely drained rich fen followed by the transfer of hay of target vegetation collected in the vicinity. Small rewetting plots (9m2) were experimentally simulated within the same object by submerging degraded topsoil in groundwater to compare the effectiveness of both methods. During three years following restoration, we measured concentrations of main nutrients in pore water sampled every fortnight and monitored vegetation development, while methane emission was measured once a month during two seasons using the following treatment types in 6-9 replicates: (1) topsoil removal with hay spread, (2) topsoil removal without hay spread, (3) rewetting, (4) control degraded sites, (5) reference.

Nutrient concentrations in pore water were much lower after topsoil removal than within rewetted and degraded sites and comparable to those in target communities. Methane emissions initially decreased witan the topsoil removal sites below the level of the target communities but after vegetation recovery they raised to the reference level, still by an order of magnitude lower than in rewetted plots. Plant biodiversity, especially brown moss species, of the topsoil removed sites evolved within three years towards desired conditions while rewetted plots became dominated by productive tall helophyte communities.

Contact Information: Łukasz Kozub, Department of Plant Ecology and Environmental Conservation, Faculty of Biology, University of Warsaw, Al. Ujazdowskie 4, 00-478 Warszawa, Poland, Phone: +48 225530571, Fax: +48 225530561, Email: lukasz.kozub@biol.uw.edu.pl

WETLAND RESTORATION AND MONITORING IN THE SOUTHWEST

Ondrea Hummel
U.S. Army Corps of Engineers, Albuquerque District, Albuquerque, NM, USA

The Albuquerque Biological Park Wetland Restoration Project was an ecosystem restoration project constructed by the Corps Albuquerque District in 2006. Restoration consisted of 15 acres of pond reconstruction, 9 acres of wetland restoration, and 48 acres of riparian woodland (bosque) restoration. The bosque was restored by enhancing hydrology and native vegetation. Non-native salt cedar, Siberian elm and Russian olive were removed. The entire project area was revegetated with native riparian and wetland species.

Since completion of construction, the Corps and its contractors have monitored various components of the restoration. Groundwater, surface water, and soils have been monitored within the wetlands and bosque from 2008 to 2010. The data are being used to demonstrate how water table levels are influenced by river stage/discharge, precipitation events, and soils. These components are being monitored to evaluate surface water/groundwater interaction between the river and the created wetland habitat.

Another research component, called the Bosque Ecosystem Monitoring Program (BEMP), which monitors the riparian area. Data is collected regarding abiotic factors such as groundwater levels and precipitation as well as biotic factors such as native and exotic tree and shrub productivity, and indicator surface arthropod activity. This has been completed at the Albuquerque Biological Park Wetland Restoration Project since 2007 by utilizing groundwater wells, vegetation transects, leaf litter traps and pitfall traps for collecting insects.

Transects monitoring avian populations in the project area were also established prior to construction and continue to be monitored. Bird communities and populations have changed due to the conversion to wetland habitat and removal of non-native vegetation.

The construction of this project, ongoing monitoring and results, and how this Information is being used to improve other restoration projects will be discussed.

Contact Information: Ondrea Hummel, Environmental Resources Section, U.S. Army Corps of Engineers, 4101 Jefferson Plaza NE, Albuquerque, NM 87109 USA, Phone: 505-342-3375, Fax: 505-342-3668, Email: Ondrea.c.hummel@usace.army.mil

DENITRIFICATION ENZYME ACTIVITY IN MID-ATLANTIC COASTAL PLAIN WETLANDS

Patrick Hunt
USDA-ARS, Florence, SC, USA

In the last several decades, there has been considerable effort to protect and restore wetlands throughout the USA. These efforts have required significant investment of both private and public funds. Accordingly, it has become important to document the effectiveness of this protection and restoration. This study for the Mid-Atlantic Region (MIAR) Wetland Conservation Effects Assessment Project (CEAP) was part of the US Department of Agriculture CEAP. It assessed natural, converted, and hydrologically restored wetlands from Delaware to North Carolina. There were forty-eight total sites. Each site was sampled at 4 landscape elevations (wettest to driest) during three years. This paper reports an assessment of soil denitrification conducted as one component of the MIAR Wetland-CEAP using denitrification enzyme activity (DEA). The converted and restored wetlands had significantly higher DEA levels than the natural wetlands. Natural wetland DEA ranged from 58 to 18 µg kg-1 h-1. The DEA in restored wetlands ranged from 83 to 33 µg kg-1 h-1. Converted wetland DEA ranged from 109 to 31 µg kg-1 h-1. The wetlands were also different in amounts of denitrification that proceeded only to nitrous oxide. The percentage of denitrification proceeding to nitrous oxide was highest in natural and lowest in converted wetlands. These data indicate that there are robust differences in denitrification enzymatic activity among these management practices.

Contact Information: Patrick Hunt, USDA-ARS, 2611 W. Lucas St., Florence, SC 29501, United States, Phone: 843-669-5203, Email: Patrick.Hunt@ars.usda.gov

APPLYING SOFIA CLASSIFICATIONS TO HERBACEOUS AND GRAMINOID DOMINATED PLANT COMMUNITIES WITHIN THE HOLE-IN-THE-DONUT, EVERGLADES NATIONAL PARK

Suzanne M. Kennedy[1], *Steven W. Woodmansee*[2], *Chris D. Haddad*[1], *Gerald C. Horak*[3] and *Jonathan E. Taylor*[4]

[1]Floravista, Inc., Merritt Island, FL, USA
[2]Pro Native Consulting, Miami, FL, USA
[3]CSS-Dynamac Corporation, Fort Collins, CO, USA
[4]National Park Service, Homestead, FL, USA

Large-scale wetland restoration projects attempt to recreate natural communities that existed before man-made alteration. The Everglades National Park (ENP) Hole-in-the-Donut (HID) is a previously farmed area encompassing 6,300 acres (2,550 hectares or 9.8 square miles) that had devolved into a monotypic Schinus terebinthifolius (Brazilian pepper) stand. Since 1989, ENP management has overseen the HID restoration project, performing activities to restore native plants and natural ecosystem function. The HID Restoration Plan involves removing Schinus terebinthifolius, its seed bank, and remnant, rock-plowed, farm soil. Seed bank removal requires scraping and removal of surface soil down to the bare rock, or subsoil level. The project has prepared 4,410 acres for native wetland vegetation community restoration.

Native wetland species recruitment and establishment into a freshwater herbaceous marsh and prairie is occurring within the restored HID. Across the herbaceous and graminoid-dominated wetland community, multiple sub-community types are forming and can be classified and spatially mapped across hydrological and elevation gradients. During the past 15 years, vegetation monitoring and analyses have demonstrated increasing native plant diversity and coverage, with minimal re-colonization by Schinus terebinthifolius or other Florida Exotic Pest Plant Council (FLEPPC) species. While restored areas exhibit favorable species composition, colonization, and formation trends, data analysis in early years (i.e. 1998-2008) could not correlate HID vegetation-monitoring data with existing ENP natural vegetation communities. Prior efforts were inhibited by lack of a detailed classification system, and a HID hydroperiod and digital elevation model, the latter two we provided to NPS 2010-2011. In 2011, we conducted analyses across hydroperiod and elevation gradients to better understand and characterize vegetative communities existing within the restored HID.

We used ordination, dendrogram classification, and plant species importance value assignment to identify and characterize distinct natural vegetation communities. Ordination methods simplify patterns within multivariate datasets and identify important gradients and relationships within biological communities. Our study ran detrended correspondence analysis (DCA), an indirect gradient ordination analysis, to identify six hydroperiod gradients impacting plant species composition. The preliminary classification was based on a square root transformed Bray-Curtis dissimilarity matrix to approximate normality. An agglomerative hierarchic clustering with average linkage criteria clustered the HID plots and species. Two-way hierarchical plot and dendrogram classification resulted in species clustered in rows and vegetation monitoring plots in columns. Species composition similarity clustered the plots. Co-occurrence frequency clustered species. We associated plot clusters with hydroperiod gradients that ordination identified. Importance value assignment identified dominant species within clusters.

The identification of communities involved reviewing dominant species and hydroperiod ranges within a cluster. The community assignments fit into existing classifications described in the South Florida Information Access (SOFIA) Vegetation Classification for South Florida Natural Areas (USGS), a classification system ENP uses outside the HID. The natural community classifications occurring currently in the restored HID comprise eight SOFIA Names: Pine Rockland-Mixed, Willow Scrub, Willow Scrub-Cattail, Graminoid Freshwater Prairie, Sawgrass-Muhly, Sawgrass-Beakrush, Cattail, and Cattail Sparse. On-going analyses will continue to monitor vegetation species and composition, and refine preliminary vegetation community classification, spatial distribution, and quantity across the restored HID.

Contact Information: Suzanne Kennedy, Floravista, Inc. Merritt Island, FL 32953 USA, Phone: 321.427.6649 or 321.745.2468, Email: sk@floravista.net

GREAT LAKES COASTAL WETLAND REHABILITATION: SYNTHESIZING YEAR 1 RESPONSES TO HYDROLOGIC RECONNECTION

K. P. Kowalski[1], *M. Eggleston*[1], *A. Czayka*[1], *S. Green*[1] and *D. Wilcox*[2]

[1]U.S. Geological Survey, Great Lakes Science Center, Ann Arbor, MI, USA

[2] Department of Environmental Science and Biology, SUNY- College at Brockport, Brockport, NY, USA

Great Lakes coastal wetlands provide vital habitat to multiple life stages of fishes, birds, and a suite of other biota. However, the condition of and access to coastal wetlands declined as the coastal zone and surrounding watersheds were developed. Wetland habitat rehabilitation projects funded through the Great Lakes Restoration Initiative (GLRI) provide a unique opportunity to study ecosystem response to management actions, as they strive to improve wetland functions and services. Through a partnership between the U.S. Geological Survey, U.S. Fish and Wildlife Service (USFWS), and Ducks Unlimited, a GLRI-funded project reestablished the hydrologic connection between an intensively managed impounded wetland and a small Lake Erie tributary called Crane Creek that is located in the USFWS Ottawa National Wildlife Refuge and within the boundaries of the EPA-designated Maumee River Area of Concern. Fish, birds, plants, and water quality in the Crane Creek coastal and impounded wetland complex were sampled quantitatively to 1) characterize spatial and seasonal patterns and 2) examine ecosystem response to restored passage to fish and increased variability in wetland hydrology driven by source water from Lake Erie and the Crane Creek watershed. Intensive sampling in the Fall of 2010 and March – November 2011 revealed striking patterns in hydrology, water quality, bird assemblages, and fish assemblages in Crane Creek coastal wetlands, an impounded reference wetland, and the reconnected wetland. Increased variability of water-level fluctuations in the reconnected wetland was tied to high levels of nutrient retention. The concentrations of nitrogen and phosphorus in the nutrient-rich source waters draining the agricultural watershed decreased greatly after pulsing through the reconnected wetland. Fish diversity, abundance, and biomass increased significantly in the reconnected wetland once full access was allowed between the vegetated wetland and Crane Creek. High-resolution sonar revealed extensive bidirectional movement of fish through the connecting structure on a daily and seasonal basis. Avian communities used all of the wetlands frequently even though water levels limited the extent of shallow water or mudflat habitats. Large patches of emergent vegetation thrived in deeper-water conditions but reflected the relatively low species richness observed elsewhere in the wetland complex. After one year of study, data suggest that maintaining a long-term hydrologic connection between diked and coastal wetlands in Lake Erie will allow fishes to use vegetated habitats regularly, reduce the concentration of nutrients in coastal waters, and maintain productive habitats for birds and other biota. If conditions degrade with time, periodic management actions involving hydrologic isolation of the rehabilitated coastal wetland could be used to mimic intermediate levels of disturbance and maintain wetland vegetation.

Contact Information: Kurt P. Kowalski, U.S. Geological Survey, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI 48105 USA, Phone: 734/214-9308, Fax: 734/994-8780, Email: kkowalski@usgs.gov

OYSTER REEF HEALTH AND RESTORATION POTENTIAL ALONG A SALINITY GRADIENT IN NAPLES BAY, FLORIDA

***S. Katie Laakkonen*[1]**, *Michael R. Bauer*[1] and *Aswani K. Volety*[2]
[1] City of Naples, Naples, FL, USA
[2] Florida Gulf Coast University, Fort Myers, FL, USA

Naples Bay, a highly urbanized estuary, has experienced altered hydrology, dredging and armoring of the shoreline since the 1950s. Historically, Naples Bay received the majority of its freshwater inflow from sheet flow and small natural tributaries, but changes to the watershed have occurred from stormwater pipes and canals now rapidly conveying stormwater into the bay. The creation of the Golden Gate Canal, which drains a large area in eastern Collier County, directly connects to the Gordon River and Naples Bay and has expanded the Naples Bay watershed from approximately 10 sq. miles to 120 sq. miles. On average, 200 million gallons per day flow into Naples Bay from this canal, disrupting the freshwater/saltwater balance that is needed to maintain a healthy estuary. This creates a longitudinal salinity gradient that varies greatly between wet and dry seasons as well as causes severe stratification in the wet summer months. Efforts are underway by the South Florida Water Management District, Big Cypress Basin, to divert some of this freshwater to restoration areas in need of rehydration which will result in decreased flows into Naples Bay.

Oyster reefs were once prolific prior to development activities and an approximate 82% loss has been observed (Schmid et al., 2006). The locations of remaining oysters reefs are documented, but health of the reefs was largely unknown. A study was initiated to characterize the health of oysters along the salinity gradient at four sites in Naples Bay and the Gordon River using body condition index, prevalence of the parasite Perkinsus marinus, and living densities. Spat recruitment was also quantified at each site using shell stringers and trays filled with shell. Data collection occurred once per month spanning one dry and one wet season from November, 2010 through October, 2011. This study will help determine the status of this important habitat in Naples Bay and will also provide a baseline assessment of the oyster population that will allow for a comparison when future water diversions begin from the Golden Gate Canal and freshwater into the bay is reduced. This study will also assist resource managers in determining potential oyster restoration sites given the current altered salinity regime in Naples Bay by linking the oyster data with monthly water quality data (temperature, DO, and salinity) collected throughout the bay system.

Contact Information: S. Katie Laakkonen, Natural Resources Division, City of Naples, 280 Riverside Circle, Naples, FL 34102 USA, Phone: 239-213-7122; Fax: 239-213-7127, Email: klaakkonen@naplesgov.com

EFFECT OF BELOW-GROUND VEGETATION ON MACROBENTHIC COMMUNITY OF TWO MANGROVE SWAMPS IN HONG KONG: IMPLICATION OF PLANTATION AND PLANT INVASION

Jonathan Y. S. Leung, *Ying Wang, Qin Hong Cai* and *Nora F.Y. Tam*
City University of Hong Kong, Tat Chee Avenue, Hong Kong SAR, China

Mangrove ecosystem is crucial for nutrient recycling, provides coastal protection and habitat for many intertidal species. Unfortunately, mangroves are globally threatened with destruction mainly through human encroachment. In the last two decades, restoration of degraded mangroves through plantation became a common practice all over the world to compensate the loss of mangrove habitats. However, how the restoration work affects the macrobenthic community, an important link to the marine food webs, is rarely reported. Below-ground vegetation may be the cardinal factor to regulate macrobenthic community since it can affect sediment properties and spatial heterogeneity. Its effect on macrobenthic community was examined by interpreting the macrobenthic, sediment and below-ground vegetation data through univariate and multivariate analyses. Two mangrove swamps in Hong Kong with different sediment textures, namely Tai O and Yung Shue O, were chosen as the study sites for comparison. In Tai O, animal and sediment samples in bare mudflat, seedling and mature Kandelia (with and without macroalgae cover) and pneumatophores were collected by sediment cores, while samples were collected along a transect in the sandflat, seedling and Kandelia areas in Yung Shue O mangrove.

Results showed that the sediment in Tai O mangrove was different from that in Yung Shue O mangrove due to smaller particle size, fewer total organic matter and higher water content. Higher redox potential and total organic matter content were observed in the densely vegetated area in Tai O mangrove. Regarding macrobenthic community, higher abundance but lower diversity indices were observed in Tai O than that in Yung Shue O mangrove swamp. Multivariate analyses (MDS and ANOSIM) revealed that different habitats had different community structures in both mangroves. SIMPER analysis indicated that fewer large-sized species appeared in the areas with greater amount of below-ground vegetation in both mangroves. Spearman correlation analysis suggested that below-ground vegetation significantly reduced the faunal abundance in Tai O but not in Yung Shue O mangrove. BIOENV analysis also revealed that below-ground vegetation was the best explanatory factor to the macrobenthic community in both mangrove swamps while sediment properties only played a secondary role. These findings implied that plantation or plant invasion in the open area could gradually change the macrobenthic community structure with time, probably due to the growth and development of root system. The reduction of large-sized polychaete species (e.g. Nereid polychaetes) in the densely vegetated areas would lead to a reduction in food availability for waterfowls. Restoration work should therefore be done carefully to prevent any detrimental effect on the macrobenthic community and even waterfowl community.

Contact Information: Jonathan Y.S. Leung, Department of Biology and Chemistry, City University of Hong Kong, Tai Chee Avenue, Kowloon, Hong Kong SAR, Phone: 852-91865810, Email: jonathan_0919@hotmail.com

ASSESSING WOODSTORK ABUNDANCE AND ALLIGATOR NESTING TRENDS IN EVERGLADES NATIONAL PARK USING GENERALIZED ADDITIVE MODELING

Dilip Shinde [1], *Mario Alvarado*[1], ***Alicia M. Lo Galbo***[1], *Mark Parry*[1] and *Troy Mullins*[1]
[1]Everglades National Park, National Park Service, Homestead, FL, USA

Everglades restoration, land development, changing water demands, and climate change in southern Florida continue to affect the Everglades ecosystem. Long-term monitoring and assessment of ecological indicators, such as wildlife, is critical in understanding indicator response to ecosystem dynamics. Aerial monitoring provides a cost effective method to relate wading bird abundance and alligator (a top predator and keystone species) nesting efforts with environmental conditions in the Everglades. Systematic Reconnaissance Flights (SRFs) have been conducted since 1985 to monitor wading bird abundance and alligator nesting effort and nesting success in Everglades National Park.

Generalized additive models (GAMs) are suited for evaluating trends in wildlife count data as they provide the flexibility in modeling any shape relationship between explanatory and response variables. They also allow varying levels of smoothing to capture fluctuation and also maintain linearity within data to capture species trends. Generalized additive models were used to characterize nonlinearities and evaluate trends in woodstork abundance and alligator nesting SRF data within Everglades National Park from 1985-2010.
Our results indicate a cyclical woodstork abundance trend with significant change points (upturns and downturns) spread over the monitoring record. Significant upturns in alligator nest trends were detected at the beginning (1985-1990) and end (2006-2010) of the period of record. These change points indicate, for these two species, potential alterations in hydrologic and habitat conditions that would be further analyzed through their inclusion as covariates in the GAM. Our study provides a useful application for natural resources managers to statistically assess long-term non-linear trends in wildlife count data. Continued assessment of wildlife reproductive and species demographic trends is recommended to evaluate restoration success and climatic effects.

Contact Information: Dilip Shinde, Everglades National Park, National Park Service, 950 N. Krome Avenue, Homestead, FL 33030 USA, Phone: 305-224-4201, Fax: 305-224-4147, Email: Dilip_Shinde@nps.gov

EVOLUTION OF SELF-DESIGNED WETLANDS IN THE SNOHOMISH RIVER ESTUARY, WASHINGTON

Scott Luchessa
Environ International Corporation, Seattle, Washington, USA

Compliance with the no net loss of wetland acreage goals of the Clean Water Act and permit requirements as well as ecologically successful wetland creation and restoration remains unacceptably low. Self-designed wetlands incorporate natural succession and can be used to create and restore wetlands at least in some circumstances. This case study of a riverine flow-through wetland restoration and buffer enhancement in the Snohomish River Estuary in Washington documents the use of the self-designed wetland concept.

In this case, dikes were breached and pulled back, re-grading was completed, and propagules of native emergent plants allowed to colonize the restored wetlands from adjacent areas in Smith Slough, a distributary of the Snohomish River. Initial restoration of 2.3 acres of wetland was completed in February 2005 to replace functions provided by 1.8 acres of agricultural ditches determined to be jurisdictional wetlands by the U.S. Army Corps of Engineers.

Annual monitoring using standard methods, including line intercept, belt transect, and quadrats have documented the evolution of restored emergent wetlands and buffer enhancement and compliance with all performance standards for seven years. Invasive species control and control of deer browsing have been critical to the successful wetland restoration. Monitoring data show self-designed wetlands that are properly designed, constructed, and maintained are similar in terms of native plant community composition and structure compared to planted mitigation sites. These findings are consistent with the work done by Bill Mitsch and others at the Olentangy River Wetland Research Park, which likewise have demonstrated planted and self-designed constructed riverine flow-through wetlands are comparable in structure and function. Self-designed wetlands take advantage of natural successional processes and are a cost-effective, proven, efficient and perhaps a better way to restore wetlands than more intrusive and labor intensive planting techniques that attempt create or restore wetlands but fail to adequately take into consideration natural succession patterns and processes.

Contact Information: Scott Luchessa, ENVIRON International Corporation, 605 First Avenue, Suite 300, Seattle, WA 98104 USA, Phone: 206-336-1654; Fax: 206-336-1651, Email: sluchessa@environcorp.com

PLANTING SUCCESS OF RIPARIAN SHRUBS AND TREES ON AN URBAN STREAM RESTORATION IN UTAH

Eric McCulley[1] and *Ty Harrison*[2]
[1]SWCA Environmental Consultants, Salt Lake City, Utah, USA
[2]Emeritus Professor of Biology, Westminster College, Salt Lake City, Utah, USA

The main goal of the Audubon/Tree Utah Migratory Bird Habitat Restoration Project is to increase the density and areal coverage of native shrub and tree complexes along Willow Creek to support neo-tropical migratory bird habitat. This project has involved modifying the hydrology of an urban stream to create a meander channel that parallels the Jordan River, which is a medium sized river that connects Utah Lake and Great Salt Lake in Utah. The financial support for this project has been provided by a variety of sources, but the Sharon Steel Natural Resource Damage Assessment Settlement provided the majority of funding. This settlement was created to compensate for injury and loss of migratory bird habitat that resulted from the release of hazardous materials from the Sharon Steel Superfund Site. Property acquisition by the Utah Reclamation, Mitigation and Conservation Commission, a federal organization was critical. Great Salt Lake Audubon and Tree Utah, local non-profit organizations, have been responsible for improving the habitat and monitoring the success of shrub and tree plantings along this newly established stream segment, which drains a city of over 40,000 people. A group of volunteers and professionals have developed a monitoring program to look at success of plantings, habitat conditions, and bird use in restored areas. This program will be used to help managers of the property to make decisions within an adaptive management framework. The preliminary results of planting success indicate that overall survivorship of shrubs was 42% in one planting area and 74% in another area, after three years of establishment. Managers of the site have determined that supplemental irrigation of shrubs increased success drastically. Tree survivorship is very low when small seedlings are planted into established pasture sod areas even with irrigation, but when containerized willow and cottonwood trees were planted along the banks of a newly excavated stream channels survivorship was very high, between 50 and 75 percent.

Habitat conditions along a 150-meter reach of Willow Creek were assessed in 2011 using the Wild Utah Project's Rapid Riparian Stream Assessment. The results of this assessment indicate that some benefits to neo-tropical migratory bird habitat structure have been achieved, but lack of mature trees and thick shrub patches likely limits the benefits to date. Bird surveys were also completed in the spring and early summer of 2011 and have been compared to baseline surveys that were completed in 1997. Results of the bird surveys indicate that the site is used by some neo-tropical migratory birds, but nesting was limited to generalist species. The limited use of the habitat by nesting neo-tropical migratory birds is likely due to the combination of the effects of the surrounding urban matrix and limited establishment of mature riparian shrubs and trees. Continued improvement of site conditions is likely to benefit migratory birds, but the surrounding urban matrix may limit establishment of significant nesting populations of nesting neo-tropical migratory birds.

Contact Information: Eric McCulley, SWCA Environmental Consultants, Salt Lake City, Utah 84111 USA, Phone: 801-520-2505, Fax: 801-322-4308, Email: emcculley@swca.com

AQUATIC HABITAT MANAGEMENT IN FLORIDA: A PROGRAM FOR STATEWIDE WETLAND MONITORING AND ASSESSMENT

Maria W. Merrill[1], *Mike Allen*[2], *Jessica Griffith*[3] and *Dave Douglas*[4]
[1]Florida Fish and Wildlife Conservation Commission, Tallahassee, FL, USA
[2]Southwest Georgia Technical College, Thomasville, GA, USA
[3]Florida Fish and Wildlife Conservation Commission, Kissimmee, FL USA
[4]Florida Fish and Wildlife Conservation Commission, Eustis, FL USA

The Florida Fish and Wildlife Conservation Commission (FWC), is a leader in aquatic restoration and enhancement activities in the state of Florida. In an effort to maximize the economic and environmental benefits of these activities, the FWC has developed an agency process that monitors and assesses each project's effectiveness toward meeting aquatic habitat restoration goals. The process known as the Aquatic Habitat Restoration Assessment Program (AHRAP), provides benefits including: (1) standard monitoring techniques allowing for statewide comparison among projects; (2) efficient storage, access, and retrieval of monitoring data required for project assessment; (3) improved understanding of aquatic habitat responses to restoration activities; (4) added accountability for project managers; (5) enhanced protection and management of rare and imperiled plant and wildlife communities; (6) implementation of adaptive management; and (7) maintenance of long-term, easily accessible records of completed restoration projects and project–related documents. The AHRAP process was developed to document primarily short-term (1-3 years after treatment) changes in habitat conditions by setting clear, measurable restoration objectives, measuring specific habitat parameters through pre- and post-treatment sampling, and evaluating the habitat responses and the extent to which the restoration treatment achieves desired objectives.

Achieving the goals of systematic long-term storage, access, and analysis of AHRAP data required design and operation of a database to meet these specific considerations. This system is capable of managing and analyzing a large volume of sampling data, relating these data to a restoration activity and project area, evaluating the effectiveness of the restoration project, and providing timely, easily interpreted results to project managers, project partners, the state legislature, or other interested stakeholders. Additionally, a web mapping component integrates AHRAP with ArcGIS and GoogleEarth resources for data display and spatial analysis.

Prior to AHRAP, Florida lacked a process-based evaluation procedure that encompassed causal linkages between restoration and enhancement practices and effects on habitat conditions. In developing the AHRAP monitoring strategy, we were guided by a need to create a practical management tool designed to provide answers to specific questions about the effectiveness of restoration and management practices used in aquatic resource conservation projects. The system also provides for the production of Information that can identify why applied practices are not effective such that adaptive adjustments and strategies can be employed to ensure the ecological goals of the project are ultimately met and applied to future projects.

Contact Information: Maria W. Merrill, Florida Fish and Wildlife Conservation Commission, 620 South Meridian Street, 6A, Tallahassee, FL 32399-1600 USA, Phone: 850-922-4330, Fax: 850-922-4338, Email: maria.merrill@myfwc.com

RESTORATION OF A GULF OF MEXICO COASTAL SALT MARSH ECOSYSTEM THROUGH BENEFICIAL USE OF DREDGE SEDIMENTS: SUCCESSES, CHALLENGES AND LESSONS LEARNED FROM FOUR YEARS OF MONITORING AND ADAPTIVE MANAGEMENT

***Douglas J. Partridge*[1]**, *Sara Mondziel*[2], *Gary Markiewicz*[1] and *Jonathan Olsen*[2]
[1]ARCADIS, U.S., Inc., Cranbury, NJ, USA
[2]ARCADIS, U.S., Inc., Houston, TX, USA

Restoration of Old River South Estuarine Marsh Complex and Coastal Wet Prairie Restoration Project (ORS Restoration Project) was undertaken on the Lower Neches Wildlife Management Area (LNWMA) in Orange County, Texas. The selected restoration site was historically a large uninterrupted freshwater marsh. However due to regional anthropogenic disturbances as well as natural processes, altered site hydrology resulted in subsidence of these freshwater wetland ecosystems. The restoration design was implemented through a pilot study which examined methods for beneficial re-use of dredge sediments, as well as water management of flow into and out of the restoration site through installation of culverts and construction of an earthen plug across the canal.
Construction and planting activities associated with the ORS Restoration Project were completed in January and April 2008, respectively. The restoration sites include approximately 54 acres of estuarine marsh and 30 acres of coastal wet prairie, and are contiguous with large historical wetland ecosystems within the LNWMA. Monitoring and adaptive management has occurred since 2008, being initiated immediately after Hurricane Ike. The adaptive management program was driven by results of the annual monitoring. As of the fall of 2011, a high percent vegetative cover has been documented on all planting platforms across the site and spread to many new locations. Natural recruitment of native species has increased the species richness throughout the site. In addition, avian utilization of the site has dramatically increased due to the restored habitat complexity throughout the site. This presentation will summarize results and observations from the four years of monitoring, as well as discuss challenges and successes encountered throughout this interval.

<u>Contact Information</u>: Douglas J. Partridge, ARCADIS U.S., Inc., 8 South River Road, Cranbury, New Jersey, USA, Phone: 347-756-3600; Email: dpartridge@arcadis-us.com

USING INFERENTIAL SENSORS FOR QUALITY CONTROL OF THE EVERGLADES DEPTH ESTIMATION NETWORK (EDEN)

***Matthew D. Petkewich*[1]**, *Paul A. Conrads*[1] and *Ruby C. Daamen*[2]

[1]U.S. Geological Survey, Columbia, SC, USA

[2] Advanced Data Mining Intl., Greenville, SC, USA

The Everglades Depth Estimation Network (EDEN) of approximately 300 real-time gages provides hydrologic data for freshwater and tidal areas of the greater Everglades. The generation of EDEN daily water-level surfaces is dependent on high quality real-time data from water-level gages. Real-time data are automatically checked for outliers using minimum and maximum thresholds for each gage. Smaller errors in the real-time data, such as gradual drift of malfunctioning pressure transducers, are more difficult to immediately identify. Correcting smaller errors in the data often is very time consuming and water-level data may not be finalized for several months. In order to provide daily water-level surfaces on a near real-time basis, EDEN needed an automated process to identify errors in water-level data and to provide estimates for the missing or erroneous data.

The Automated Data Assurance and Management (ADAM) software uses 'inferential sensor' technology often used in industrial applications. Rather than installing a redundant sensor to measure a process, inferential sensors, or virtual sensors, are developed that make very accurate estimates of the process measured by the hard sensor. The inferential sensors in the ADAM software are empirical models for each EDEN gage. The advantage of ADAM is that it provides a redundant signal to the sensor in the field without the risk of damage due to the environmental setting. In the event that a gage does malfunction, ADAM provides an accurate estimate for the period of missing data. The virtual signals can be compared to the real-time data and if the difference between the two signals exceeds a predefined tolerance, corrective action can be taken. The ADAM software also incorporates 16 filters that identify data that violate user-specific thresholds of maximum and minimum values and various rates of water-level change values. The ADAM software is currently (2012) being used for automated real-time quality assurance of the EDEN data. The development and application of inferential sensors is easily transferable to other real-time hydrologic monitoring networks.

<u>Contact Information</u>: Matthew Petkewich, U.S. Geological Survey, Stephenson Center, Suite 129, 720 Gracern Road, Columbia, SC, 29210 USA; Phone: 803-750-6171; Fax: 803-750-6181; Email: mdpetkew@usgs.gov

VEGETATION RESPONSE IN A RESTORED MARSH, JAMAICA BAY, NEW YORK, USA

Patricia S. Rafferty[1]*, Mary-Jane James-Pirri*[2]*, Charles T. Roman*[3]
[1]National Park Service, Northeast Region, Patchogue, NY, USA
[2]University of Rhode Island, Narragansett, RI, USA
[3]National Park Service, Narragansett, RI, USA

Jamaica Bay is a shallow estuarine lagoon with numerous salt marsh islands located within a highly modified urban watershed. Excluding dredging and fill activity, between 1951 and 2008, 66% by area of the vegetated salt marsh islands in the bay have converted to subtidal and intertidal mudflats (Christiano and Mellander, National Park Service, unpublished data). Marsh restoration, by increasing elevation through the addition of sediment to the marsh surface, is one tool that is used to understand and manage marsh loss in Jamaica Bay. In 2006-2007, restoration of 13.4 ha of marsh at Elders Point East was completed. Vegetation monitoring data from 2005-2009 were analyzed to characterize the structure and function of reference (JoCo) and restored (Elders Point East) marshes before (2005) and after (2006-2009) restoration and to understand factors contributing to marsh loss. Percent total live vegetated cover, standing aboveground biomass, and annual belowground production were equivalent in the reference and restored marshes within 2 years after restoration. Root: shoot ratios in 2008 and 2009 in both marshes were less than 1. Low root: shoot ratios may negatively impact sediment organic matter accumulation and the ability of these marshes to maintain elevation relative to sea level.

Contact Information: Patricia S. Rafferty, National Park Service, Northeast Region, 120 Laurel Street, Patchogue, NY 11772 USA, 631-687-4767, 631-758-4037 (FAX), patricia_rafferty@nps.gov

ASSESSING THE CONDITION OF EXOTIC PLANT SPECIES IN BIG CYPRESS NATIONAL PRESERVE AND EVERGLADES NATIONAL PARK

Jed R. Redwine[1] and *Mario Londono*[1]
[1]National Park Service, Palmetto Bay, FL, USA

The National Park Service Exotic Plant Management team and the South Florida Water Management District Vegetation Management group work together to identify the spatial distribution and abundance of exotic plant species every two years using a digital area sketchmapping process. A pilot map was created in 2005, and mapped again in 2008 and 2010. Placing these maps into a GIS framework supports analysis of spatial patterns across multiple scales, and the identification of hypothesized causal processes driving exotic species infestations using mixed effects models. Preliminary results suggest that the spatial patterns of invasions are different among species based on dispersal type, and that soil disturbance, roads, trails, management boundaries, and hydrologic conditions are significant determinants of the invasion intensity in both Everglades National Park and Big Cypress National Preserve. The result of this analysis is an assessment of the condition of landscape scale management units, and the factors predominantly associated with exotic plant species presence within each unit.

Contact Information: Jed R. Redwine, National Park Service, 18001 Old Cutler Road Suite 419, Palmetto Bay, FL 33157 USA, Phone:305-252-0347, Fax:305-253-0463, Email: jed_redwine@nps.gov

APPLE SNAIL POPULATION MODEL FOR USE IN GREATER EVERGLADES RESTORATION PROJECT ASSESSMENT

S. Romañach[1], *P. Darby*[2], *D. DeAngelis*[1], *J. Bridevaux*[3] and *K. Suir*[3]
[1] Southeast Ecological Science Center; U.S. Geological Survey; Davie, FL, USA
[2] University of North Florida; Department of Biology; Pensacola, FL, USA
[3] National Wetlands Research Center; U.S. Geological Survey; Lafayette, LA, USA

The multi-species goals for conservation in peninsular Florida wetlands subject to restoration (Everglades, Upper St. Johns Marsh) include a wide range of species sensitive to both local and entire watershed conditions. The endangered snail kite (Rostrhamus sociabilis) is one such species, and the well being of its population is determined by the abundance of its almost sole prey, the apple snail (Pomacea paludosa), in impounded wetland units of the Everglades and other breeding areas in central and southern Florida. The prey-predator dynamics that exist between apple snails and snail kites are emblematic of the spectrum of ecological scales that need to be taken into account. The response of both species to habitat condition and water management regimes are viewed as performance measures for wetlands restoration in Florida. Apple snail populations respond to changes in timing and quantity of hydrologic conditions. Here we present a size-structured population model to simulate the response of apple snails to a range of water conditions that include timing, frequency, duration, and other aspects of hydrologic regimes pertinent to wetlands restoration and management in peninsular Florida. The model uses the Everglades Depth Estimation Network (EDEN) as hydrologic input, as well as air temperature data, to simulate the apple snail population at 400 x 400 m spatial resolution. Model output yields the number of individuals and eggs produced over durations of several years on a daily time step. Here we present results from simulated hydrologic conditions to explore impacts on apple snail populations from extreme dry and extreme wet conditions. We developed these simulations by extracting dry year data from EDEN and repeating those data for three simulated years in a row, and also simulated extreme wet conditions by repeating wet year data for three simulated years in a row. The results of our model can be used to meet Greater Everglades restoration project assessment needs. Future plans are to link this model with an existing snail kite population model to see how these endangered predator populations are affected by their apple snail prey.

Contact Information: Stephanie S. Romañach; U.S. Geological Survey; 3205 College Ave.; Davie FL 33314, USA; Phone: 754.264.6060, Fax: 954.475.4125, Email: sromanach@usgs.gov

JOINT ECOSYSTEM MODELING (JEM): MODELS AND DATA TOOLS FOR GREATER EVERGLADES RESTORATION

S. Romañach[1] and *C. Conzelmann*[2]
[1] Southeast Ecological Science Center; U.S. Geological Survey; Davie, FL, USA
[2] National Wetlands Research Center; U.S. Geological Survey; Lafayette, LA, USA

The Greater Everglades modeling community has made significant advancements in the development of linked ecological and hydrological models for evaluation and assessment of restoration plans. Joint Ecosystem Modeling (JEM) has provided a mechanism of interagency collaboration to share resources with the goal of getting ecological models into the hands of users. JEM is a partnership among federal agencies, state agencies, universities, and other organizations. In addition to developing ecological models, JEM has made substantial progress developing user-friendly modeling and data tools requested by the user community. JEM collaborators have also developed a data standard which has allowed not only more effective sharing of data, but also use of common data visualization and manipulation tools. EverVIEW was developed as a common platform for visualizing models supporting Everglades restoration. EverVIEW can show model outputs and inputs overlaid on a three-dimensional global view of the Earth's surface. This visualization software allows users to explore species models for assessment (apple snail population dynamics, amphibian community richness) and evaluation (habitat suitability for roseate spoonbills, their prey, and for crayfish) to assist with restoration decision making.

Contact Information: Stephanie S. Romañach; U.S. Geological Survey; 3205 College Ave.; Davie FL 33314, USA, Phone: 754.264.6060, Fax: 954.475.4125; Email: sromanach@usgs.gov

MODELING AMPHIBIAN OCCURRENCE AND RICHNESS AS ECOSYSTEM INDICATORS IN THE GREATER EVERGLADES

J. Hardin Waddle[1], *Susan C. Walls*[2] and ***Stephanie S. Romañach***[3]

[1]U.S. Geological Survey, Lafayette, LA, USA
[2]U.S. Geological Survey, Gainesville, FL, USA
[3]U.S. Geological Survey, Davie, FL, USA

Amphibians are an important part of the ecosystems they inhabit. They can constitute a large proportion of the biomass in a system due to their abundance. They are intermediate in many food webs, functioning as both predators and prey. Amphibians can also serve as useful ecosystem indicators due to their permeable skin, aquatic larval phase, and sensitivity to many environmental stressors.

In the Everglades, even the more terrestrial amphibians such as toads and treefrogs require water in which to lay eggs and develop as larvae. The hydrology of a site interacts with its habitat to determine suitability for occurrence of each species. Some amphibians require shallow, short-hydroperiod wetlands for breeding where fish and other aquatic predators are absent, present but in low density, or mediated by extensive vegetative cover to offer protection to vulnerable eggs and tadpoles. Other species require long hydroperiods or even permanent water to accommodate long larval periods. Therefore, the interaction of habitat and hydrology can be an important determinant of which amphibian species are present at a site.

We used a multi-species occupancy model to build a series of linear models representing the relationship between hydroperiod and occurrence of 12 anuran species in the greater Everglades in five general habitat types. These relationships were then used to predict probability of occurrence across the entire Everglades landscape using available or simulated hydrologic data and a habitat map. Our model framework includes stochasticity in occurrence as presence in a cell is determined by a weighted coin flip (draw from a Bernoulli distribution) with probability being the estimated probability of occurrence in the cell. This is done simultaneously across all 12 species at all cells, and species richness in any cell is then obtained by summing all species present.

This type of model can be used as a tool to help evaluate alternative management actions or restoration plans. The relative effect to any species or to the anuran community can be predicted for any potential change to the Everglades hydrology or habitat. This will be useful in predicting the effects of climate change as well as Everglades restoration. The effects of salinity can also be incorporated into this model framework to examine the impact of sea level rise on low-lying coastal habitats.

Contact Information: J. Hardin Waddle, U.S. Geological Survey, National Wetlands Research Center, 700 Cajundome Blvd., Lafayette, LA 70506 USA, Phone: 337-266-8671, Fax: 352-266-8586, Email: waddleh@usgs.gov

PRE- AND POST-DREDGING MONITORING OF *SPARTINA ALTERNIFLORA* PRODUCTIVITY IN A THREATENED SALT MARSH

Ellen Russell [1], *Kevin McGarigal*[1], *Michelle DaCosta*[1], *Baoshan Xing*[1] and *Eric Cody*[2]
[1]University of Massachusetts, Amherst, MA, USA
[2]Friends of Ellisville Marsh, Inc., Plymouth, MA, USA

In order to help guide future environmental management decisions for Ellisville Marsh in Plymouth, Massachusetts, study of the salt marsh's soil, pore water and vegetation characteristics before and after dredging of its tidal inlet channel was performed. The 28 ha salt marsh has undergone multiple anthropogenic disturbances, including inlet channel dredging from 1770 through 1987 to support the local fishing industry. When fishing industry, and thereby dredging, ceased in 1987, migrating sands occluded the channel to the point where an apparent coincident loss of 3.5 ha of Spartina alterniflora vegetation occurred. Subsequent formation of mud flat and open water, as well as dune and coastal bank erosion caused by changes in tidal inlet course, again necessitated dredging intervention in 2003. While this appeared to temporarily forestall losses of S.alterniflora, no specific documentation of recovery occurred. To help determine the impact the next dredging event (2011) had upon the marsh vegetation, repeated measurements were made during the growing season before dredging (2010) and following dredging (2011) of marsh pore water chemistry, including sulfide, ammonia-nitrogen, soluble phosphate, salinity, pH and oxidation-reduction potential; soil organic matter, grain size and stable plant fragment content; and vegetation diversity, abundance, and productivity (above and below ground biomass, leaf height and stem density), from 96 fixed plot locations within the marsh. These measurements were made in conjunction with permit requirements to monitor water quality and to survey nearby beach topography and populations of shellfish and offshore eel grass. Inexpensive button-type temperature loggers were used to determine hydraulic differences caused by spatial variation in marsh surface elevation. Estimates of the extent and duration of plot specific inundation (hydroperiod) were then related to soil, pore water and vegetation characteristics. Standard pressure logging devices were used to monitor tidal range.

Mean semi-diurnal tidal range increased by 0.4m following dredging. After accounting for changes in local ambient and water temperatures, surface soil temperature changes from each plot were translated to hydroperiod estimates. Mean August hydroperiod across the 96 plots was reduced by 44% from pre-dredge to post-dredge conditions. Direct observation of a 10% proportion of the plots confirmed logger derived inundation time periods. The number of plots with tall form S. alterniflora increased by10% post-dredging. Significant differences were found between 2010 and 2011 groupings (n=75) of hydrology, chemistry and S.alterniflora variables using non-parametric MRPP (multi-response permutation procedure) (Euclidean distance measure, $p<0.001$, $A=0.049$). If this salt marsh is to be preserved as it has been for the last two centuries, continued documentation of the temporal and spatial changes in community structure and environmental conditions will be important in determining the timing of maintenance dredging.

Contact Information: Ellen Russell, Department of Plant, Soil and Insect Sciences, University of Massachusetts, Stockbridge Hall, 80 Center Campus Way, Amherst, MA, 01003; Phone: (413) 545-2004, Fax: (413) 545-3958, Email: ekrussel@acad.umass.edu

EFFECT OF CLIMATE CHANGE ON FUNCTION AND STRUCTURE OF A RESTORED SALT MARSH

Anastasia C. Shippey and *Christine R. Whitcraft*
California State University Long Beach, Long Beach, CA, USA

Salt marshes provide several critical ecosystem functions, e.g. nutrient cycling, faunal biodiversity support, and filtration. These functions have been threatened by human activities such as urban development, pollutants, and climate change. One strategy to deal with loss and deterioration of salt marsh ecosystems is restoration. We know current methods, e.g. actively planting native plants, are effective under known climate conditions. Yet the success of restorations under altered climate conditions is unknown. Southern California has a Mediterranean climate characterized by rain in the winter and dry conditions in the summer. Climate change projections for this region include increased frequency of severe storms, longer periods of drought, and increases in temperature (2-10°C). In order to understand these effects I am evaluating how altered precipitation and increases in temperature will affect a restored high marsh berm in a southern California salt marsh. Structures made of PVC pipe and greenhouse plastic mimic these environmental changes and have been placed along the berm in a randomized block design. Pre-treatment invertebrate counts demonstrated no difference among blocks with an overall low total abundance (0-2 organisms/18.1m2). Continuous data loggers placed within each experimental plot indicate treatments are effective. Four month sampling indicates an increase in plant height and algal biomass, but later sampling points may indicate changes in the invertebrate community. Our final results can provide managers of future restorations Information to assist in design and budgets by understanding the success of restoration under different climate change scenarios.

Contact Information: Anastasia C. Shippey, Biological Sciences Department, California State University Long Beach, 1250 N Bellflower Blvd., MS 9502, Long Beach, CA 90840-9502 USA, Phone: 714-230-9263; Fax: 562-985-8878 Email: acshippey@gmail.com

ENVIRONMENTAL CONSTRAINTS AND SPECIES DIFFERENCES IN ESTABLISHMENT AND EXPANSION OF THREE FRESHWATER TIDAL MARSH PLANT SPECIES

Taylor M. Sloey[1] and *Mark W. Hester*[1]
[1]University of Louisiana at Lafayette, Coastal Plant Ecology Laboratory, Lafayette, LA, USA

Understanding factors that influence plant species establishment and zonation patterns in restored wetlands remain an area of research need. This study evaluated the effects of edaphic and hydrologic conditions on vegetation establishment and expansion in a developing tidal freshwater wetland restoration site. The Sacramento-San Joaquin Bay Delta in California is recognized for its role in providing important ecological services; however, historical manipulation via levee construction of these fertile deltaic sediments for agriculture has resulted in vast losses of wetland habitat. The associated loss of wetland ecosystem services has given impetus to assessing the potential of intentional breaching of these levees to re-introduce hydrologic connectivity and restore the land to tidal freshwater wetlands. The levees surrounding Liberty Island, CA, were breached in 1997, making this site an ideal setting to assess constraints on wetland plant establishment and species interactions. Using four transplant sites that varied in proximity to previously colonized marsh shorelines and extent of adjacent open water, we examined the effects of these varying environmental conditions on the establishment and expansion of three tidal marsh macrophytes: (Schoenoplectus acutus, Schoenoplectus californicus and Typha latifolia) at two life history stages (rhizome and adult). Environmental characterization elucidated that soil bulk density is positively correlated with distance from the existing colonized marsh shorelines and negatively correlated with extent of open water. Preliminary results indicate variation in species survival as S. californicus has established more successfully than the other species and expanded to more than an order of magnitude greater (in terms of area colonized) than the other two species. Furthermore, degree and depth of the compacted soil layers may be differentially influencing species survival and expansion. Total area of expansion of all species was more than 2.5 times greater in areas of lesser compacted soils. A subsequent seed-bank assay, conducted alongside the transplant plot areas, revealed a viable seed-bank exists at Liberty Island but environmental conditions impede seedling recruitment. Species richness and seed density increased in areas adjacent to marsh fringe and exposed to larger extents of open water.

The Information gained from this study will aid restoration planning by optimizing plant species selections to meet restoration goals and further refine restoration trajectories for the Delta. However, the results of this research are applicable to a variety of regions where these species are present and achieving a better understanding of the modulating effects of environmental factors on species establishment and zonation can enhance the success of wetland restoration and creation projects.

Contact Information: Taylor M. Sloey, Coastal Plant Ecology Lab, Department of Biology, University of Louisiana at Lafayette, 300 St. Mary Blvd, Lafayette, LA 70504, Phone: 337-482-5235 Fax: 337-482-5834, Email: taylorsloey@gmail.com

EVALUATION OF POTENTIAL IMPACTS TO NEAR SHORE SALINITY IN WESTERN BISCAYNE BAY FROM OFFSHORE GROUNDWATER WITHDRAWALS

Roy S. Sonenshein, *Amy Renshaw* and *Erik Stabenau*
National Park Service, Homestead, FL, USA

The restoration of western Biscayne Bay within and adjacent to Biscayne National Park is among the many goals of the Comprehensive Everglades Restoration Plan (CERP). Ecologic and hydrologic targets developed by the National Park Service for conditions in western Biscayne Bay require freshwater flows from the mainland that result in mesohaline conditions throughout most of the year. Salinities should generally range from 5 to 20 parts per thousand (ppt) and not exceed 30 ppt during the dry season (November to May). The Biscayne Bay Coastal Wetlands CERP project is designed to increase the flows to western Biscayne Bay in an attempt to reach these targets. The operator of the Turkey Point power plant located on the western shore of Biscayne Bay has a proposal to install radial collector wells beneath Biscayne Bay as a backup water supply for proposed new nuclear reactors at the Turkey Point plant. This effort was focused on analyzing the impacts of this withdrawal on the salinity distribution in Biscayne Bay.

A 2-dimensional surface water salinity model of Biscayne Bay was used to represent the potential impacts of the radial collector wells on the salinity of western Biscayne Bay. The Biscayne Bay Simulation Model, developed by John Wang (University of Miami, retired), uses a full hydrodynamic finite element approach to evaluate salinity impacts from changes in the volume, timing, and distribution of freshwater input due to CERP projects. In the current implementation, a region of the bay representing the cone of influence of the radial collector wells was identified and water was removed from the corresponding cells to simulate the withdrawals. This was a significant deviation from the original intent of the model which required several changes to the model code and a re-evaluation of the model output. Details of this process, the limitations inherent in the approach, and the interpretation of results for resource management decisions will be presented.

Contact Information: Roy S. Sonenshein, South Florida Natural Resources Center, Everglades National Park, 950 N. Krome Avenue, 3rd Floor, Homestead, FL 33030 USA; Phone: 305-224-4250; Fax: 305-224-4147; Email: roy_sonenshein@nps.gov

A CLOSER LOOK AT THE ECOSYSTEM HISTORY OF SOUTH FLORIDA'S ESTUARIES DATABASE

Bethany Stackhouse
U.S. Geological Survey, Reston, VA, USA

The Ecosystem History of South Florida's Estuaries Database (developed in Microsoft Access) contains Greater Everglades Ecosystem field data from 1995-2011. This database was started as a way to compile Information in order to monitor change over time in South Florida's estuaries. By observing change in the modern environment and analyzing patterns in sediment cores, a baseline for restoration efforts can be established. Modern field data and core data are collected from site locations including areas in Florida Bay, Biscayne Bay, and the Southwest Coast of Florida and recorded in the database. For the modern field Information, site surveys include latitude, longitude, a general area description, any noticeable changes since the last visit, and water chemistry measurements such as salinity, temperature, and pH. Notes on terrestrial vegetation, aquatic vegetation, live and debris molluscan species, and other species such as crabs and fish are also documented. Physical sample collection methods include petite ponars, grid samples, plankton tows, and/or grab samples. When a sediment piston core is taken, the general location Information, core length, substrate description, and species counts are noted in the database.

In 2008, the focus shifted from noting the presence of live species to counting the number of live individuals in a fixed sample to provide an estimate of the density of live species at different sites. In order to make these live counts easier to access, the modern field Information form in the database was modified. In the original database the presence or absence of live and debris species was recorded with a checkbox system, which means any live counts were typed out in a memo box in the subsample form. The revised form has a table in which the species and counts are entered along with the corresponding sample they came from and additional comments. The query function in Microsoft Access allows the user to pull out the Information they are interested in from multiple tables in the database. Specific and complex questions can easily be answered with queries. The user can extract live or debris count data for one or more species from a certain location. For example, if the user wants to know how the density of live Bulla striata in Florida Bay relates to salinity, a query with those fields from the corresponding tables can answer the question.

The original and new version of the Ecosystem History of South Florida's Estuaries Database can be found at **http://sofia.usgs.gov/exchange/flaecohist/**. This database is a useful tool for those interested in field data from the estuaries of the Greater Everglades Ecosystem and those considering Microsoft Access as a program to record and organize their own data.

Contact Information: Bethany Stackhouse, Eastern Geology and Paleoclimate Science Center, U.S. Geological Survey, MS926A, National Center, Reston, VA 20192 USA, Phone: 703-648-6092, Fax: 703-648-6953, Email: bstackhouse@usgs.gov

HYDROLOGY, SUBSTRATE TYPE AND DENSITY EFFECTS ON SPECIES GROWTH AND SURVIVAL IN CREATED EVERGLADES TREE ISLANDS

Susana L. Stoffella[1], *Michael S. Ross*[1], *Jay P. Sah*[1], *Pablo Ruiz*[1] and *Eric Cline*[2]
[1]Southeast Environmental Research Center, Florida International University, Miami, FL, USA
[2] South Florida Water Management District, Everglades Division, West Palm Beach, FL, USA

Sharp declines in the number and area of tree islands have been reported for some portions of the Everglades. Tree island loss has generally been attributed to management-related changes in hydrologic regime, either prolonged periods of high water, which can cause death in all but the most flood-tolerant woody species, or excessively dry conditions, which increase the likelihood of catastrophic peat fires. Less dramatic hydrologic influences, for instance impacts on stand composition or forest productivity are pervasive.

The Loxahatchee Impoundment Landscape Assessment (LILA) site is a 32-hectare model of the Everglades ecosystem located at the Arthur R. Marshall Loxahatchee National Wildlife Refuge in Boynton Beach, Florida. LILA, with its controlled hydrologic framework, provides an excellent opportunity to investigate species responses to flooding during tree island development. An experiment was therefore designed to test hydrologic effects on seedling growth and survivorship, as well as the effects of tree spacing on individual tree and stand growth.

A peat and a limestone-core island representing two major types found in the Everglades were constructed in each of four 8-ha macrocosms. Mixtures of 8-9 tree species were planted on each island in March of 2006 and 2007 following a stratified random selection procedure that assigned a species to each planting position. The islands were divided into four quadrants (24 x 16 m each), with each planted at different spacing, e.g., 1.0 m, 1.66 m, 2.33 m, 3.0 m. Survival and height growth of seedlings were assessed periodically through fall 2011. Relative elevation was used as a hydrologic variable indicating ground elevation above or below the mean surface water adjacent to the island over the period January, 1st 2008 to December 31st, 2010. A distance-based competition index (CI) was calculated to test the hypothesis that biomass growth is enhanced at lower densities because of lower levels of competition.

Survival and growth improved with increasing relative elevation on both tree island substrate types. Most species exhibited higher survival on the limestone tree islands, and faster growth on their peat-based counterparts. Contrary to our expectation, the effect of tree density, expressed as CI, on biomass growth and survival were still negligible 4.5 and 5.5 years after planting. We will continue to monitor this stand dynamic, as the timing of the natural thinning process could have profound implications for restoration of forests on existing landforms and artificial creation of tree islands.

<u>Contact Information</u>: Susana L. Stoffella, SERC, FIU, 11200 SW 8th St., MM Campus, OE-148, Miami, FL 33199, USA, Phone: 305-348-1658, Fax: 305-348-4096, E-mail: stoffell@fiu.edu

QUANTITY, QUALITY, TIMING, AND DISTRIBUTION OF FLOW ALONG THE TRANSITION ZONE OF SHARK RIVER SLOUGH, EVERGLADES NATIONAL PARK, FLORIDA

Mark Zucker and *Jeff Woods*
U.S. Geological Survey, Davie, FL, USA

Improving the quantity, quality, timing, and distribution (QQTD) of freshwater flows through Everglades National Park (ENP) is a primary goal of the Comprehensive Everglades Restoration Plan (CERP). The U.S. Geological Survey (USGS), in cooperation with the Greater Everglades Priority Ecosystem Science Program (GEPES) and the CERP RECOVER Monitoring Assessment Program, operates a coastal network of hydrologic stations to quantify the volume of freshwater delivered to the estuaries of ENP. The USGS coastal network is designed to measure the flows at the mouths of coastal rivers and flows at the transition zone between the freshwater wetlands and the headwaters of tidal creeks. Flows represent pre-CERP baseline hydrologic conditions useful for comparing with conditions after restoration efforts.

Flow in the Shark River Slough transition zone was monitored at Upstream North River (UNR), Bottle Creek near Rookery Branch (BC), and Upstream Broad River (UBR) from 2004 to 2011. The combined mean monthly flow through all four S-12 structures (A-D) along U.S. 41 is correlated with the combined mean monthly flow at the transition stations. No significant time lag exists between the total flows through the S-12 Structures and flows at each of the transition stations. In contrast, flows monitored at the mouths of coastal rivers were typically one month ahead of the total flows through the S-12 structures, likely due to a shorter response time to observed rainfall over the intervening study area.

Water levels were monitored at the USGS surface water station Eden 3, slightly upstream of UBR, from 2005 to 2011. Correlations were developed between mean monthly water levels at Eden 3 and mean monthly flow at each transition station for the period from November 2005 to September 2009. The R2 values and standard error of the regression ranged from 0.80 to 0.88 and 4.6 ft3/s to 17.4 ft3/ respectively. Correlations between additional water level stations, with longer period of records, and flow from the transition stations will be analyzed in the future to evaluate flow prior to 2004 and post restoration.

The Tamiami Trail Bridge Modifications Project and Decompartmentalization projects are expected to increase water levels and flows in Shark River Slough. Transition stations provide flow volumes at locations where hydrologic models are known to be less accurate due to model calibration errors near freshwater-seawater boundaries. The flows at the transition zone stations do not represent the total flow volume due to unmeasured sheet flow. Relationships between water level and flow in the transition zone may be useful for detecting change. Flow volumes at selected streams before and after restoration could serve as a proxy for QQTD of total flow from the transition zone to the coast.

Contact Information: Mark Zucker, U.S. Geological Survey, Florida Water Science Center, Davie, FL, 33314, USA, Phone 954-377-5952, Fax 954-377-5901, Email: mzucker@usgs.gov

ECOSYSTEM SERVICES - ECOTOURISM

TRANSLATING CONDITION ASSESSMENT DATA TO ECOSYSTEM SERVICES: IS THERE AN APP FOR THAT?

Denice H. Wardrop[1], *M. Siobhan Fennessy*[2], *Jessica B. Moon*[1] and *Hannah M. Ingram*[1]
[1] Penn State University, University Park, PA, USA
[2] Kenyon College, Gambier, OH, USA

The provision of ecosystem services has become elemental in the definition of sustainability, and the need to manage for ecosystem services has been deemed essential for meeting societal expectations in solutions to all critical issues for humanity, including energy policy, food security, and water supply (Holdren, 2008; Robertson et al., 2008). Wetlands are critical pieces of the global ecosystem in terms of their ability to be substantial contributors to the most valued of these ecosystem services, and their common location between human activities (e.g., agriculture, development) and critical water resources (e.g., aquifers and rivers used as water supplies, streams for recreational use) adds to their importance. The critical and substantive role of wetlands in these discussions requires us to leverage the substantial amount of condition Information that exists into expressions of ecosystem services, forecast the provision of these services in response to land cover and climatic change, so that we know how manage these systems for provision of these services at a variety of spatial scales. We have identified headwater riverine wetlands of Ohio and Pennsylvania as an extremely important aquatic resource, whose ability to provide recognized ecosystem services are dependent upon their condition, which is dependent upon stressors associated with land cover and climate change. We are developing ecosystem service delivery models for three ecosystem services (denitrification, carbon storage, and flood storage) that utilize condition assessment data as input, and predict the resultant ecosystem service profile for a variety of relevant spatial scales (e.g., watershed). We recently utilized three assessment methods of denitrification potential on a group of 12 sites: nitrogen isotopes, acetylene-block cores, and a push-pull method utilized in groundwater. The methods vary widely in both their results and spatial and temporal integration of wetland denitrification characteristics and potential, but collectively portray a defensible expectation of ecosystem service. We then relate the denitrification potential to various pieces of condition assessment data to build a transferable model of ecosystem service management on a small watershed scale.

Contact Information: Denice H. Wardrop, Department of Geography, 302 Walker Building, University Park, PA 16802 USA, Phone: 814-863-1005, Fax: 814-863-7943, Email: dhw110@psu.edu

ECOSYSTEM SERVICES - VALUATION OF ECOSYSTEM SERVICES

INTEGRATING BIOPHYSICAL AND ECONOMIC VALUES OF WETLANDS: RECENT ADVANCES IN ECOSYSTEM SERVICE VALUATION

Damian C. Adams
University of Florida, Gainesville, FL, USA

Preference-based valuation, the dominant approach to valuing non-market goods and services from wetlands, faces a major challenge when venturing beyond single-service valuation for well-known services. System complexity and ecosystem service bundles and tradeoffs introduce tremendous difficulties for economic valuation methods; yet, these are fundamentally important to informing policy decisions. In this discussion, recent advances in environmental accounting and valuation will be reviewed, including attempts to assess values for ecosystem functions, multi-service studies, and system complexity. The presentation will contribute to the broader discussion on the integration of biophysical and preference-based valuation methods.

Contact Information: Damian C. Adams, School of Forest Resources & Conservation, University of Florida, Gainesville FL 32611-0410 USA, Phone: 352-846-0872, Fax: 352-846-1277, Email: dcadams@ufl.edu

HABITAT EVALUATION SCORING METHOD TO ESTIMATE ECOSYSTEM SERVICE IMPROVEMENTS FROM RESTORATION

Timothy Barber*, Jennifer Lawton Lyndall* and *Wendy Mahaney*
ENVIRON International Corporation, Burton, OH, USA

Restoration projects are often implemented to offset mitigation requirements or liability for natural resources damages. Most frequently Habitat Equivalency Analysis (HEA) is used as a standard methodology to determine and scale potential restoration credits. HEA requires several input parameters including an estimate of post-restoration service improvements compared to pre-restoration "baseline" conditions. No universal method currently exists to estimate potential ecosystem services for restoration projects. Many of the standard functional assessment methods used to estimate habitat quality have limited value for estimating restoration value for a variety of reasons including: regional specificity, habitat specificity, difficult or labor-intensive metrics and/ computations.

This habitat evaluation scoring method was developed to allow for the evaluation of potential increases in services that projected to occur if a particular restoration project was completed. This evaluation method includes similar metrics to those used in other assessment methods (Florida's WRAP method, Louisiana's WVA methods, USGS' FQI method), but are tailored for use across a variety of habitat types and regions. The hybrid model evaluates numerous metrics representing biological, chemical, physical, and human use functions. Example metrics include vegetation quality (% ground cover), wildlife utilization (birds), hydrologic connectivity, carbon export, and nutrient cycling. The advantage of this method is that variables can be weighted according to importance, there are few metrics, each metric is easily measurable, and the method can be applied across multiple habitat types and regions. This method can take into account a variety of factors that may complicate the estimation of ecosystem services, including salinity alterations (freshwater diversions, saltwater intrusion), sea level rise, and invasive species.

Available Information about a proposed restoration site is used to complete a pre-restoration evaluation, as well as a projected estimate of the post-restoration improvements or benefits. The services that are evaluated are grouped into one of several categories (biological functions, physical functions, chemical functions, and human use functions). Each service is scored on an interval scale from 0 to 4, with 4 being the highest level of service or function and 0 representing low or no service provided. Scoring is based on pre-determined definitions for each metric in order to reduce subjectivity. Weighting factors can be used for services that are not relevant to a project (score of 0), are relevant but not highest priority services (score of 1), and for services that are important to a project (score of 2). The sum of all metrics provides a total pre-restoration score and post-restoration score for the project. The percent improvement in services from pre- to post-restoration at various time intervals can then be used as an input parameter for the HEA credit estimate.

Contact Information: Timothy Barber, ENVIRON International Corporation, 13801 W. Center St., Ste 1, PO Box 405, Burton, OH 44021, USA, Phone: 440-834-1460, Fax: 440-834-1560, Email: tbarber@environcorp.com

ASSESSING TRADEOFFS AMONG WETLAND ECOSYSTEM SERVICES IN A PAYMENT-FOR-ECOSYSTEM-SERVICES PROGRAM ON FLORIDA RANCHLANDS

Patrick J. Bohlen[1], *Elizabeth Boughton*[2], *John E. Fauth*[1], *David Jenkins*[1], *Pedro Quintana-Ascencio*[1], *Sanjay Shukla*[3] and *Hilary Swain*[4]

[1]University of Central Florida, Orlando, FL, USA
[2]MacArthur Agro-ecology Research Center, Lake Placid, FL, USA
[3]University of Florida, Southwest Florida Research and Education Center, Immokalee, FL, USA
[4]Archbold Biological Station, Lake Placid, FL, USA

Agricultural lands provide many of the essential ecosystem services desired by society, beyond merely food and fiber. Yet models of land-use intensity often emphasize a trade-off between agricultural production and other ecosystem services, in which the diversity of services declines with increasing management intensity. Although production often occurs at the expense of e.g. biodiversity, water quality, and soil conservation, alternative policies and management of agricultural lands offers the potential to enhance the provision of multiple ecosystem services. Recent literature emphasizes the need to incorporate sustainability into models to understand interactions among ecological, physical, economic and social effects However, few studies quantify delivery of multiple ecosystem services or trade-offs among services; even fewer consider how environmental stressors affect the level of services provided.

A range of programs have provided opportunities for farmers and ranchers to enhance ecosystem services on their land. Well-known examples include the Conservation Reserve Program, the Environmental Quality Incentive Program, and the Wetlands Reserve Program. One approach for farmers and ranchers to enhance ecosystem services on their land increasing appeal is market-based or market-like programs to pay for ecosystem services, or PES. These focus on environmental results and not just practices, encouraging producer-sellers to innovate and seek cost efficiencies in producing services. Unfortunately, limited documentation of ecosystem services hampers market-like programs.
To assess the effects of agricultural PES on ecosystem services we are evaluating the tradeoffs among ecosystem services in a PES program that is paying ranchers to provide water-related ecosystem services on Florida ranchlands. This innovative program is collecting in-depth hydrologic data to document the services being paid for—water retention and reduction in nutrient runoff for 3,665 ha of ranchland. However, the effects of water management on other valued services, such as biodiversity and forage production, or tradeoffs for environmental stressors. Herein we provide a framework for evaluating benefits and trade-offs in ecological and hydrological measures likely to be affected by the various water management alternatives (WMAs) being implemented on ranches.

Three of our main objectives are to: (1) Quantify biodiversity and production services (vegetation, aquatic vertebrates and invertebrates) in the context of an existing water services pilot project provided by the Florida Ranchlands Environmental Services Project (FRESP) in the Northern Everglades watershed (2) evaluate the degree to which provision of water services might create positive or negative trade-offs for the additional ecosystem services of biodiversity, or forage production (3) determine how environmental stressors of water availability, nutrients, and pests /invasive species constrain services provided and whether enhancing water services affects stressors. In this talk we will present our overall framework and preliminary analysis of two years' data.

Contact Information: Patrick Bohlen, University of Central Florida, 4000 Central Florida Blvd, Bldg 20, Orlando, FL 32816 United States, Phone: 407-823-1940, Email: patrick.bohlen@ucf.edu

TRADE-OFFS IN WETLAND ECOSYSTEM SERVICES: IDENTIFICATION, SPATIAL SCALE, AND MANAGEMENT IMPLICATIONS

Elizabeth Boughton
MacArthur Agro-ecology Research Center, Lake Placid, FL, USA

Trade-offs in ecosystem services stem from management actions, which can change the type, magnitude, and mix of services provided by ecosystems. Wetlands are among the highest service providers of all ecosystems, providing a range of provisioning, regulating, supporting, and cultural services. In addition, the scale of influence of wetland ecosystem services can range from local to regional spatial scales. Because the range of ecosystem services from wetlands is so high, wetland management can result in trade-offs among these services. Knowledge and awareness of interactions between ecosystem services are necessary for making sound management decisions.

Management strategies for wetlands affect the structure and function of the ecosystem resulting in differential responses of ecosystem stressors, and potential favoring of either local or regional ecosystem services. For example, some wetlands are managed to filter nutrients from regional watersheds resulting in a benefit to downstream ecosystems, while shifts in plant communities due to accumulating nutrients could be negative to local community diversity. In addition, local management for wetland conditions that encourage the abundance of waterfowl may lead to increases in greenhouse gas emissions. In wetlands where water level can be controlled there is a trade-off between maintaining water levels to achieve biodiversity objectives, and maintaining low water levels to maximize water storage capacity. There are many possible trade-offs in wetland ecosystem services that can occur when wetland management is strongly influenced by human desires and goals, often resulting in increased focus on either local or regional management which may lead to lack of effective management at the spatial scale least considered.

Identification of trade-offs in ecosystem services is the first step in becoming aware of how wetland management decisions affect service provision. A variety of techniques have been used including tabulation, modeling, and decision support scenario analysis but most identification of trade-offs is conducted at large spatial scales. More work should be conducted on identifying trade-offs at both local and regional scales and policy implications should be explored. Wetland policies should provide guidance to minimize the effects of ecosystem service trade-offs and work to provide a range of wetland ecosystem services across the landscape.

Contact Information: Elizabeth Boughton, MacArthur Agro-ecology Research Center, Archbold Biological Station, 300 Buck island Ranch Road, Lake Placid, FL 33852, USA, Phone: 863-699-0242 ext1, Email: eboughton@archbold-station.org

INTEGRATING BIOPHYSICAL AND ECONOMIC VALUES OF WETLANDS

Mark T. Brown
University of Florida, Gainesville, FL USA

This talk will focus on the integration of historically divergent systems of estimating values of wetland ecosystem functions and services, toward better policy generation and decision-making. Biophysical and preference-based approaches to valuing stem from different axiomatic frameworks and value theories, and therefore are not generally compatible. Despite these limitations, demonstrating the approximate contribution of ecosystems to the economy remains urgently needed and the consequence of not doing so is that policy makers assign a value of zero to these contributions. A main challenge to current research is to combine analytical techniques of biophysical approaches with preference-based approaches to capture the plurality of ecosystem service values of wetlands.

We lack accessible economic models that tie total ecosystem productivity to holistic economic well-being. Preference based approaches do not account for economic contributions directly, but instead elicit indirect estimates of willingness-to-pay, which may not capture the value of important but subtle functions and processes. Since environmental decision-making is reliant on economic benefit-cost analysis, practicable models of interrelated ecosystem values are necessary to evaluate the inevitable trade-offs between protection and preservation of wetland ecosystems and different forms of economic activity (agriculture, industry, urban development).

This talk will address the following key question: How can preference-based concepts of value be reconciled with biophysical concepts of value to provide better Information for policy formation and decision making regarding wetland management? Examples of the divergence of biophysical and economic values of wetland ecosystem services and suggestions integration will be given.

Contact Information: Mark T. Brown, Howard T. Odum Center for Wetlands, 100 Phelps Lab, Museum Road, University of Florida Gainesville, FL 32611, USA Phone: 352-392-2425, Email: mtb@ufl.edu

LAND AREA CHANGE IN COASTAL LOUISIANA FROM 1932 TO 2010

***Brady R. Couvillion*[1]**, *John A. Barras*[1], *Gregory D. Steyer*[1], *William Sleavin*[2], *Michelle R. Fischer*[1] and *Holly Beck*[3]

[1]U.S. Geological Survey, Baton Rouge, LA, USA
[2]Noble Supply and Logistics, Granby, CT, USA
[3]Five Rivers Services, LLC, Baton Rouge, LA, USA

Coastal Louisiana wetlands make up the seventh largest delta on Earth, contain about 37 percent of the estuarine herbaceous marshes in the conterminous United States, and support the largest commercial fishery in the lower 48 States. These wetlands are in peril because Louisiana currently experiences more coastal wetland loss than all other states in the contiguous United States combined. Documenting and understanding the occurrence and rates of wetland loss are necessary for effective planning, protection, and restoration activities. The analyses of landscape change presented here used historical surveys, aerial data, and satellite data to track landscape changes. Summary data are presented for 1932–2010; trend data are presented for 1985–2010. These later data were calculated separately because of concerns over the comparability of the 1932 and 1956 datasets (which are based on survey and aerial data, respectively) with the later datasets (which are all based on satellite imagery). These analyses show that coastal Louisiana has undergone a net change in land area of about -1,883 square miles (-4,877 square kilometers) from 1932 to 2010. This net change in land area amounts to a decrease of about 25 percent of the 1932 land area. Persistent losses account for 95 percent of this land area decrease; the remainder are areas that have converted to water but have not yet exhibited the persistence necessary to be classified as "loss." Trend analyses from 1985 to 2010 show a wetland loss rate of 16.6 square miles (42.9 square kilometers) per year. If this loss were to occur at a constant rate, it would equate to Louisiana losing an area the size of one football field per hour. The use of 17 datasets plus the application of consistent change criteria in this study provide opportunities to better understand the timing and causal mechanisms of wetland loss, which are critical for forecasting landscape changes in the future.

Contact Information: Brady R. Couvillion, USGS, National Wetlands Research Center, Coastal Restoration Assessment Branch, c/o Livestock Show Office, LSU, Baton Rouge, LA 70803, USA, Phone: 225-578-7484, Fax: 225-578-7927, Email: couvillionb@usgs.gov

EVALUATING WETLAND ECOSYSTEM SERVICES IN THE OKEFENOKEE NATIONAL WILDLIFE REFUGE, GEORGIA, USA

Douglas Patton[1], *John Bergstrom*[1], ***Alan Covich***[2] and *Rebecca Moore*[3]
[1]Department of Agricultural and Applied Economics, University of Georgia, Athens, GA, USA
[2]Odum School of Ecology, University of Georgia, Athens, GA, USA
[3]Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA, USA

The rapid increase in interest among natural resource managers to use ecosystem services for communicating with stakeholders and policy makers about the value of natural processes in wetlands has generated a need for clarifying terminology and approaches that will integrate ecological concepts with economic concepts. While many ecosystem goods and services contribute to societal needs, people often consider these goods and services to be "free" because they generally are not asked to pay for them. Furthermore, because most wetland ecosystem services are not traded in markets, estimates of their values are difficult to determine that are useful for comparative studies. The National Wildlife Refuge (NWR) System's 95 million acres in over 500 refuges in the United States include diverse wetlands that differ in their capacities to provide ecosystem goods and services such as clean water, clean air, flood mitigation, carbon sequestration, and recreation. With limited conservation funds, identifying ecological and sociological variables that influence the value of ecosystem services supported by wetlands is necessary to ensure efficient conservation plans.

Our analysis of the Okefenokee NWR in southeastern Georgia (30.84 degrees north latitude) provides the first estimates for the values of carbon sequestration in wetlands in this region. Our estimates of ecosystem functions were based on previously published rates of primary production, decomposition, and net ecosystem carbon storage in wood and peat deposits. We used a benefit transfer approach to estimate the per unit value of stored carbon. We estimated the gross values of carbon storage using a methodology consistent with the 2006 IPCC Guidelines for Greenhouse Gas Inventories. This approach assumes steady-state carbon stocks that are divided into above-ground and below-ground pools, which are each divided into living and dead carbon. For the price component we considered estimates based on the Regional Integrated Model of Climate and Economy (RICE) 2011 model that proposed the 2015 estimated global social cost (Global Value) of carbon in the "business as usual" scenario to be $13.02 per ton of CO_2e. This approach indicates values of $141 per acre and the total value for the Okefenokee NWR to be $53 million per year. These values are subject to inter-annual fluctuations in both the amount of carbon produced and stored because of climatic variability, wildfires, etc. as well as the values associated with mitigating greenhouse gases (CO_2 and CH_4). Nonetheless, this approach is likely to be useful in discussions with managers and planners who need additional parameters when deciding which tradeoffs can be most effective in establishing and sustaining protections for different types of wetlands.

Contact Information: Douglas Patton, Department of Agricultural and Applied Economics, University of Georgia, Athens, GA 30602, USA, Phone: (909) 263-1107, Email: douglaspatton@gmail.com

ECOSYSTEM SERVICES OF RESTORED FRESHWATER WETLANDS OF THE AGRICULTURAL MIDWEST: MEASUREMENT AND VALUATION

Christopher Craft[1], *Anya Hopple*[1], *John Marton*[1], *Brianna Richards*[1] and *Siobhan Fennessy*[2]
[1]School of Public and Environmental Affairs, Indiana University, Bloomington, IN, USA
[2]Department of Biology, Kenyon College, Gambier, OH, USA

We measured ecosystem services associated with biodiversity, water quality improvement and carbon (C) sequestration in ten freshwater marsh wetlands restored under the USDA Wetland Reserve Program (WRP) and in ten natural reference wetlands of the Glaciated Interior Plains (Corn Belt region) of Indiana. Twelve years after restoration, the WRP wetlands, had alpha and beta plant species richness that was comparable to natural wetlands but they contained a greater proportion of lower quality species based on the coefficient of conservatism. Restored wetlands contained more opportunistic and tolerant species than reference wetlands. WRP wetlands also had fewer wet (Obligate, Facultative wet) species than reference wetlands, suggesting that the restored wetlands have a shorter hydroperiod than natural wetlands.

WRP wetlands also contributed less to water quality improvement than reference wetlands. Denitrification rates in WRP wetlands were half of those measured in reference wetlands. The amount of phosphorus (P) sorbed by restored wetland soils was about one third of the P sorbed by soils of reference wetlands.

Soil organic C and nitrogen pools (0-15 cm) were significantly smaller in restored versus reference wetlands whereas soil P pools did not differ among the two wetland types. On a positive note, greenhouse gas (CO_2, CH_4, N_2O) emissions from restored wetlands were less, presumably because of smaller C pools and shorter hydroperiod.

For restored (and natural wetlands), ecosystem services associated with water quality improvement and C sequestration can be valued and enrolled in future regional water quality and national/international carbon trading programs. Valuation of biodiversity functions of wetlands in the region and elsewhere is problematic.

Contact Information: Christopher Craft, School of Public and Environmental Affairs, Indiana University, MSB II room 408, 702 N. Walnut Grove Ave., Bloomington, IN 47405 USA, Phone: 812-856-1837, Fax: 812-855-7802, Email: ccraft@indiana.edu

RESTORING SOUTHEASTERN WETLANDS THROUGH THE WETLANDS RESERVE PROGRAM: ECOLOGICAL AND PROGRAMMATIC TRADE-OFFS

Diane De Steven[1] and *Joel M. Gramling*[2]
[1]U.S. Forest Service Southern Research Station, Stoneville, MS, USA
[2]The Citadel, Charleston, SC, USA

The U.S. Department of Agriculture's Wetlands Reserve Program (WRP) restores degraded wetlands on private working lands by means of financial incentives and easement-based land retirement. Because ecological functions differ among wetland hydrogeomorphic (HGM) types, knowledge of HGM types is a necessary foundation for identifying the possible trade-offs in ecosystem services that may result from program implementations. This theme is illustrated for the Southeastern U.S., a region of diverse wetlands where the nature and outcomes of WRP restorations are largely unstudied. We characterized >100 WRP projects across the region with respect to the wetland types restored and whether restoration actions favored original or alternative HGM functions.

The Southeastern projects encompassed multiple HGM types including depressions, flats, low-order riverine headwaters, and mainstem river floodplains. Pre-restoration habitats varied from agricultural sites to drained vegetated wetlands and timber-harvested bottomlands. Hydrology-restoration methods interacted with wetland type and prior condition to yield different functional implications. Restoration of depressions and flats generally favored original hydrodynamic function, albeit sometimes with added water management for waterbird habitat. Restoration of low-order riverine sites and prior-agriculture floodplains tended to alter hydrodynamics in favor of water retention and managed impoundments for waterbirds, at probable trade-offs with other riverine functions. Conversely, restoration of timber-harvested floodplains favored the removal of barriers to hydrologic and biotic connectivity; these sites also showed unique potential for synergistic landscape-scale benefits to multiple ecosystem services. Rapid field surveys suggested that most restorations achieved positive indicators of functional wetland conditions, although wetland quality remains to be assessed.

The findings highlight several relevant issues. Trade-offs are inherent even in natural wetlands, as no single wetland type maximizes all services. Wetland HGM concepts can improve conservation outcomes by providing a framework for clarifying the functional implications and potential constraints of restoration decisions. However, these decisions are also shaped by programmatic statutory objectives and policies, cost and effort considerations, and landowner motives for participating in voluntary programs. All are practical challenges to planning for sustainable wetland ecosystem services at landscape scales.

Contact Information: Diane De Steven, U.S. Forest Service, Center for Bottomland Hardwoods Research, P.O. Box 227, Stoneville, MS 38776 USA, Phone: 662-686-3602, Fax: 662-686-3195, Email: ddesteven@fs.fed.us

CLIMATE CHANGE AND PEATLANDS IN THE SE-ASIAN TROPICS

Hans Joosten and ***René Dommain***
University of Greifswald, Greifswald, Germany

The peatlands of SE-Asia are the largest area of tropical peatland and store approximately 70 Gt carbon. Land-use and land-use changes pose a significant threat to this major terrestrial carbon reservoir. Here we present an overview on past carbon-climate interactions of peatlands from Peninsular Malaysia, Sumatra and Borneo and on how modern human activities have changed carbon-cycling in these peatlands together with the related impact on the global climate.

SE-Asian peatlands are of Holocene origin and developed in clear relation to past climate changes. The greatest spatial expansion of these peatlands occurred during a wet climate phase between 7000 and 4000 years before present. During this period carbon accumulation of coastal peatlands (constituting ~80% of the region's peatlands) was also at a Holocene maximum, reaching over 100 g C m^{-2} yr^{-1}. Afterwards carbon sequestration decreased as climate seasonality became more pronounced. In southern Borneo peatlands even stopped accumulating peat over the last 2000 years in response to intensified activity of the El Niño phenomenon. Yet the overall carbon burial from SE-Asian peatlands prior to human disturbance is estimated at over 8 mega tones (Mt) per year.

Colonization and conversion of peat swamp forests started in the 1960s and massively accelerated over the past 20 years. Currently the worldwide highest deforestation rates are observed in SE-Asian peat swamp forests. Of the original 15 million ha forested peatlands on Peninsular Malaysia, Sumatra and Borneo less than 5 million ha remained by 2010. The extent of peat swamp forest in this region shrunk by 5 million ha over the last decade due to ongoing legal and illegal logging, accelerated conversion to industrial tree-crop plantations of oil palm and Acacia and recurrence of human induced peat fires. Drainage of cultivated peatlands leads to rapid peat subsidence of 5 cm yr^{-1} and associate CO_2 emissions of up to 80 t ha^{-1} yr^{-1} or more. The number and extent of peat fires is clearly correlated to the occurrence of El Niño events and the positive mode of the Indian Ocean Dipole (IOD). During the El Niño and positive IOD events of 1997/98, 2002 and 2006 between 0.5 to 1.5 million ha peat swamp forests were affected by fire. Average annual emissions from peat fires are estimated at 75 Mt carbon (= 350 Mt CO_2 equivalent) for the period 2000-2006. Combining CO_2 emissions from drainage related peat oxidation of currently over 530 Mt CO_2 and from fire shows that SE-Asian peatlands emit almost one giga tonnes CO_2 equivalents per year. Today over 90 % of the peatlands in the study area act as a significant carbon source emitting 25 times more carbon than they would sequester naturally. The climate regulation service of peatlands in SE-Asia is thus severely disrupted.

<u>Contact Information</u>: René Dommain, Institute of Botany and Landscape Ecology, University of Greifswald, Grimmer Straße 88, 17487 Greifswald, Germany, Phone: +49-3834-864177, Fax: +49-3834-864114, Email: rene.dommain@gmx.de

SUSTAINING WETLANDS IN WORKING LANDSCAPES: USING FUNCTIONAL PROCESSES TO INFORM TRADEOFF DECISIONS

N. H. Euliss, Jr.[1], *L. M. Smith*[2], *D. M. Mushet*[1], *S. T. McMurry*[2] and *W. R. Effland*[3]

[1]U.S. Geological Survey, Jamestown, ND, USA
[2]Oklahoma State University, Stillwater, OK, USA
[3]USDA, Natural Resources Conservation Service, Beltsville, MD, USA

Modern landscapes have been highly modified to accommodate a rapidly growing human population that the United Nations has forecast to peak at 9.1 billion by 2050. Consequently, there is great concern over the sustainability of contemporary working landscapes to provide ecosystem services for future generations of humans. Wetlands are among the most complex ecosystems on the planet and provide a wide variety of ecosystem services valued by society. Because human activities in upland areas can alter wetland functional processes that support all ecosystem services, it is important that we look far beyond wetland boundaries in our management efforts. Additionally, since wetlands perform multiple services, simultaneous quantifications of the effects of human activities on multiple services will better inform decision makers charged with evaluating trade-offs and synergisms known to accompany land use change. When used in a modeling context, the real costs of managing for a particular ecosystem service or groups of services can be determined in terms of the potential effects on other services or on overall sustainability of wetland ecosystems and the landscapes that support them. Our goal with this presentation is to foster interest in developing a new paradigm in which management options can be handled as societal choices with decisions being made within a spatial and temporal context that considers functional processes and identifies trade-offs, synergies, and effects on long-term sustainability. In the near future, monitoring and modeling capabilities will improve to the point that we can take the incredible complexities of these ecosystems and boil them down into specific ecosystem services that people can understand and use to design management and policy options that yield sustainable landscapes that deliver multiple ecosystem services. We emphasize the need to be especially cognizant of slowly changing factors (e.g., geologic weathering) that affect functional processes or supporting ecosystem services that may manifest into irreversible problems over time—especially the need to design and implement monitoring systems at relevant spatial scales to track temporal change to ensure early detection and allow time for effective corrections. Wetland ecosystem modeling and monitoring capabilities focused on functional processes will be especially relevant as we move into alternate climate futures. Our portfolio of tools to detect and avoid damage to ecosystem function or detrimental cascading effects must be diverse and effective.

Contact Information: N. H. Euliss, Jr., U.S. Geological Survey, Northern Prairie Wildlife Research Center, 8711 37th Street SE, Jamestown, ND 58401 USA, Phone: 701-253-5564, Fax: 701-253-5553, Email: ceuliss@usgs.gov

THE EFFECTS OF CATTLE GRAZING ON BREEDING WATERFOWL IN INTERMOUNTAIN DEPRESSIONAL WETLANDS

Lauchlan H Fraser[1], *Bruce Harrison*[2], *W. Marc Jones*[1,3], *Denise Clark*[1] and *Brian A. Heise*[1]

[1]Thompson Rivers University, Kamloops, BC, Canada
[2]Ducks Unlimited Canada, Kamloops, BC, Canada
[3]University of British Columbia Okanagan, Kelowna, BC, Canada

We assessed waterfowl breeding pair and brood use of 34 small depressional wetlands in relation to the amount of water retained through the breeding season (wetland fullness), the amount of wetlands on the landscape in 500-meter or 2,000-meter buffers, and wetland exposure to livestock grazing, using bare ground as a measure of grazing intensity. Wetlands ranged from ungrazed to heavily grazed. The study was conducted over two years in the southern interior of British Columbia, Canada. Waterfowl were classified into four functional groups: dabbling ducks, diving ducks, and two subgroups of diving ducks, overwater nesters and cavity nesters. We evaluated candidate models with variables considered singly and in combination using the Akaike Information Criterion. The global model was the best approximating model for dabbler broods and diver and cavity nester pairs. Bare ground appeared in the best models for all groups except cavity nester broods, wetland density in all models except for dabbler and overwater nester pairs, and wetland fullness in models for diver and cavity nester pairs and dabbler and cavity nester broods. For a subset of 17 wetlands, we collected Information on aquatic invertebrates over one breeding season. When invertebrate density was included in the candidate models for breeding pairs, it was the best approximating model for dabblers, divers, and overwater nesters (the latter with the addition of bare ground). For all models, bare ground and wetland density were negatively associated with breeding use while wetland fullness was positively associated. Overall, the most important variables affecting breeding waterfowl use of wetlands were bare ground and wetland fullness where breeding use was between 109% and 434% higher in full wetlands and declined between 38% and 87% as bare ground increased by 2 SD. Wetland water levels are obviously intrinsic to their ability to support waterfowl, but grazing also limited waterfowl breeding use by reducing wetland vegetation biomass and altering vegetation community composition. As grazing intensity increased, we observed a continuous reduction in the value of a wetland for waterfowl, rather than a hard threshold; however, even moderate amounts of grazing noticeably decreased waterfowl pair and brood use.

Contact Information: Lauchlan H. Fraser, Department of Biological and Natural Resource Sciences, Thompson Rivers University, Kamloops, BC V2C 5N3 Canada, Phone: 250-377-6135, Fax: 250-377-6069, Email: lfraser@tru.ca

ESTIMATING THE CUMULATIVE ECOLOGICAL EFFECT OF LOCAL SCALE LANDSCAPE CHANGES IN SOUTH FLORIDA

Dianna M. Hogan[1], *William Labiosa*[2], *Leonard Pearlstine*[3], *David Hallac*[3,4], *David Strong*[1], *Paul Hearn*[1] and *Richard Bernknopf*[2,5]

[1]US Geological Survey Eastern Geographic Science Center, Reston, VA, USA
[2]US Geological Survey Western Geographic Science Center, Reston, VA, USA
[3]NPS South Florida Natural Resources Center, Everglades and Dry Tortugas National Parks, FL, USA
[4]PS Yellowstone Center for Resources, Yellowstone National Park, USA
[5]Department of Economics, University of New Mexico, USA

Ecosystem restoration in south Florida is a state and national priority centered on the Everglades wetlands. However, urban development pressures affect the restoration potential and the remaining ecologic and habitat functions of natural undeveloped and preserved areas. Land use planning often focuses at the local level, but a better understanding of the regional cumulative effects of small projects may help support landscape level ecosystem restoration and preservation. Many of the effects of development on ecological processes including biodiversity, landscape fragmentation and integrity, and habitat provision for native species, may best be estimated at a regional scale.

A priority when making land use decisions that directly or indirectly influence wetlands is to ensure that Information about the benefits and values provided by wetland ecosystem services is considered. This presentation demonstrates a way to calculate ecological value in environments ranging from preserved wetland habitat to urban areas as a function of local land use and land use changes. Ecological value is evaluated using modeled ecological criteria based on ecosystem services using metrics for (1) biodiversity potential, (2) threatened and endangered species, (3) rare and unique habitats, (4) landscape pattern and fragmentation, (5) water quality buffer potential, and (6) ecological restoration potential. This work was done as part of the development of the South Florida Ecosystem Portfolio Model - a Geographic Information System-based regional land use planning tool developed to help stakeholders visualize the regional effects of different land use scenarios.

The calculation of ecological value will be presented using two case studies based in south Florida: (1) assessing altered ecological value by comparing 2004 land use patterns to potential land use in 2025 and 2050, and (2) the cumulative impact of adding limestone mines south of Miami. The case studies show changing regional ecological value resulting from conversion of natural and agricultural areas to urban, industrial, or extractive use, and demonstrate methods that may facilitate the incorporation of ecological value into land use decision making.

Hogan, Dianna, Labiosa, William, Pearlstine, Leonard, Hallac, David, Strong, David, Hearn, Paul, Bernknopf, Richard. 2012. Estimating the Cumulative Ecological Effect of Local Scale Landscape Changes in South Florida. Environmental Management. DOI: 10.1007/s00267-011-9771-8

Contact Information: Dianna Hogan, Eastern Geographic Science Center, US Geological Survey, Reston, VA 20192, Phone: 703-648-7240, Fax: 703-648-4603, Email: dhogan@usgs.gov

AN EVALUATION OF COASTAL RESTORATION PROJECTS IN LOUISIANA FOR NUTRIENT CREDIT TRADING IN THE LOWER MISSISSIPPI RIVER BASIN

Guerry Holm, Jr.[1], *Ruth Rouse*[2], *Lisa Bacon*[3], *Brian Perez*[1], *Jim Bays*[4], *Charles Killebrew*[5] and *Jennifer Mouton*[5]

[1] CH2M HILL, Baton Rouge, LA, USA
[2] CH2M HILL, Raleigh, NC, USA
[3] CH2M HILL, Albuquerque, NM, USA
[4] CH2M HILL, Tampa, FL, USA
[5] Coastal Protection and Restoration Authority of Louisiana, Baton Rouge, LA, USA

Wetland restoration projects in Louisiana will increasingly rely on resupplying freshwater and sediments from the Mississippi River to its coastal basins. Louisiana is evaluating how its management of river diversions can reduce nutrients to the gulf, and more importantly, the capacity of river diversions to reduce upstream nutrient loads. Recently, Louisiana's Coastal Protection and Restoration Authority (CPRA) assessed whether its coastal restoration projects could create a supply of water quality credits, with a focus on nitrogen and phosphorus. The revenue from these credits would be used by CPRA to provide long-term maintenance, enhancement, and the capacity to expand its restoration projects.

The assessment included an evaluation of the scientific, regulatory, and economic basis for CPRA to generate nutrient credits for different types of projects, with special regard to river diversions. To estimate the potential nutrient credits that could be generated with river diversions, a combination of data from the literature and an area-based nutrient removal model were used to examine how different loading rates affected nutrient removals. The existing science and preliminary modeling demonstrate that delta wetlands have a high capacity for nutrient removals. For example, wetlands receiving flow from one Mississippi River diversion operating for three months with a capacity of 10,000 cfs can remove 3.7 million lbs of TN per year and 560,000 lbs of TP per year.

In Louisiana, the regulatory framework and economic conditions are favorable for producing a supply of nutrient credits at costs that are comparable with selected benchmarks from other states. Since the market potential for CPRA nutrient credit sales is significant, the State is improving monitoring and verification of nutrient reduction, while moving forward with developing the stakeholder, policy, and legal framework to support future nutrient credit trading. Ultimately, there could be significant demand for CPRA nutrient credits. New nutrient criteria in Louisiana and other Mississippi River basin states could generate credit demand and earlier opportunities for demonstration trades or real credit sales. This study will provide insight on how CPRA is establishing the fundamental elements of a nutrient credit trading program that can help advance gulf coast ecosystem restoration.

Contact Information: Guerry Holm, Jr., CH2M HILL, Baton Rouge, LA 70808 USA, Phone: 225-663-5230, Email: gholm@ch2m.com

ON THE MECHANISM AND VALUATION OF ECOLOGICAL SERVICES OF THE DANSHUEI RIVER, TAIWAN

Hwey-Lian Hsieh and *Chang-Po Chen*
Academia Sinica, Taipei, Taiwan

The Danshuei River was a clean and healthy river in the past 50 to 60 years. It provided not only services and goods for people, but also suitable habitats for organisms, such as sweet fish (*Plecoglossus altivelis*), an indicator fish species for good water quality. However, fast urbanization and industrialization seriously degraded the river that its carrying capacity and biodiversity are very limited now.

To provide a basis for a sustainable restoration plan, we applied three different mythologies to evaluate and compare the ecological value of Danshuei River. We first applied a matrices method to relate and prioritize ecosystem functions to human's well-being. By integrating factors of tidal property, section of the river, conception of biomes and land use types, we categorized the Danshuei River ecosystem into 11 sub-ecosystems. Each sub-ecosystem was then evaluated by four functions and services: regulation, provision, support and culture. The preliminary weighting analysis indicated that the main ecosystem functions provided the current Danshuei River are regulation, support, and culture. The function of provision is relatively weak.

Secondly, we designed survey questions to evaluate people's willingness to pay for services and goods provided by the Danshuei River. However, when there are no markets for certain services and goods, it is difficult to apply economic evaluation method. To fill this gap, we thirdly applied the concept of emergy to the valuation process, so that the total value of a sustainable ecosystem can be estimated.

Our study provides a new framework for a more completed view of the mechanism and valuation of river ecosystem services, and can be used to inform policy makers a clearer direction to reconstruct the functions and its corresponding services of the Danshuei River ecosystem.

Contact Information: Chang-Po Chen, Biodiversity Research Center, Academia Sinica, No128 Academia Rd., Sec2, Nankang, Taipei, Phone: 886 2 27899846, Fax:886 2 27858059, Email: zohl@gate.sinica.edu.tw

EFFECTS OF RAISED WATER LEVELS ON WET GRASSLAND PLANT COMMUNITIES IN SOUTHERN ENGLAND

Chris B. Joyce[1] and *Sarah E. Toogood*[2]
[1]School of Environment and Technology, University of Brighton, UK
[2]Halcrow Group Ltd., Worcester, UK

Wet grasslands are of international importance for the characteristic biological diversity they support but many have been destroyed or degraded by agricultural intensification, usually involving drainage. This study examined the effects of raised water levels on wet grassland plant communities in a series of meadows (cut for hay) and pastures (grazed) in south east England. It aimed to establish the extent to which time since raised water levels, vegetation management, and water regime influenced community composition. Plant communities and hydrology were monitored for three years within 23 wet grassland meadows and pastures where water levels had been raised for nature conservation at different times over 21 years. Community variations were examined using species abundance and ecological traits. Water regime, measured by duration of flooding, groundwater level and soil moisture, was significantly related to plant community variation. Communities were divided into grasslands where inundation was shallow (≤8 cm) and relatively short (≤3 months) and sites where deeper flooding was prolonged (≥5 months) supporting a variety of wetland vegetation. With increasing wetness, sites were characterized by more bare ground and wetland plants such as sedges, helophytes and hydrophytes, and species with a Stress-tolerating Competitive strategy. All sites showed considerable annual dynamics, especially those with substantially raised water levels. There were no significant relationships between time since water levels were raised and plant community composition. Grassland management exerted a limited influence upon vegetation compared to water regime. The study suggests that grassland plant communities are responsive to raised water levels and have potential for a rapid transition to wetland vegetation, irrespective of grazing or cutting management. Creation or restoration of wet grasslands by (re)wetting is feasible but challenging due to the high dynamism of wetland plant communities and the need for substantially raised water levels and prolonged flooding to produce significant community changes. Reconciling water levels for nature conservation within an agricultural landscape may therefore be difficult as grazing or hay-cutting can be delayed where high water levels persist, leading to lost production and the need for financial compensation for farmers.

Contact Information: Chris B. Joyce, School of Environment and Technology, University of Brighton, Cockcroft Building, Lewes Road, Brighton, BN2 4GJ, United Kingdom, Phone: +44 1273 642422, Fax: +44 1273 642285, Email: c.b.joyce@brighton.ac.uk

TRADITIONAL LOW-DENSITY CATTLE RANCHING AS A TOOL FOR THE PROTECTION OF THE PANTANAL

Wolfgang J. Junk[1,2] and *Catia Nunes da Cunha*[1,2]
[1] Universidade Federal de Mato Grosso, Brazil
[2] Brasilian Institute of Science and Technology for Wetland, Brazil

Low-density cattle ranching is an economic activity that has been carried out by Europeans in the Pantanal for about three centuries. The savanna vegetation provides natural pasture for cattle and horses and is a source of economic wealth to the ranchers.

In the past, the impact of low-density cattle ranching on habitat and species diversity was small. But we have to recognize that large areas of the Pantanal are no longer pristine wetlands, but carefully managed “cultural landscapes”, which maintain natural habitat-, species- and functional diversity.

However, in recent decades, the situation has changed. First, the high flood in 1974 resulted in dramatic economic losses of the ranchers, and second, intensive cattle ranching in the uplands surrounding the Pantanal created a heavy economic competition to the ranchers inside the Pantanal. Their response has been to intensify ranching, with negative side effects on the Pantanal's ecosystem subsequent to the increased animal density per unit area, the planting of exotic grasses to increase food availability, and the destruction of the forest cover to expand pasture area.

Therefore, for many environmentalists, cattle ranching is now perceived as posing a threat to the Pantanal's integrity. Nonetheless, an analysis of the environmental conditions of the region shows that low-density cattle ranching continue to be wetlands-friendly and that there is no better economic alternative to this traditional activity. To maintain the Pantanal as a highly valuable wetland, an agreement must be reached between the ranchers, who own more than 80% of the Pantanal, and the state government, which is responsible for environmental protection and its enforcement.

The management measures in this agreement must recognize the economic situation of the ranchers but also protect key habitats that are essential for the Pantanal's functioning as an ecosystem and for the maintenance of its species diversity. Tax exemptions for protected habitats can be an important economic incentive to achieve these goals.

Contact Information: W. J. Junk, INCT-Wetlands, UFMT, Cuiabá, MT Brazil,78060-090, Phone: 0055-65-36158896, Fax 0055-65-36158878, Email: wjj@evolbio.mpg.de

MONEY AND EMBODIED ENERGY-BASED VALUATIONS FOR WETLANDS UTILIZATION OF WASTEWATER TREATMENT

Jae-Young Ko
Texas A&M University at Galveston, Galveston, TX, USA

Incorporating ecosystem services into environmental policy-making processes have been strongly advocated by academicians and government officials. In Louisiana forested wetlands have been used to provide advanced secondary and tertiary treatment for municipal wastewater for a number of cities in southern Louisiana. Wetland assimilation provides the same services of conventional methods (e.g., sand filtration), such as nutrient, organic matter, and suspended solids reduction, while having positive impacts on the wetlands, including increased vegetative productivity, surface accretion, and carbon sequestration.

The City of Breaux Bridge, Louisiana, has been permitted by the Louisiana Department of Environmental Quality and the US Environmental Protection Agency in 1997, to discharge treated municipal wastewater for secondary level into a forested wetland. Natural forested wetlands near the existing treatment facility have been utilized as a way to meet the increased criteria of water quality to the level of tertiary treatment in treating wastewater. Benefits and costs of utilizing forested wetlands for the additional treatment using conventional money-based cost-benefit analysis and embodied energy analysis are assessed.

Methodologically, embodied energy analysis accounted for non-monetary values such as carbon sequestered by wetlands ecosystem, while conventional cost-benefit analysis provided market price-based assessment. Wetlands treat more wastewater per unit of energy, and with less financial cost than conventional methods.

The comparative approach will provide new insights in discussions of ecosystem service valuation, and in designing sustainable community, by providing an input to policy makers and stakeholders to broaden their appreciation of the complex interconnectivity between natural ecosystem services and the human economy**,** for improved management of natural ecosystems including wetlands, because the quantified values of financial and energy analyses reflect epistemological differences.

Contact Information: Jae-Young Ko, Dept of Marine Science, Texas A&M at Galveston, Galveston, TX 77553 USA, Phone: 409-740-4919, Fax: 409-740-4787, Email: koj@tamug.edu

BRINGING TOGETHER SCIENCE AND POLICY TO PROTECT AND ENHANCE WETLAND ECOSYSTEM SERVICES IN AGRICULTURAL LANDSCAPES: RESULTS OF THE OECD WORKSHOP

Richard Lowrance
USDA-ARS, GA, USA

A workshop sponsored by the Organisation for Economic Cooperation and Development (OECD) was held in Rotorua, New Zealand in September, 2011. The workshop will provided a forum to bring together both scientific and policy understandings of the value of wetlands in agricultural landscapes. It was hoped that outcomes from the workshop would provide a valuable resources for OECD countries seeking to obtain a broader range of ecosystem services from agricultural landscapes that include healthy and biodiverse wetlands. Invited speakers were asked to address the following questions.
To what extent has policy development been guided by wetland science and what additional science is needed to show or quantify the costs and benefits of wetland restoration? How does policy currently impact the science and implementation of wetland restoration ecology? How do wetland policies relative to agriculture differ among OECD countries and how do those differences manifest themselves in landscape management approaches and programs? Is the concept of environmental credits and trading markets ready to be implemented based on our current knowledge of wetland ecosystem functions? What tools are available for quantitative analysis of agricultural landscapes and how can those tools is improved to quantify wetland ecosystem services? What level of agricultural intensity and concomitant impacts can wetlands realistically mitigate and sustainably tolerate? Is there a balance of wetland ecosystem services that policy can or should encourage? How might that be accomplished? What is the optimal scale and location of wetlands to provide such a balance of ecosystem services? How can agricultural landscapes comprised of multiple individually-owned farms be holistically managed in order to provide a sustainable suite of ecosystem services? This presentation will summarize the ideas presented in the workshop and the outcomes of the meeting.

Contact Information: Richard Lowrance, USDA-ARS, 2379 Rainwater Road, Tifton, GA 31794 USA, Phone:229-386-3894, Email:richard.lowrance@ars.usda.gov

WETLAND ECOSYSTEM SERVICES – FINDINGS FROM UK NATIONAL ECOSYSTEM ASSESSMENT AND RELEVANCE TO US

Edward Maltby
Louisiana State University, USA and University of Liverpool, UK

Perception and appreciation of the value of wetlands has changed dramatically from prehistoric to modern times and varies enormously depending on cultural and geographic setting. Early human communities were highly dependent on wetlands for food, shelter and safety but such relationships were commonly under – or not expressly stated and even simply taken for granted. Wetlands became the focus of conflicts in societal priorities in historic times with competing demands for water and land use contributing to severe degradation and loss. Little or no social or economic value was attributed to the work performed by natural wetland ecosystems that were converted to other uses which appeared to yield greater human benefits. Conservation of wetlands is a relatively recent priority, but has generally failed in its traditional form to compete with alternative uses. More recently, however, there has been a shift from protection and / or restoration of remaining wetlands as a biodiversity resource towards a focus on the many, formerly largely undervalued beneficial functions that these ecosystems provide to society.

The UK National Ecosystem Assessment (NEA) assesses the status, trends, ecosystem services and future prospects of eight broad habitat types, including wetlands. Despite problems such as an inconsistent inventory of wetlands, fragmented policy instruments and conflicts with other policy areas, the NEA has enabled an initial assessment of the extent, condition and trends of the current wetland resource in the UK including the degree of loss of different wetland types and their broad implications not only for biodiversity, but for the delivery of a wide range of ecosystem services. It has also highlighted some of the ways in which wetland ecosystem services can be beneficially exploited, for example as buffer zones, in management of freshwater resources or in flood risk management, as well as the trade-offs inherent in different management priorities. The findings of the NEA are summarised in relation to some key challenges of linking wetland science to policy.

The evolution of land use policy and of supporting subsidies indicates transitions in the valuation of different services over the past sixty years. Recognition of the importance of all provisioning, regulatory, cultural and supporting services needs to further shape policy for the sustainable benefit of society. A range of published ecosystem service assessments and studies, including the NEA, have been significant in developing new thinking and policy encapsulated in HM Government's June 2011 White Paper *The Natural Choice*.

This thinking has been tested in the context of the coastal wetlands of Louisiana and a conceptual framework is presented which links the typology of wetlands through functioning to ecosystem services and the needs of different sectors of human society.

Contact Information: Edward Maltby, Louisiana State University, 3267 Energy, Coast & Envir. Bldg., Baton Rouge, LA 70803, USA, Phone: 225-578-6875, Email: emaltby@lsu.edu, School of Environment, University of Liverpool, Email: e.maltby@liv.ac.uk

ABOVE AND BELOW GROUND NUTRIENT CYCLING IN NORTHERN PRAIRIE WETLANDS

Lindsey M. Meyers, *Edward S. DeKeyser, Jack E. Norland* and *Thomas DeSutter*
North Dakota State University, Fargo, ND, USA

Nutrient cycling in wetlands provides crucial ecosystem services. Over the summer of 2011, 53 wetlands were visited across the state of North Dakota. Plant and soil samples were collected at each wetland site and examined primarily for Phosphorus, Carbon, and Nitrogen content. The plant and soil samples were taken at three different landscape positions in and adjacent to the wetland: upland, toe slope, and shallow marsh. These samples were also taken in conjunction with several wetland assessments which were important for comparison modeling: the National Wetland Condition Assessment (NWCA), the Index of Plant Community Integrity (IPCI), the ND Rapid Assessment (NDRAM), and the Hydrogeomorphic Model (HGM). Nutrient resource pools were examined according to wetland type, landscape position, location in North Dakota, surrounding land use, and wetland condition. Significant differences in resource pools vary depending on land use and location across the state. Additional results are presented here.

Contact Information: Lindsey M. Meyers, School of Natural Resource Sciences, North Dakota State University, NDSU Dept. 7650, P.O. Box 6050, Fargo, ND 58108 USA; Phone: 651-428-7398; Fax: 701-231-7861; Email: Lindsey.Meyers@ndsu.edu

RESTORATION OF A RIPARIAN BUFFER: TRADITIONAL AND NON-MARKET BENEFITS AND COSTS

Ron Nelson[1] and *Heather MacKay*[2]
[1] Whatcom Farm Friends, Lynden, WA, USA
[2] FHB Consulting Services Inc., Lynden, WA, USA

This paper reports on the estimation of non-market values for ecosystem services associated with stream buffer restoration on Fourmile Creek in the Nooksack watershed, Washington State.

The Fourmile Creek is a tributary of the Nooksack River. The creek runs through high-value commercial farmland that has historically been drained to support intensive berry, dairy and corn production. Prior to the start of the restoration project, little or no riparian vegetation remained along Fourmile Creek. The stream channel was infested with reed canary grass and choked with sediments. Regular dredging of both the ditches and the creek were necessary to maintain adequate drainage of agricultural land. Instream fish habitat was in a poor state, due to limited water flow and high water temperatures from lack of shade cover.

A partnership was established with the Conservation District, local landowners and Washington Department of Fish and Wildlife (WDFW). Funding was provided by grants from WA Department of Ecology, WDFW and local matching funds. The restoration project involved removal of accumulated sediments and non-native reed canary grass from the stream channel to improve drainage, and then planting of native trees and shrubs in riparian buffers between 15 and 30 feet in width. Since the project was completed in 2005, some maintenance and replanting of vegetation has occurred, but the channel remains clear of sediments and reed canary grass and the water quality meets requirements at the confluence with Tenmile Creek downstream. Instream temperature and dissolved oxygen concentration are still being monitored to gauge the long-term success of the restoration.

Since the initial investment in restoration, the project has generated tangible benefits for agricultural landowners, fish habitat and water quality. In an attempt to quantify these, a pre-analysis of the benefits and costs was undertaken using non-market valuation methods and the benefit transfer method to estimate ranges of values for the ecosystem services provided by the stream restoration. Ecosystem services included increased pollinator habitat, aesthetic value, water quality and biodiversity.

Contact Information: Ron Nelson, Department of Agricultural and Resource Economics Clark B-320, Colorado State University, Fort Collins, CO 80523 USA, Phone: 360-201-2827, Email: Ron.Nelson@colostate.edu

ECOSYSTEM SERVICES OF EUROPEAN WETLANDS – OVERVIEW OF CURRENT SITUATION AND FUTURE PERSPECTIVES

Tomasz Okruszko[1], *Harm Duel*[2], *Mike Acreman*[3], *Mateusz Grygoruk*[1], *Martina Flörke*[4] and *Christof Schneider*[4]

[1]Division of Hydrology and Water Resources, Warsaw University of Life Sciences, Poland
[2]Deltares, Utrecht, The Netherlands
[3]Centre for Ecology and Hydrology, Crowmarsh Gifford, Wallingford, UK
[4]Center for Environmental Systems Research, University of Kassel, Germany

An appropriate hydrological regime within a wetland is essential to maintain its goods and services. This regime is related to the source of water, which is different for particular kinds of wetlands. This paper presents an overview of ecosystem services of European wetlands based on a representative sample of 102 protected wetlands larger than 5000 ha and the implications of hydrological alterations caused by future climate and socio-economic changes. Six major ecosystem services of wetlands were assessed namely: biodiversity in terms of plants and animals, biomass production, nutrient removal, carbon storage and fish production. Data showed that on average, four services were present in each wetland.

The impact of climate change, water management and land use change was examined under different future scenarios. Major potential changes in hydrological regime (i.e. precipitation, groundwater recharge and river flow) were quantified up to the 2050s using simulated runoff and river flow data of the WaterGAP model driven by the climate input of two different General Circulation Models (GCMs), i.e. IPCM4 and MIMR. Thresholds of hydrological change were identified that would endanger each ecosystem service. If the change of the component were greater then arbitrary chosen threshold the particular service has been flagged as endangered. The impacts of future scenarios were distributed across Europe with potential threats to ecosystem services of European wetlands resulting in the loss between 26 to 46% of all identified ecosystem services in 2050.

The models and scenarios suggest that the most significant loss of ecosystem services is likely to occur in central Europe (Hungary, Germany, France, Belarus, Poland). In general, the most fragile services (the largest number lost) are projected to be those connected to the surface water dynamics – mostly the services of wetland birds and fish spawning. Ecosystem services dependent on groundwater dynamics and water balance changes, are seemingly expected to be more buffered to the hydrological stress.

Contact Information: Tomasz Okruszko, Division of Hydrology and Water Resources, Warsaw University of Life Sciences - SGGW, 02-722 Warszawa, Nowoursynowska 159, Poland, Phone: +48 22 59 35 300, Email: t.okruszko@levis.sggw.pl

COASTAL ECOSYSTEM SERVICES AND SEA LEVEL RISE IN FLORIDA: UNDERSTANDING PUBLIC PERCEPTIONS AND VALUES

Laila A. Racevskis
University of Florida, Gainesville, FL, USA

Global sea levels are rising, but the magnitude and future impacts of sea level rise remain uncertain. Florida is particularly vulnerable to the effects of sea level rise because of its extensive coastline and importance of coastal areas for both human and ecological needs. Most of Florida's population lives in coastal areas, and many of Florida's most sensitive and vulnerable wildlife habitats are in coastal areas. Because of the vulnerability of coastal estuaries and the continuation of coastal commercial and residential development, policies and programs are needed to create incentives for the protection of coastal habitats. As we face increases in sea level and continued coastal development, improved Information on stakeholder and public perceptions and awareness of these issues is needed as a key input to equip decision makers with Information that can be used to create innovative, incentive-based conservation and restoration programs.

The objectives of this work are: 1)To improve understanding of the current state of sea level rise policy and planning at the local level in Florida; 2) To develop incentive-based policy scenarios for mitigating the ecosystem effects of sea level rise; and 3) To assess the perceptions, attitudes, knowledge and values of Florida residents with respect to sea level rise and its potential effects on ecosystem services in four coastal regions: Pensacola Bay, Apalachicola Bay, Charlotte Harbor, and Treasure Coast. Objectives are achieved through focus groups, individual interviews and a mail survey.

Three focus groups with general public have been conducted, and multiple stakeholder interviews have been conducted. Information collected from focus groups and stakeholder interviews has been used to design the survey instruments. The first survey has been implemented in the Apalachicola Bay region (Bay, Gulf and Franklin counties). One thousand surveys will be administered by mail (with an online response option) to a random sample of the population in each study region, for a total of 4000 mailed surveys. Some examples of question categories included in the survey include: How you use the coast, Local coastal economy, Coastal storm impacts, Coastal natural resources/ecosystem services, Sea level rise, Environmental attitudes, Economic trade-offs, and additional demographic Information.

Analysis of survey results will provide Information on public awareness of sea level rise and associated coastal ecosystem services, as well as Information on public acceptability of alternative sea level rise adaptation policy scenarios. Analysis will allow statistical estimation of monetary and other trade-offs the public is willing to make in order to protect specific coastal ecosystem services. By collecting data from a representative sample of Florida residents in the study area, as well as Information from key stakeholders, this study provides Information on how Florida residents and stakeholders perceive the potential ecological, economic, and social effects of sea level rise.

Contact Information: Laila Racevskis, Food and Resource Economics Department, University of Florida/IFAS, PO Box 110240, Gainesville, FL, 32611 USA, Phone: 352-392-1826 x324, Fax: 352-392-3646, Email: racevskis@ufl.edu

HYDROECOLOGIC MODELING AND DECISION SUPPORT SYSTEM FOR EVALUATING ENVIRONMENTAL SERVICES FROM RANCHLANDS IN THE NORTHERN EVERGLADES

Sanjay Shukla[1], *Gregory A. Kiker*[1], *Elizabeth Boughton*[2], *Patrick J. Bohlen*[3], *John E. Fauth*[3], *David Jenkins*[3], *Pedro Quintana-Ascencio*[3] and *Hilary Swain*[4]

[1]Agricultural and Biological Engineering Department, University of Florida, Immokalee and Gainesville, FL, USA
[2]MacArthur Agro-ecology Research Center, Lake Placid, FL, USA
[3]University of Central Florida, Orlando, FL, USA
[4]Archbold Biological Station, Lake Placid, FL, USA

Agricultural lands can provide multiple ecosystem services including food, water storage, and wildlife habitat. The Northern Everglades (NE) basin in South-central Florida has been experiencing unnatural flow of water and nutrients to the Lake Okeechobee, adjacent estuaries, and the Everglades and this environmental challenge has created a high demand for water storage. To date, few studies have attempted to field-verify the delivery of multiple ecosystem services (e.g. water storage, biodiversity) and to develop hydroecologic decision tools to evaluate the trade-offs among services. The Florida Ranchlands Environmental Services Program (FRESP), a Payment for Environmental Services (PES) program implemented at eight ranches in NE basin, is paying ranchers for the ecosystem services of increasing water storage and phosphorus treatment. However, FRESP does not include other services or stressors and tradeoffs. Our objectives are to: 1) derive functional models to evaluate trade-offs and feedbacks among existing FRESP measures of hydrology and nutrient reduction, a suite of biodiversity and forage services, and the invasive and pest species stressors; 2) develop hydroecologic models to predict ecosystems services for a suite of water management (WM) scenarios; and 3) develop a Decision Support System (DSS) tool for ranchers and decision makers to compare ecological and economic benefits of an integrated suite of ecosystem services.

We adopt a systems approach to link FRESP water measurements to biodiversity by collecting additional ecological data and conducting quantitative analyses of the tradeoffs among ecosystem services and stressors for a suite of WM scenarios. A spatially distributed hydrological model is used to evaluate the baseline, FRESP, and additional WM scenarios on surface and groundwater fluxes and inundation (upland and wetland) characteristics. The weather and hydrologic data from FRESP is being used to validate the model and use long-term simulations to evaluate the WM scenarios. The scenarios involve different discharge elevations at the outlet of FRESP ranches. The spatially distributed water level and flow predictions will be used to summarize the water depth and hydroperiod that are used to predict changes in forage production, biodiversity, weeds, pests, and invasive species using regression-based relationships between hydrology (measured and simulated) and the field-observed crop production, biodiversity, and pest data. The relationships and the associated impacts on production, biodiversity and stressors will be used within a spreadsheet-based DSS for trade-off analysis of differing ecosystem services and water storage levels.

We use Multi-Criteria Decision Analysis (MCDA) to organize the Information provided by site-specific sampling and hydrologic modeling and the Information resulting from decision maker valuations, environmental factors and situation criticality. Different hydrological and nutrient flow regimes will be input with representative tables showing aggregated hydroperiod and flow characteristics with respect to specific habitat areas. The spreadsheet will allow for exploration of criteria values or criteria weights for exploring various “what if” scenarios with respect to their own management alternatives or through environmental drivers. Users can explore the “sensitivity” of alternative rankings to various preference values or environmental inputs. Our approach is generalizable and will apply beyond this case study of Florida ranchlands to other threatened agro-ecosystems.

Contact Information: Sanjay Shukla, University of Florida, 2685 SR 29 N, Immokalee, FL 34142 USA, Phone: 239-658-3425, Email:sshukla@ufl.edu

WETLAND ECOSYSTEM SERVICES IN AGRICULTURAL LANDSCAPES: OPPORTUNITIES AND RISKS

J. T. A. Verhoeven
Ecology and Biodiversity, Department of Biology, Utrecht University, The Netherlands

Riparian zones along streams and other small wetlands perform important ecosystem services in agricultural landscapes. They improve water quality by retaining nutrients from through-flowing water, sequester carbon and attenuate flood peaks at high discharge. At the same time, they have been shown to enhance biodiversity at the landscape as well as regional scale. However, there is concern about loss of biodiversity and enhanced greenhouse gas emissions where wetlands have become overloaded with nutrient-rich surface water or groundwater. This paper identifies conditions for the best performance of riparian zones and other small wetlands in agricultural landscapes in terms of nutrient and greenhouse gas retention and biodiversity.

The different behaviour of N and P in diffusely loaded riparian zones requires consideration in wetland management and restoration initiatives. Two extreme examples are
(1)catchments with wetlands receiving subsurface drainage water from crop fields or pastures as groundwater input. This water is often very rich in nitrate and poor in phosphates (N:P ratios > 100). N retention in the wetlands is effective and occurs as denitrification and, to a lesser extent, as storage in vegetation and soil organic matter
(2)catchments with wetlands receiving surface runoff from crop fields and pastures where much organic fertilizer is applied. This water is rich in particulate nutrients and is high in N as well as P (N:P ratios <15). Wetland P retention is dependent on soil chemistry (presence of Fe, Ca and Al) and on sequestration in vegetation and soil organic matter.

Agricultural regions with catchments of the first category have large nitrate outputs in their streams. Catchments of the second category have a more impervious soil so that water drains mostly superficially as (sub)surface runoff. In such areas, nitrogen as well as phosphorus loadings to streams are high, and riparian zones along the streams are important for N and P retention. Nutrient richness of such buffer zones increases over time, which often has a reducing effect on wetland diversity. In regions where riparian zones are restored for nutrient retention, it is important to take into account previous agricultural use of these zones. If there is a history of agricultural use, soils may contain large amounts of phosphorous, which could be released upon rewetting and lead to a very eutrophic status of the restored wetland. In such cases, only N retention may still be possible, while combinations with biodiversity enhancement remain unlikely.

High nitrous oxide emissions have been identified in riparian zones used for N retention and could be a concern which would diminish the overall environmental benefit of riparian zones. However, it has been shown that nitrous oxide emissions mainly occur at pH values lower than 4. Such conditions occur mostly in stream headwater areas only, whereas higher-order streams and their riparian zones often have higher pH values, supporting effective denitrification with low nitrous oxide emission.

<u>Contact Information</u>: Jos Verhoeven, Utrecht University, Padualaan 8, Utrecht 3584 CH, Netherlands, Phone: +31302536851, Email:j.t.a.verhoeven@uu.nl

CARBON ACCUMULATION IN COASTAL LOUISIANA WETLANDS: WHAT IS THE CARBON CREDIT VALUE OF RESTORATION?

John R. White and *Ronald D. DeLaune*
Louisiana State University, Baton Rouge, LA, USA

The highly visible coastal phenomenon of wetland loss in coastal Louisiana (LA) can be examined through the prism of carbon accumulation and loss. Carbon storage or sequestration in the rapidly subsiding LA coastal marsh soils was based on vertical marsh accretion rates and aerial change data. Marshes sequester significant amount of carbon through vertical accretion however, large amounts of carbon, previously sequestered in the soil profile is lost through annual deterioration of these coastal marshes. Hurricanes, such as Katrina and Rita, have triggered instantaneous large carbon losses of sequestered soil carbon through the destruction of large areas of marsh. Our analysis shows that proposed coastal restoration efforts will not be sufficient to restore carbon losses by storms and annual marsh deterioration, but efforts do have some value in terms of slowing the rate of wetland loss and sequestering carbon. Further, we have estimated the economic benefit of carbon sequestration for coastal wetland restoration efforts on a carbon-credit basis. While large-scale wetland restoration come with even larger economic costs, we have calculated the carbon-credit value of not only restoring degrading wetland systems but also the economic value of preserving or maintaining the substantial carbon stores present in the soil profile. Coastal Louisiana wetlands provide an annual value of between 29 and 44 million US dollars in carbon credits assuming a credit of between 10 and 15 dollars per ton of C sequestered. With few dollars available for large-scale restoration projects, carbon credits may be the only viable mechanism for funding projects costing in the billions of dollars. In addition, the wetland loss rates and associated restoration techniques in the subsiding LA coastal region may serve as a model predicting the potential for impacts that future predicted increasing global sea level rise will have on carbon sequestration for coastal regions worldwide, because the relative rate of sea level is one order larger than the global eustatic sea level rise.

Contact Information: John R White, Wetland & Aquatic Biogeochemistry Lab, Department of Oceanography, Louisiana State University, Baton Rouge, LA 70803 USA, Phone: 225-578-8792, Fax: 225-578-6423, Email: jrwhite@lsu.edu

HOW DOES THE PROVISION OF ECOSYSTEM SERVICES CHANGE ALONG A GRADIENT OF ECOLOGICAL CONDITION: A CASE STUDY OF CARBON SEQUESTRATION

Sally A. Wilson[1], *Siobhan Fennessy*[1], *Denice Wardrop*[2], *Jessica Moon*[2] and *Alexandra Stamatoiu*[1]
[1]Kenyon College, Gambier, OH, USA
[2]Penn State University, State College, PA, USA

Wetland ecosystem services are critical for human health and well-being (Millennium Ecosystem Assessment, 2003). This has confirmed a need for assessment protocols that quantify the level of services provided by wetlands, detect the impact of human activities on these services, and provide guidance on their restoration. The link between the delivery of ecosystem services and ecological condition lies in the assumption that measures of condition reflect wetland ecosystem processes that in turn drive the delivery of services. If condition is excellent (i.e., least-disturbed, or equal to reference condition), then the provision of services typical of that wetland type should occur at reference levels. Unfortunately, there have been few studies quantitatively testing this assumption, or how the flow of services change as stressors accumulate.

We set out to study the relationship between condition and key ecosystem services such as denitrification, flood storage and carbon sequestration. Wetland soils are a major reservoir of soil carbon yet carbon sequestration in wetlands has been understudied relative to terrestrial ecosystems. We propose an ecosystem service delivery model using measures of condition to predict carbon accretion rates in twenty wetlands located in Ohio and Pennsylvania, where a wealth of biological assessment data already exists. To do this soil cores were collected from riverine and depressional wetlands. Medium-term (40- year) C accretion rates were measured using the radionuclide marker Cesium- 137 (^{137}Cs) in the soil. The depth in the soil profile where Cs-137 activity is maximum indicates the location of the soil surface in approximately 1964. We estimated the rate of carbon accretion using the ^{137}Cs vertical accretion rate, bulk density, and carbon concentration of soil core samples. Carbon accretion was variable across the sites with the highest rates found in floodplain depressions. Links between C accretion rates and measures of ecosystem condition provide models of the accrual of services at site and landscape scales.

Contact Information: Siobhan Fennessy, Biology Department, Kenyon College, 202 N. College Park, Gambier, OH 43022 USA, Phone: 740-427-5455, Fax: 740-427-5741, Email: fennessym@kenyon.edu

EXTREME EVENTS- DROUGHT

DRY DISTURBANCE AND FISH REDUCTION PRODUCE ENHANCED CRAYFISH DENSITIES IN A FRESHWATER WETLAND

Nathan J. Dorn[1] and *Mark I. Cook*[2]

[1]Department of Biological Sciences, Florida Atlantic University, Davie, FL

[2]South Florida Water Management District, West Palm Beach, FL

Dry disturbances are a reality for animal communities in many wetlands. The net effects of drying for any particular population will depend on the life histories/resilience of multiple members of the food web as well as the severity of the disturbance. Drying kills individuals of many aquatic species and sets back the growth of aquatic plants, but when wetlands are subsequently re-flooded the community dynamics may be altered temporarily via food web reorganization (predator release) or nutrient release from soils. Subtropical wetlands in south Florida experience hydrological regimes that include local drying on annual to decadal timescales. Low water conditions reduce the abundances of predatory fishes in these wetlands and the potential for this impact to cascade and release populations of smaller animals has been largely uninvestigated, but populations of some aquatic invertebrates may be temporarily encouraged by fish reductions. In this study we investigated the effects of water level variation on middle trophic levels with a simulated dry disturbance in large replicated wetlands (Loxahatchee Impoundment Landscape Assessment; LILA) over two hydro-years. Abundances of large-bodied predatory fishes (e.g., sunfishes) and densities of smaller animals (crayfish and smaller fishes) were quantified in 2009 and 2010 in four replicate wetlands. From 2008-2010 all wetlands experienced a similar hydrologic regime. In 2010 two wetlands were experimentally dried for 14 days and large-bodied fishes were reduced in the remaining peripheral ponds. After re-flooding the animals were sampled again in the wet and dry seasons. The animal abundances were analyzed with repeated measures models. We also conducted two assays (predation assay, growth assay) after re-flooding in 2010 to examine potential mechanisms that might enhance crayfish recruitment levels.

Large predatory fish abundance, measured by passive trap captures, was temporarily reduced in dried wetlands after the re-flooding in 2010. Juvenile crayfish tethered for a week in the four wetlands in 2010 survived best in the dried wetland with the lowest predatory fish abundance. Growth of small juvenile crayfish fed algae from all four wetlands in 2010 was unaffected by the source of the algae (control or dried wetlands). Before drying, crayfish densities were similar across all wetlands, but in the year after the drying the crayfish density was almost 3-fold higher in dried wetlands. Small fish densities were unaffected, relative to controls, by the experimental drying.

In a complimentary study we quantified crayfish densities from natural sloughs of the Everglades from 2006 to 2011 and modeled the spatiotemporal density variation as a function of seasons (wet or dry) and hydrological covariates. Crayfish densities in sloughs were negatively correlated with average slough depths in the year prior to sampling, but the correlation was seasonally dependent. Taken together, these results suggest aquatic predators depress crayfish densities and that drying temporarily releases crayfish populations from top-down control. These observations may have important implications for understanding the annually variable nesting effort of wading birds like the White Ibis that feed crayfish to their nestlings.

Contact Information: Nathan Dorn, Department of Biological Sciences, Florida Atlantic University, 3200 College Ave., Davie, FL 33314 USA, Phone: 954-236-1315; Fax: 954-236-1099, Email: ndorn1@fau.edu

EFFECTS OF DROUGHT ON RESTORED AND REFERENCE BRACKISH MARSHES IN THE NORTHWESTERN GULF OF MEXICO

***E. L. Kinney**, A.R Armitage* and *A.S. Quigg*
Texas A&M University at Galveston, Galveston, TX, USA

Texas has been experiencing an exceptional drought since October 2010, which has substantially increased salinity in brackish marshes in the Northwestern Gulf of Mexico. A long-term restoration monitoring project in the Lower Neches River Wildlife Management Area (Texas, USA) provided a unique opportunity to quantify brackish marsh community response to severe drought conditions. We examined differences in emergent vegetation and submerged aquatic vegetation (SAV) biomass as well as invertebrate and fish biomass associated with SAV before and during the drought in both reference and restored marsh sites. We found no significant changes in emergent vegetation cover and a marked, but not significant, reduction in SAV biomass, especially in milfoil (*Myriophyllum spicatum*), but also in *Ruppia maritima* biomass at both restored and natural sites. We found significant reductions in the most abundant invertebrate and fish species at all sites, most likely in response to the change in SAV. Milfoil is intolerant of salinities above 15 ppt, and disappeared completely when salinity increased beyond that threshold. While *Ruppia* can tolerate salinities above 25 ppt, biomass did not increase significantly with the reduction in milfoil. The length of this extreme drought appears to have affected *Ruppia's* ability to replace milfoil as the dominant SAV in this system. SAV communities in both reference and restored sites were similarly decimated by the extreme drought conditions, although it is possible that increased rainfall in November and December of 2011 might improve conditions enough to allow for a rebound in the SAV and faunal communities. The different responses of emergent and SAV to changes due to extreme drought highlights the importance of inclusion of SAV in salt marsh restoration monitoring programs.

Contact Information: Erin L. Kinney, Texas A&M University at Galveston, 200 Seawolf Parkway, Ocean and Coastal Studies Building, Room 208, Galveston, TX 77553 USA, Phone: (516)297-2434, Fax: 409-740-5001, Email: kinneye@tamug.edu

EXTREME EVENTS- FIRE

FIRE AND CARBON CYCLING IN BOREAL NORTH AMERICAN PEATLANDS

Brian W. Benscoter[1] and *Merritt R. Turetsky*[2]
[1]Department of Biological Science, Florida Atlantic University, Davie, FL, USA
[2]Department of Integrative Biology, University of Guelph, Guelph, Ontario, Canada

Wildfire is the dominant natural disturbance in peatland ecosystems of boreal North America. Not only do wildfires directly impact regional peatland carbon stocks through peat combustion, but they can also alter the magnitude and direction of peatland carbon exchange through indirect effects on post-fire biotic and abiotic conditions. By removing the living vegetation and altering microhabitat conditions, wildfire resets the successional sequence. Coupling of peatland vegetation structure and carbon storage ability results in concomitant functional change through the successional trajectory, the shape and duration of which is largely controlled by fire severity. However, the relationship between wildfire and peatlands is not unidirectional. The soil conditions, vegetation structure, and distribution of peatland landforms can influence patterns of wildfire occurrence and severity from local to landscape scales. Through these cross-scale, multi-directional feedbacks, peatlands and wildfire interact to control regional carbon dynamics. Synergistic impacts of multiple disturbances have the potential to drastically alter peatland dynamics, compromising ecosystem resilience. Understanding these complex feedbacks has become increasingly important, as future climatic change is projected to increase the frequency and severity of wildfires, placing peatlands and their carbon stocks at risk. In this session, we will discuss the vulnerability, impact, and response of peatland ecosystems from multiple biomes to investigate the global implications of disturbance on peatlands and their carbon dynamics.

Contact Information: Brian Benscoter, Department of Biological Sciences, Florida Atlantic University, 3200 College Ave., Davie, FL 33314 USA, Phone: 954-236-1141,; Email: bbenscot@fau.edu

A SUCCESSIONAL MODEL FOR RESTORATION AND MANAGEMENT OF SOUTH FLORIDA PLANT COMMUNITIES

Michael Duever[1], *Richard Roberts*[2] and *Jean McCollom*[3]
[1]Natural Ecosystems, Naples, FL, USA
[2]Richard Roberts, Florida Department of Environmental Protection (retired), Hobe Sound, FL, USA
[3]Florida Fish and Wildlife Conservation Commission, Felda, FL, USA

An Ad Hoc Committee of the South Florida Interagency Fire Management Council developed a Successional Model for South Florida, which describes relationships among the major natural plant communities in terms of the region's two major environmental processes, its hydrologic and fire regimes. The goals of creating the model were to provide a framework for predicting long-term consequences of alterations in the region's hydrologic and fire regimes that would be precipitated by either offsite activities as surrounding lands are developed or by onsite restoration and management activities. The model was adapted from previous models developed for a number of sites in south and central Florida with different mixes of communities that occurred in the area. The initial step in the process was to define the major plant communities present in South Florida, and to characterize them in terms of their topographic position, substrates, dominant vegetation, and their hydrologic and fire regimes. The direction and timing of transitions between communities in this and the previous models were based largely upon many years of field experience on the part of the authors and other collaborators and on old and recent aerial photography. We also incorporated available field data, such as tree ages and organic soil C-14 dates, which allowed us to extend the temporal depth of the models. We used "best professional judgment" to fill Information gaps. Major assumptions in the models are the constant availability of seeds that could facilitate a transition to another community type if environmental conditions are altered, a long-term perspective for the development of the communities, and the absence of human disturbance. The final models represent our current hypothesis about successional mechanisms that influence the distribution of major plant communities in South Florida for different time durations since the occurrence of a severe fire.

Contact Information: Michael Duever, Ecologist, Natural Ecosystems, 985 Sanctuary Rd., Naples, FL, USA 34120, Phone: (239) 304-1847, Fax: (239) 352-8943, Email: mikeduever@naples.net

A TRANSITIONAL FIRE MODEL FOR RESTORATION AND MANAGEMENT OF NATURAL SOUTH FLORIDA PLANT COMMUNITIES

Richard Roberts[1], ***Michael Duever***[2] and *Jean McCollom*[3]

[1]Richard Roberts, Florida Department of Environmental Protection (retired), Hobe Sound, FL, USA
[2]Natural Ecosystems, Naples, FL, USA
[3]Florida Fish and Wildlife Conservation Commission, Felda, FL, USA

The previous successional model for South Florida was useful for describing how plant communities change over time in the absence of fire. However, the application of fire to the management of natural communities is an important aspect of their restoration and management. While experimental studies of the effects of fire are invaluable for improving management practices, these studies are usually of relatively short duration. An Ad Hoc Committee of the South Florida Interagency Fire Management Council developed Transitional Fire Models for South Florida in an attempt to provide a long-term perspective on how fire regimes determine successional and disturbance transitions among the region's major natural plant communities. Transitions between communities were based largely upon many years of field experience on the part of the authors and other collaborators. Much of this experience was gained from personal observations during and after prescribed burns and wildfires. In addition, Information gleaned from old and recent aerial photographs and available field data, such as tree ages and C-14 dates of organic soils associated with charcoal and ash layers allowed us to extend the temporal depth of the models. We used "best professional judgment" to fill Information gaps. Plant communities were modeled separately for organic and mineral substrates to reduce the complexity of a single model. Major assumptions in the models are the constant availability of seeds that could facilitate a transition to another community type if environmental conditions were altered, a long-term perspective for the development of the communities, and differences in rates of change across a transition boundary depending on the direction of change. The final models represent our current hypothesis about environmental mechanisms that have determined the current distribution of major plant communities in South Florida, and how these communities would be likely to change under different fire regimes. We also identified some transitions that were unlikely to occur without mechanical intervention.

<u>Contact Information</u>: Michael Duever, Ecologist, Natural Ecosystems, 985 Sanctuary Rd., Naples, FL, USA 34120, Phone: (239) 304-1847, Fax: (239) 352-8943, Email: mikeduever@naples.net

PATTERNS IN FIRE - THE RECORDED HISTORY OF FIRE IN EVERGLADES NATIONAL PARK AND BIG CYPRESS NATIONAL PRESERVE

Ann M. Foster[1], *Thomas J. Smith III*[2] and *Ursula Anckarstrom-Bohm*[3]
[1]U.S. Geological Survey, Southeast Ecological Science Center, Gainesville, FL, USA
[2]U.S. Geological Survey, Southeast Ecological Science Center, St. Petersburg, FL, USA
[3]Jacobs Technology, Inc., Gainesville, FL, USA

Fire in the south Florida landscape is influential in shaping the ecosystem. The link between hydrology, soil formation, and fire is a critical complex component in the persistence of the biotic components of the Everglades. As a result, Everglades National Park has been at the forefront of NPS fire policy development since the park was established in 1947. It was the first to allow prescribed burns and one of the first to develop a fire management plan. Shortly after the establishment of Big Cypress National Preserve in 1974, their fire program began as well. Over the past several decades both the Everglades National Park and Big Cypress National Preserve fire programs have acquired a substantial amount of fire history data in the form of paper records, tabular data, fire perimeters hand drawn on 1:24,000 scale USGS topographic maps, and digital data. From these data a geodatabase of fire maps and data has been constructed.

From 1948 to 2010 there were a total of 2,125 fires reported by Everglades National Park. Of these, 1,049 were suppressed, 499 were natural, and 577 were prescribed. The number of fires by year varied greatly, with the fewest number of fires (6) reported in 1966 and the most (91) from 1992 . The high number of fires occurring in 1992 can be attributed to a large number of trash fires started after the passage of Hurricane Andrew. During the last 32 years Big Cypress National Preserve had 2,659 recorded fires. These records span the period 1978 through 2010. Of these, 1455 were suppressed, 594 were natural and 610 were prescribed. There was also great variation in fire numbers over the years. In 1978 only 14 fires were reported while in 1984 133 fires were recorded, the most for any year in the record.

The significant role of wildfire on the landscape makes the availability of these data in a readily usable format vital for many park planning and operational functions. These data can be used in fire management planning and implementation, fire ecology studies as well as for addressing a variety of resource management issues related to the Comprehensive Everglades Restoration Plan. Upon completion, these data will be available in a spatial format to those interested in the fire history of both Everglades National Park and Big Cypress National Preserve.

Contact Information: Ann M. Foster, Southeast Ecological Science Center, U.S. Geological Survey, Gainesville, FL 32653 USA, Phone: 352-264-3565, Fax: 352-378-9546, Email: amfoster@usgs.gov

EFFECTS OF FIRE ON RIVER CANE (*ARUNDINARIA GIGANTEA*) IN A BOTTOMLAND HARDWOOD FOREST FOUR YEARS AFTER BURNING

Paul R. Gagnon and *Heather A. Passmore*
Murray State University, Murray, KY, USA

Canebrakes were vast, monodominant stands of cane (*Arundinaria gigantea* Walt. [Muhl.]), a bamboo native to bottomland hardwood forests in the southeastern USA. Canebrakes were valued as wildlife habitat but have been reduced in areal coverage by an estimated 98% over the last 200 years because disturbance regimes were drastically altered in their riverine habitat. Various canebrake restoration efforts are now ongoing, but are hampered by incomplete understanding of the species' response to natural disturbances. These include periodic fire, which is thought to be a key for the bamboo to attain the monodominant stand structure that characterizes canebrakes.

We used a large tornado blowdown and multiple prescribed fires to quantify the response of cane to the sequential disturbances of windstorm and fire in the Tensas Watershed of NE Louisiana. We have previously demonstrated that fire is beneficial to cane in the short term (1 yr post-fire), especially cane growing in the open tornado blowdown. With this study we returned to the fieldsite 4 years after the prescribed fires to determine long-term effects of fire on cane. We compared stands of cane growing under forest canopy and in the large tornado blowdown, using number and condition of bamboo stems (culms) as our response variable. We hypothesized that: 1) burned cane stands would comprise younger culms than unburned stands, 2) rates of culm damage would be lower in burned stands, and 3) culms would be more abundant in burned than in unburned stands.

Four years after fires, age distributions of culms were younger in burned than in unburned cane stands in both tornado blowdown and forest habitats. Damage rates did not differ for culms in burned and unburned stands ($P = 0.60$) but were higher in forest than in blowdown habitats ($P < 0.01$). Burned 1 m^2 subplots contained on average 4 (± 1.20 SE) more survivors than comparable unburned subplots, and culms were twice as abundant in blowdown than forest subplots (mean = 12.3 ± 1.50 SE vs. 5.9 ± 1.45 SE culms). Our results indicate that fire has a lasting effect on culm demography in cane stands – burning increases culm density and "refreshes" cane stands with newer, more vigorous, culms. Fire can be a useful tool for canebrake management in bottomland hardwood forests. By periodically resetting cane stands, fires may have played a key role in canebrake formation over ecological time in this now threatened wetland ecosystem.

Contact Information: Paul R. Gagnon, Department of Biological Sciences, Murray State University, 2112 Biology Building, Murray, KY 42071, USA, Email: pgagnon@murraystate.edu

PLANT NUTRIENT AVAILABILITY AND SOIL ORGANIC MATTER DECOMPOSITION RESPONSE TO PRESCRIBED WINTER BURNS IN MID-ATLANTIC TIDAL MARSHES

George W. Geatz[1], *Brian A. Needelman*[2], *Raymond R. Weil*[2], *Martin C. Rabenhorst*[2] and *Patrick J. Megonigal*[3]

[1]Illinois Natural History Survey, University of Illinois, Urbana, IL, USA
[2]University of Maryland, College Park, MD, USA
[3]Smithsonian Environmental Research Center, Edgewater, MD, USA

Prescribed winter burning is a commonly used management practice in coastal marshes along the Atlantic Coast to promote the growth of wetland vegetation species favorable for waterfowl habitat, and to facilitate hunting and trapping activities. However, the effects of burning on plant nutrient availability and soil organic matter decomposition rates have not been studied. Two manipulative experiments were conducted at the Blackwater National Wildlife Refuge, USA, within long-term annual burn and no-burn management areas. The study aimed to elucidate the impacts of the two primary postulated burn mechanisms (ash deposition and canopy removal) on nutrient dynamics and plant-soil responses.

Data were collected on plant nutrient contents for two primary species, growing season nutrient availability (resin capsules and porewater), plant ash nutrients, and soil organic matter decomposition rates (cotton tensile strength loss; CTSL). Resin capsule nutrients did not differ between treatments in either the no-burn or burn areas in either May or July. Soil organic matter decomposition rates did not differ between treatments from 0–20 cm during May or July for annually burned areas. No-burn areas with the canopy removal treatment showed significantly lower decomposition rates (66.5 ± 5.46% CTSL) than treatments with a canopy (74.1 ± 4.89% CTSL; $P=0.0448$) in July. Porewater nutrient measurements at no-burn plots in July showed significantly lower amounts of NH_4^+ in sites with canopy removal (0.15 ± 0.06 mg/L) compared to sites with a canopy (0.73 ± 0.28 mg/L; $P=0.0043$). Burn islands also had significantly lower porewater NH_4^+ readings in sites with the canopy removed by burning (0.13 ± 0.04 mg/L) in July compared with the canopy replacement treatment (0.79 ± 0.20 mg/L; $P=0.0049$). Plant ash provided a fertilizer pulse of 0.22 ± 0.02 g N/m^2 and 0.16 ± 0.02 g P/m^2. Considering the literature on fertilization studies in coastal marshes, the ash nutrient data in conjunction with the timing of burning (i.e. which occurs months before the start of the growing season) in an open intertidal system, suggest that an ash fertilization contributed amounts of nitrogen and phosphorus too small to have any effect on vegetation.

<u>Contact Information</u>: George W. Geatz, Wetlands Group, Illinois Natural History Survey, 1816 S. Oak St., Champaign, IL 61820 USA, Phone: 217-244-6716, Email: ggeatz@illinois.edu

CAN SHRUB REMOVAL OR FIRE RESTORE AMPHIBIAN HABITAT IN FIRE-SUPPRESSED PINE FLATWOODS WETLANDS?

***Thomas A. Gorman*[1]**, *Carola A. Haas*[1] and *John G. Himes*[2]
[1]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, Virginia, USA
[2]Florida Fish and Wildlife Conservation Commission, Panama City, Florida, USA

Although fire is recognized as an important disturbance in longleaf pine uplands of the southeastern US, less is known about the importance of fire or other disturbances in the wetlands embedded in this system. Reticulated flatwoods salamanders (*Ambystoma bishopi*), a federally endangered species, breed in the grassy understory of ephemeral pine flatwoods wetlands. These areas contain water in the winter, but dry by April or May in most years, making it possible for fire to carry through them during the summer lightning season. Years of fire suppression allowed a dense mid-story of woody shrubs to develop in these wetlands, and the disappearance of a grassy understory not only removed an important component of larval salamander habitat, but removed the fine fuels important for carrying a fire through the dry wetland in summer. Fire rarely carries through ponds during winter because of the presence of standing water at this time of year (nor are winter fires desirable, due to the risk they may pose to surface-active salamanders). Flatwoods salamanders and possibly other amphibians (e.g., ornate chorus frogs (*Pseudacris ornata*)) are less likely to occur in wetlands with high canopy cover, dense mid-story, or low herbaceous groundcover, conditions that can occur from fire exclusion. We experimentally evaluated mechanical removal of shrubs as a substitute for fire, because these overgrown wetlands were difficult to burn. Our objective was to evaluate whether mechanical treatments could serve as a surrogate for fire, and create vegetative conditions that are similar to high-quality breeding sites (sites that have supported flatwoods salamander larvae in recent years; n=4). Therefore, we chose a series of wetland ponds, including sites that have recently supported flatwoods salamander breeding (i.e., high-quality), and sites with no recent use by flatwoods salamanders that had a dense mid-story and low herbaceous groundcover (i.e., low-quality). A subset of the low-quality ponds was then assigned to be mechanically treated (i.e., treatment sites, n=8), burned (n=4), or serve as a reference (n=7). Mechanical treatments reduced canopy cover (from 55.7% to 41.4%) to similar levels as high-quality sites (36.7%), however herbaceous groundcover had not recovered (17.2% post-treatment compared to 37.3% at high-quality sites). Fire reduced the canopy cover (from 41.3% to 33.0%), however again herbaceous groundcover (33.2% post-treatment compared to 36.3% pre-treatment) did not increase as of 4-months post burn). More time will be required to assess the response of herbaceous groundcover and whether mechanical methods can be used as a surrogate for fire to restore amphibian breeding habitat. Identifying surrogates for fire could add an important technique to our management toolbox.

Contact Information: Thomas A. Gorman, Department of Fish and Wildlife Conservation, Virginia Tech, MC 0321, Blacksburg, VA 24061 USA, Phone: 540-250-8594; Fax: 540-231-7580, Email: gormant@vt.edu

THE IMPACT OF FIRE ON SOIL AND PLANT NUTRIENT LEVELS IN CALCAREOUS SUBTROPICAL WETLANDS

Patrick W. Inglett*,* *Benjamin A. Hogue, Cassandra A. Medvedeff, Xiaolin Liao* and *Todd Osborne*
University of Florida, Gainesville, FL, USA

Fire is a critical regulator of biogeochemical cycles in approximately 40% of the earth's land surface. Fire is known to increase the abundance of desired plant species in wetlands, however, it also releases phosphorus stored in plant biomass and soil organic matter which may further exacerbate the problem of phosphorus (P) enrichment in these systems. We used laboratory and field experiments to evaluate the potential negative impacts fire may have on a young, more N-limited restored wetland and a native P-limited, marl prairie reference wetland in Everglades National Park, Florida, USA.

The sites undergoing restoration from P loading contained woody and undesirable plant species, allowing for a greater storage of P in plant biomass. All sites recorded an increase in P after the fire; however, overall soil P storage was not greatly altered. Conversely, storage of extractable P was doubled after the fire and did not diminish greatly up to one year later. Periphyton may have played a critical role in the initial uptake and storage of P and most likely contributed to the observed release of P over time. Measured phosphatase activity and biomass nutrient ratios indicated that P limitation persisted after burning except at the most enriched site. This may indicate that while fires do increase P availability, an overall shift away from P limitation will most likely not occur except in sites of high P enrichment.

During muffle and lab combustion of both plant biomass types, carbon and nitrogen (N) were volatilized (>99%), while P remained in high concentrations in the residues. It was also found that of the N and P remaining in flame combustion residues, only 5% N and 50% P was extractable. These results are in contrast with similar muffle furnace residues where 95% N and 90% P remaining was readily extractable. Because the flame combustion was most like an actual field fire, we concluded this method was more appropriate for mimicking field fire residues in the laboratory. These results can be adapted to fire impact models to predict potential nutrient enrichment that may occur after a fire-event.

Contact Information: Patrick W. Inglett, Soil and Water Science Department, University of Florida, Gainesville, FL 32611 USA, Phone: 352-392-1804, Fax 352-392-3399, Email: pinglett@ufl.edu

ESTIMATING EVERGLADES PEAT VULNERABILITY TO COMBUSTION

James T. Johnson and *Brian W. Benscoter*
Florida Atlantic University, Davie, FL, USA

Fire is an important ecological component of wetlands. Natural fire regimes help maintain native vegetation communities and their ecosystem functions and services. However, disruptions of natural disturbance regimes can have detrimental impacts on peatlands, jeopardizing ecosystem health. In particular, peatlands like the Florida Everglades store massive amounts of carbon as soil organic matter, comprising one of the largest terrestrial carbon stocks on Earth. While this soil carbon is largely protected under natural fire conditions, hydrologic disturbances from water management practices or climate-induced drought as well as shifts in vegetation or soil properties can alter wetland fire behavior and place these soil carbon stocks at risk. In order to better understand the risk of soil carbon loss during combustion, we applied a heat-balance model of combustion severity developed for boreal peatlands to soil profiles representative of the Everglades to evaluate the interactive effects of soil fuel properties on the depth of soil burning. Peat cores collected from Everglades Water Conservation Area 3A during the drought of 2011 were used to create high resolution profiles of soil bulk density, moisture and carbon content, and composition. We then applied these fuel distributions to the combustion model framework to assess potential depth of burning and carbon loss under different fire behavior scenarios. Understanding the mechanistic controls of soil combustion behavior during wildland fires in the Everglades will provide a valuable tool for fire management agencies as well as aid in assessing the vulnerability of subtropical peatlands to synergistic or altered disturbance regimes and their impact on wetland ecosystem resilience.

Contact Information: James T. Johnson, Environmental Sciences, Florida Atlantic University, 3200 College Ave. Davie, FL 33314 USA, Phone: 706-308-6396, Email: jjohn249@fau.edu

TRACKING EVERGLADES FIRE SCAR VEGETATION RECOVERY THROUGH ARCHIVAL LANDSAT IMAGE INTERPRETATION

John W. Jones[1], *Annette E. Hall*[1], *Thomas J. Smith*[2] and *Ann M. Foster*[3]
[1]U.S. Geological Survey, Reston VA, USA
[2]U.S. Geological Survey, St Petersburg, FL, USA
[3]U.S. Geological Survey, Gainesville, FL, USA

We are exploring the utility of tracking vegetation recovery in the wake of fires in the Florida Everglades through visual interpretation of a time series of false color composited Landsat imagery. Thus far, 34 fire scars that formed between 2000 and 2004 within three landscape units (The Northern Rocky Glades, Western Perrine Marl Prairie, and NE Shark River Slough) are being evaluated for the length of time required to reestablish green vegetation at the site ("greenup"), and for the length of time required for the scar to disappear ("recovery"). Greenup is declared when a scar's contents shift from brown, black, or tan, to green. Recovery is declared when a scar's original edges are no longer visible in wet season imagery. Everglades Depth Estimation Network (EDEN) water level data are being used to evaluate possible links between hydrology and the progression of vegetation recovery in the wake of Everglades fires.

Our preliminary findings suggest that satellite imagery can, indeed, be used in this fashion to follow vegetation recovery. To be most effective, future work should characterize functional recovery times through field work and evaluate how the timing of the return to full ecosystem function relates to a scar's disappearance in the satellite imagery. And, in addition to hydrology, other factors that may affect recovery times, such as burn intensity, burn duration, and the pre-burn character of the vegetation and substrate in the area, may be important and could also be evaluated in conjunction with image interpretation.

Contact Information: Annette E. Elmore, Eastern Geographic Science Center, U.S. Geological Survey, MS521, National Center, Reston, VA 20192 USA, Phone: 703-648-4805, Fax: 703-648-4163, Email: aelmore@usgs.gov

RESPONSE OF MICROBIAL ACTIVITY, RESPIRATION AND METHANOGENESIS TO FIRE RESIDUES (ASH AND CHAR) IN TWO CONTRASTING SUBTROPICAL WETLAND SOILS

***C.A. Medvedeff**, B.A. Hogue, K.S. Inglett* and *P.W. Inglett*
Department of Soil and Water Science, University of Florida, Gainesville, FL, USA

Fire is a common restoration and management technique in the southern United States. Fires (prescribed and natural) in calcareous subtropical wetlands can have drastic effects on ecosystem function however; there are few studies investigating the effects of fire on carbon (C) cycling in these ecosystems. To determine the effect of fire on C cycling, combustion residues (ash and char) were created using litter material from high and low phosphorus (P) marl subtropical wetlands (Everglades National Park) and added to experimental microcosms of soils from these sites. The objective of this study was to determine if fire residues affect soil enzymes (β-glucosidase, cellobiohydrolase, phosphatase, bis-phosphatase and leucine amino peptidase), aerobic and anaerobic respiration ($CO2$) potentials, extractable C and methanogenesis differently in high and low P wetlands.

Our results show stimulation of all enzymes (C/N/P) in high P amended soils. Regardless of soil P concentration, char stimulated enzyme activity to a greater extent than ash treated soils. Extractable soil total organic carbon (TOC) was increased from low P soils amended with ash and char however; char added to high P soils resulted in decreased extractable TOC. Both fire residues enhanced anaerobic $CO2$ and $CH4$ potentials in low P soils, but simultaneously reduced aerobic $CO2$ production. In contrast, aerobic C processing was increased and methanogenic potentials decreased by adding both fire residues to high P soils. Results of this study indicate that depending on fire characteristics and vegetation type, the effect of fire residue is highly variable and depends on ecosystem characteristics. Fire may stimulate anaerobic C cycling in low P wetlands, but in high P wetlands, it may enhance aerobic C processing and simultaneously suppress methane production.

Contact Information: C.A. Medvedeff, Department of Soil and Water Science, University of Florida, 106 Newell Hall, Gainesville, FL, 32511, USA. Email:medvedeff22@ufl.edu

EFFECTIVE USE OF PRESCRIBED FIRE FOR THE CONTROL OF *MELALEUCA QUINQUENERVIA* AND *LYGODIUM MICROPHYLLUM* IN THE FLORIDA EVERGLADES

Todd Z. Osborne[1], *Robert Compitello*[1] and *Jimi Sadle*[2]

[1]Wetland Biogeochemistry Laboratory, Soil and Water Science Department, University of Florida, Gainesville, FL USA

[2]National Park Service, Everglades National Park, Homestead, FL, USA

Exotic and invasive vegetation in the Florida Everglades continues to be a major ecological threat to the management and restoration of the ecosystem. *Melaleuca quinquenervia*, a widely dispersed tree native to Australia and *Lygodium microphyllum*, a climbing fern native to Asia, both have significant detrimental effects on the wetlands and aquatic systems that make up the Everglades. Both species are known to respond positively to fire, making the use of prescribed fire for their control challenging. While monitoring prescribed fire effects on vegetation communities in the Arthur R. Marshall Loxahatchee National Wildlife Refuge during the 2007-2010 fire seasons, the use of prescribed fire, in concert with significant water on the landscape was successfully employed to maintain native vegetation and remove Lygodium infestations in emergent marsh communities. This practice was also found to successfully kill young Melaleuca seedlings and repress germination of new seedlings. Results suggest that while in some cases, prescribed fire is not recommended for *Melaleuca* and *Lygodium* control, there are specific conditions under which it is a significantly useful tool in control of these invasive and exotic species.

Contact Information: Todd Z. Osborne, Wetland Biogeochemistry Laboratory, Soil and Water Science Department, 106 Newell Hall, Gainesville, FL 32611, USA, Phone: 352-392-1804, Fax: 352-392-3399, Email: Osbornet@ufl.edu

PEAT BOG WILDFIRE SMOKE EXPOSURE IN RURAL NORTH CAROLINA IS ASSOCIATED WITH CARDIO-PULMONARY EMERGENCY DEPARTMENT VISITS

Robert B. Devlin[1] ***Ana G. Rappold***[1] , *Susan L. Stone*[1], *Wayne E. Cascio*[1], *Lucas M. Neas*[1], *Vasu J. Kilaru*[2], *Martha Sue Carraway*[1], *James J. Szykman*[3], *Amy Ising*[4], *William E. Cleve*[5], *John T. Meredith*[6], *Heather Vaughan-Batten*[7] and *Lana Deyneka*[7]

[1]Environmental Public Health Division, National Health and Environmental Effects Research Laboratory, US EPA, Research Triangle Park, NC, USA

[2]National Exposure Research Laboratory, US EPA, Research Triangle Park, NC, USA

[3]Environmental Sciences Division, National Exposure Research Laboratory, US EPA, c/o NASA Langley Research Center, Hampton, VA, USA

[4]Department of Emergency Medicine, School of Medicine, University of North Carolina at Chapel Hill

[5]Pitt County Memorial Hospital, Greenville, NC, USA

[6]Brody School of Medicine at East Carolina University, Department of Cardiovascular Sciences and the East Carolina Heart Institute, Greenville, NC, USA

[7]NC Division of Public Health, NC Division of Health and Human Services, USA

In June 2008 burning deposits of peat produced haze and air pollution far in excess of National Ambient Air Quality Standards, encroaching on rural communities of eastern North Carolina (NC). While the association of mortality and morbidity with exposure to urban air pollution is well established, the health effects associated with exposure to wildfire emissions, and more specifically to peat fire emissions, are less well understood.

To investigate health effects associated with this fire, we obtained daily emergency department visits for cardiac and respiratory conditions for eastern NC counties reported through the state-wide syndromic surveillance system. Satellite measured aerosol optical density was used to distinguish counties most impacted by the dense smoke plume from surrounding reference counties.

This is the first population-based health study of peat bog fire exposures and is based on a nearly comprehensive record of health outcomes from an entire geographic region. We determined relative risk of cardio-respiratory outcomes, cumulative over the lag days 0 through 5 of the exposure to smoke, using Poisson log-linear model with distributed lags . The study demonstrated that exposure to smoke from the wildfire increased visits for asthma, COPD, pneumonia, acute bronchitis and heart failure in a sparsely populated non-urban area. In the exposed counties significant increases in cumulative relative risk for asthma (1.65(95% confidence interval [1.25, 2.17]), COPD (1.73[1.06, 2.83]), pneumonia and acute bronchitis (1.59[1.07, 2.34]) were observed. Emergency Department visits associated with cardiopulmonary symptoms (1.23[1.06, 1.43]) and heart failure (1.37[1.01, 1.85]) were also significantly increased.

This is the first study to demonstrate both respiratory and cardiac effects following brief exposure to peat wildfire smoke. Satellite data and syndromic surveillance were combined to assess the health impacts of wildfire smoke in rural counties with sparse air quality monitoring. A consistent increase in relative risk in the exposed counties for nearly all outcome categories is striking and persuasive in comparison to the reference counties and has potentially significant public health implications.

<u>Contact Information</u>: Ana G. Rappold , US Environmental Protection Agency, Box MD 58 B, 109 T.W. Alexander Drive, Research Triangle Park NC, 27711, USA, Phone: 919-843-9504, Email: Rappold.ana@epa.gov

SMOLDERING COMBUSTION OF ORGANIC SOILS ON THE NORTH CAROLINA COASTAL PLAIN

J. Reardon[1] and *Gary M Curcio*[2]
[1]U.S. Forest Service, RMRS Fire Science Laboratory, Missoula, MT, USA
[2] IPA Fire Environment Specialists, Kinston, NC, USA

Fire plays an important role in the creation and maintenance of wetland communities. Forest and shrub dominated wetlands with large amounts of live and dead surface fuels are common on the North Carolina coastal plain and have the potential to support intense flaming combustion of relatively short duration.

In contrast, longer duration smoldering combustion is supported by the organic soils associated with these wetlands, histisols and mineral soils with thick organic horizons. These wetlands present unique fire management challenges due to potential for prolonged emissions and severe fire effects resulting from the high density of surface fuels and the smoldering of the organic soils.

The organic soil horizons of interest are the porous upper horizon (root mat) which is dominated by roots and moderately decomposed organic material and the denser lower sapric horizon which is composed of more highly decomposed organic material. Laboratory studies were conducted to determine the moisture thresholds that constrain smoldering in these soil horizons. The result of these studies was a simple model that linked the probability of sustained smoldering combustion with soil moisture and soil mineral content. Separate relationships were developed for the upper horizon root mat dominated soils and lower horizon sapric soils. These estimated smoldering probabilities (ESP) are representative of common situations where lightning strikes, the passage of flaming combustion fronts and burning embers are short term ignition events but then smoldering and soil consumption are influenced by soil moisture content and mineral content distribution.

In the current phase of our research, prescribed burning was done to validate our laboratory results. Several prescribed burns were conducted in pocosin wetlands under a range of conditions. These burns also allowed us to examine the effects of large scale variability in moisture content and mineral content during operational burning. Soil moisture and mineral content were sampled before burning. Post burn soil consumption was compared with the estimated smoldering probability (ESP). For root mat and sapric soil horizons an ESP of 10% or less was calculated for soil moisture thresholds greater than 170% and 270% respectively. These thresholds were used in the pre-burn planning and decision making process. One burn was conducted at moisture levels expected to sustain smoldering and subsequent burns were conducted at moisture levels above the thresholds. The results of these burns have been consistent with the predictions based on our laboratory work.

Contact Information: Jim Reardon, RMRS Fire Science Laboratory, Missoula, MT 59808 USA, Phone: 406-329-4849, Email: jreardon@fs.fed.us

SMOULDERING MEGA-FIRES IN WETLANDS AND POSITIVE FEEDBACKS TO THE CLIMATE SYSTEM

Guillermo Rein and *Rory Hadden*
University of Edinburgh, UK

Smouldering fires, the slow, low-temperature, flameless burning, represent the most persistent type of combustion phenomena and the longest continuously fires on Earth system. Indeed, smouldering mega-fires of peatlands occur with some frequency during the dry session in, for example, Indonesia, Canada, Russia, UK and USA. Smouldering fires propagate slowly through organic layers of the ground and can reach depth >5 m if large cracks, natural piping or channel systems exist. It threatens to release sequestered carbon deep into the soil. Once ignited, they are particularly difficult to extinguish despite extensive rains, weather changes or fire-fighting attempts, and can persist for long periods of time (months, years) spreading deep and over extensive areas. Recent figures at the global scale estimate that average annual greenhouse gas emissions from smouldering fires are equivalent to 15% of man-made emissions. These fires are difficult or impossible to detect with current remote sensing methods because the chemistry is significantly different, their thermal radiation signature is much smaller, and the plume is much less buoyant. These wildfires burn fossil fuels and thus are a carbon-positive fire phenomena. This creates feedbacks in the climate system because soil moisture deficit and self-heating are enchanted under warmer climate scenarios and lead to more frequent fires. Warmer temperatures at high latitudes are resulting in more frequent Artic fires. Unprecedented permafrost thaw is leaving large soil carbon pools exposed to smouldering fires for the fist time since millennia. Although interactions between flaming fires and the Earth system have been a central focus, smouldering fires are as important but have received very little attention. But differences with flaming fires are important. This paper reviews the current knowledge on smouldering fires in the Earth system regarding combustion dynamics, damage to the soil, emissions, remote sensing and feedbacks in the climate system.

Contact Information: Guillermo Rein, School of Engineering, University of Edinburgh, Edinburgh, EH93JL, UK,
Phone: +44 131 650 7214, Email: reingu@gmail.com

MAPPING AND ASSESSING TREE ISLAND FIRE DAMAGE & RECOVERY WITHIN THE SHORT-HYDROPERIOD MARL PRAIRIE GRASSLANDS OF THE EVERGLADES

Pablo L Ruiz[1], *Adam A Spitzig*[1], *Jay P Sah*[1] and *Michael S Ross*[1,2]
[1]Southeast Environmental Research Center, Florida International University, Miami, FL, USA
[2]Department of Earth & Environment, Florida International University, Miami, FL, USA

A GIS and remote sensing technique was developed and used to map and evaluate the impact of a fire on tree islands within the short-hydroperiod marl prairie grasslands of the Everglades. This fire, which burned for almost a month, consumed approximately 16,250 ha of environmentally sensitive wetlands within Everglades National Park. Prior to the extinguishment of the fire, aerial surveys indicated that significant portions of the landscape were devoid of all plants and that most tree islands experienced topkill of all trees and were left with little or no standing live biomass.

Normalized Difference Vegetation Index (NDVI) calculated from 2004 and 2009 CIR aerial photography were used to: 1) create a pre-fire, 2008, vector map of all tree islands (≥ $36m^2$) within and up to 500 m beyond the fire boundary and 2) determine post-fire, 2009, tree island burn status. Three-year, 2011, post-fire tree island burn status (recovery) was determined through visual inspection of natural color imagery in Google Earth. Logistic regression models were developed to predict the observed trends in post-fire tree island burned status and recovery.

A total of 7,412 tree islands were identified within the fire boundary. Tree island size varied from 36 m^2, the minimum mapping unit, to a maximum of 63,827 m^2. Tree island density, expressed as a kernel density function, revealed a heterogeneous landscape where tree island density ranged from 0 to nearly 3 tree islands ha^{-1}. The 2009 post-fire analysis revealed that nearly 90% of all tree islands within the fire perimeter burned with the vast majority, approximately 76%, showing some early sign of recovery. By 2011, three-years post-fire, 96% of all tree islands burned showed signs of recovery. For the most part, however, tree island post-fire recovery appears to be slow and mostly associated with early successional herbaceous species (ferns, vines, etc) and shrubs and surviving palms. Nonetheless, limited resprouting and recruitment of trees species has occurred on some islands. The results of the logistic regression model suggested that marsh water table, tree island size and hydroperiod were important parameters that determined the probability of a tree island burning and recovering from a fire.

<u>Contact Information</u>: Pablo L Ruiz, Southeast Environmental Research Center, Florida International University, Miami, Fl, 33199, Phone: 305-348-0493, Fax: 305-348-4096, Email: plruiz.fiu@gmail.com

FIRE AND FLOODING INTERACTIONS: VEGETATION TRAJECTORIES IN THE SOUTHERN EVERGLADES MARL PRAIRIES, FLORIDA, USA

Jay P. Sah[1], *Michael S. Ross*[1], *Pablo L. Ruiz*[1] and *James R. Snyder*[2]
[1]Florida International University, Miami, FL, USA
[2]US Geological Survey, Southeast Ecological Science Center, Ochopee, FL, USA

In an ecosystem, interacting multiple disturbances of different physical and/or biological forms often result in changes in plant community attributes different from, and less predictable than, the independent effects of each disturbance. Fire and flooding are two important ecological processes affecting plant community structure and composition in seasonally-flooded wetlands. In this study, we examined how post-fire vegetation trajectories in wetlands are influenced by various levels of flooding, occurring at different intervals after fire. We collected vegetation composition data pre-fire and two to five years after fire at 70 sites burned between 2005 and 2008 in the southern Everglades marl prairies, the short-hydroperiod grasslands that are the habitat of Cape Sable seaside sparrow (CSSS), a federally-listed endangered species. We analyzed vegetation data using a non-metric multidimensional scaling (NMDS) ordination, and tested differences in vegetation composition between pre-burn and each post-burn year using analysis of similarity (ANOSIM). We examined vegetation recovery by analyzing a change in post-fire vegetation composition at individual sites through trajectory analysis and calculating changes in normalized vegetation difference index (NDVI). NDVI was derived from atmospherically corrected Landsat TM imagery. Sites affected by rapid flooding after fire took a more circuitous route back toward their pre-fire composition, and, for a given time after fire, had higher dissimilarity between pre- and post-fire vegetation composition than sites where water level increased gradually after fire. Within burned areas, NDVI recovery was also related to hydrologic conditions in the first post-fire year. In summary, fire, an integral part of the marl prairie ecosystem, creates vegetation patchiness within the landscape, particularly when its effects on vegetation structure and composition are mediated through changes in hydrologic regime. While the interval between fire and post-fire hydrologic events is important in shaping the response of vegetation to the synergetic effects of these two stressors, it is the relative strength and duration of post-fire flooding that determines the course of vegetation recovery trajectories, which in turn shapes the vegetation mosaic. Finally, we recommend that, in order to produce habitat benefits, fire management in seasonally-flooded wetlands take into account likely post-burn hydrologic conditions, or even manipulate those conditions.

Contact Information: Jay P. Sah, Florida International University, Southeast Environmental Research Center, MM Campus/OE148, Miami, FL 33199, Phone: 305-348-1658, Fax: 305-348-4096, Email: sahj@fiu.edu

FIRE, WATER, SOIL AND SEA LEVEL INFLUENCE THE POSITION OF MANGROVE – MARSH ECOTONES THROUGH TIME

T.J. Smith III[1]*, A.M. Foster*[2]*, G.T. Range*[3] and *J.W. Jones*[4]
[1]USGS, Southeast Ecological Science Center, St. Petersburg, FL, USA
[2]USGS, Southeast Ecological Science Center, Gainesville, FL, USA
[3]Jacobs Technology, St. Petersburg, FL, USA
[4]USGS, Eastern Region Geography, Reston, VA, USA

Ecotones are a dynamic aspect of all landscapes and are areas of sharp environmental gradients between two more homogeneous vegetation types. Ecotones are also responsive to climate change and shifts in the position of ecotones across the landscape can be an indication of a changing environment. In the coastal Everglades a dominant ecotone type is that of mangrove forest and marsh. However, there are a variety of plants that can form the marsh component, including: sawgrass (*Cladium*), needlerush (*Juncus*), spikerush (*Eleocharis*) and succulent (*Sarcocornia*). Environmental factors vary across these ecotones influencing their dynamics, including: water depth, soil type, and occurrence of fires. Increasing sea level over the past 100 years may have also had an impact.

Salinities vary from fresh (0 psu) to hypersaline (>40 psu). Soil types may be highly organic peats or mineral soils. Fires occur commonly along many, but not all, of these ecotone types. Additionally, the frequency of fire varies for any given type of mangrove – marsh ecotone.

We used charts and aerial photographs to map the position of mangrove – marsh ecotones in three coastal regions of Everglades National Park: Lostmans, Harney and upper Shark Rivers. Maps and photos were available for 1928, 1940, 1952, 1964, 1987 and 2004. Images were georeferenced and imported into a GIS. The widths of the mangrove fringe (open water to mangrove-marsh interface) were measured at numerous points along each ecotone, for each date. The number of fires that had occurred along the ecotones was determined from the Everglades Fire History geodatabase.

Ecotones did not show a uniform pattern of expansion over time. Some ecotones had expanded >140m whereas others had not shifted. A significant positive relationship between ecotone movement and fire was found. Ecotones having more fires expanded more than those with fewer fires. For the Harney and upper Shark River study areas ecotone movement was negatively related to sea level rise recorded at Key West. During intervals of more rapid sea level rise, ecotones shifted least, whereas during periods of stable sea level, mangroves expanded into adjacent marshes. However, sea level was not related to ecotone shifts at the Lostmans study area. Finally soil type did not appear to have an influence on mangrove marsh ecotones as those associated with both organic and mineral soils had similar patterns. Water levels at the upper Shark River study area have increased steadily since 1953 and the area of mangrove habitat has increased correspondingly. Continuing work will attempt to determine the amount of variation that each of these factors contributes to the overall ecotone movement.

Contact Information: T.J. Smith, Southeast Ecological Science Center, U.S. Geological Survey, St. Petersburg, FL 33701 USA, Phone 727-803-8747, Fax: 727-803-2030, Email: tom_j_smith@usgs.gov

MASS MORTALITY OF HARDWOOD SHRUBS AFTER A SINGLE FIRE IN SEASONALLY FLOODED PRAIRIE

James R. Snyder[1] and *William T. Hilton*[2]

[1]U.S. Geological Survey, Ochopee, FL, USA
[2]Jacobs Technology, Ochopee, FL, USA

Fire is often seen as a mechanism by which to reverse the invasion of hardwoods into prairies. In south Florida, hardwood shrubs, including wax myrtle (*Myrica cerifera*), are occasionally found growing in seasonally flooded prairies, although wax myrtle is found in higher than normal densities in some disturbed prairies within Big Cypress National Preserve. These prairies were farmed during the 1940s and 1950s but in general retain the species composition of undisturbed prairies. The prairies have been burned several times in the last 25 years and, although fires typically kill the aboveground portion of the shrubs (topkill), the plants resprout from the base and the overall shrub density does not appear to decline. In 2010 we observed a prairie in which there was no apparent resprouting of shrubs topkilled by a June 2008 prescribed fire. Nearby prairies that had burned recently showed only minimal mortality.

The most likely explanation for the nearly complete mortality of the woody plants in this prairie was that the site was flooded soon after the fire and the belowground parts of the wax myrtles could not survive the period of anoxia. Data from the Everglades Depth Estimation Network (EDEN) database confirmed that water levels were well below the ground surface at the time of the burn and rose above the ground surface within 2.5 weeks after burning.

To see how rapidly topkilled wax myrtles regrow we observed the pattern of resprouting of wax myrtles following a February 2011 fire. No plants had basal sprouts until more than 2 weeks postfire and it took nearly four weeks for half of the plants that survived to resprout. The delay in activation of dormant meristems results in a longer period of vulnerability to flooding in woody plants than in graminoids such as sawgrass or cattails whose active meristems are not killed by fire.

Mortality of emergent herbaceous prairie plants such as sawgrass and muhly grass due to flooding soon after fire has been observed frequently, but to our knowledge this is the first time it has been documented for woody plants.

Contact Information: James R. Snyder, Southeast Ecological Science Center, U.S. Geological Survey, 33100 Tamiami Trail, Ochopee, FL 34117 USA, Phone: 239-695-1180, Fax: 239-695-3007, Email: jim_snyder@usgs.gov

FIRE EFFECTS ON WADING BIRD FORAGING HABITAT AND RESOURCES

Louise S. Venne and *Peter C. Frederick*
Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL, USA

Prescribed fire is commonly used to manage upland habitat for the benefit of wildlife; however, how fire effects translate to impacts on wetland-dependent species and their usage of wetlands is poorly understood. Past studies conducted show that species respond both positively and negatively to fire, generally dependent on their life history traits (e.g., species preferring dense vegetation are rarely found in recently burned areas). Wetland dependent species such as waterfowl benefit from burns due to the new vegetation that grows after the fire. Preliminary studies in cattail-dominated marshes suggest that long-legged wading birds (i.e., herons, egrets, ibises, storks, spoonbills, order Ciconiiformes) are attracted to recently burned areas preferentially. This may be due to shallower water, increased prey density, or availability of prey. To further explore this issue, we conducted a number of studies to quantify fire effects on primary producers and consumers, determine whether wading birds prefer burned areas, and establish reasons why wading birds may prefer these areas. Our results indicate that immediately after a burn, primary producers increase in biomass after a fire, but fish do not. Immediately after the fire, wading birds were found in greater numbers in burned areas than in adjacent sloughs, but this changed as water levels dropped and prey moved to the sloughs. Thus, the open habitat created by fire over shallow water probably enhances availability of fish to wading birds, resulting in an increased number of wading birds in burned areas immediately after the fire.

Contact Information: Louise S. Venne, Department of Wildlife Ecology and Conservation, University of Florida, 110 Newins-Ziegler Hall, PO Box 110430, Gainesville, FL 32611 USA, Phone: 352-846-0643; Fax: 352-392-6984, Email: lvenne@ufl.edu

TROPICAL PEATLANDS OF SOUTHEAST ASIA: FUNCTIONS, THREATS, AND THE ROLE OF FIRE IN CLIMATE CHANGE MITIGATION

Matthew Warren[1] and *J. Boone Kauffman*[2]

[1]USDA Forest Service, Northern Research Station. Durham, NH, USA

[2]Oregon State University, Dept. of Fisheries and Wildlife, Corvallis, OR, USA

Approximately 11% of Earth's peatlands occur in the tropics, distributed throughout 61 countries in Africa, Asia, Central America and the Caribbean, South America, Australia and the Pacific. The majority (56%) of tropical peatlands occur in Southeast Asia. Indonesia alone contains about 47% of the world's tropical peatlands, where vast freshwater peat swamp forests occur on coastal plains and in low lying interior basins of Borneo, Sumatra, and West Papua. Indonesia's wetland forests are well known as refugia for threatened species with high conservation value including orangutans, gibbons, Sumatran tigers, clouded leopards, and flora such as *Nepenthes* pitcher plants and orchids. Wetland forests on organic soils supply valuable ecosystem services to local populations including hydrological regulation, timber for construction and fuel, non-timber forest products, protection from tidal and storm surges and buffer coastal systems from terrestrial sedimentation and pollutants. Tropical peat swamp forests also store immense pools of belowground carbon from the steady accumulation of organic matter over millennia. Our recent studies indicate that Indonesian peat swamp forests are among the most carbon dense terrestrial ecosystems on Earth, storing ten- to fifty times more carbon than upland tropical, temperate and boreal forests per hectare. However, the carbon stored in these wetland forests is extremely vulnerable. Despite their values, deforestation rates of tropical wetland forests exceed those of any other forest type throughout insular Southeast Asia, and current trends of wetland draining and burning continue at an alarming pace.

Here we provide an overview of the current state of knowledge and extent of Asian peatlands impacted by fire, discuss underlying causes, consequences, and mitigation strategies, and apply original data to assess the climate implications of C emissions associated with tropical peat fires. Indonesia is now one of the world's top 5 emitters of greenhouse gases, yet 50% of those emissions are due to land use and land cover change, most of which occurs on peatlands. Peat oxidation from burning and decomposition contribute substantially to Indonesia's emission profile, which could be greatly reduced if underlying social and environmental causes of peatland fires are confronted. In addition, increasing frequency, severity, or duration of dry periods in insular Southeast Asia associated with climate change would exacerbate the negative consequences of peat fires and associated greenhouse gas emissions, contributing to additional climate forcing.

Contact Information: Matthew Warren, USDA Forest Service, Northern Research Station, 271 Mast Road, Durham NH 03824 USA, Phone: 603-868-7744, Fax: 603-868-7604, Email: mwwarren@fs.fed.us

SCALE-DEPENDENT MICROCLIMATE EFFECTS OF WETLAND WILDFIRE

Adam C. Watts*, Leda N. Kobziar* and *Timothy A. Martin*
University of Florida, Gainesville, FL, USA

During severe or prolonged droughts, wildfires may enter wetlands normally protected from fire by inundation or fuels sufficiently moist to prevent combustion. In addition to myriad effects on biogeochemical cycles, hydrology, and carbon pools, the combination of plant mortality and consumption of biomass by fire may cause substantial changes to the physical structure of wetland plant communities during these rare events. One indirect suite of effects that may be predicted from these structural changes is alteration of local microclimate. For example, the removal of dense understory vegetation by fire, and thinning of live trees via mortality, may be expected to increase insolation to the understory or soil surface, and therefore mean or maximum temperatures near ground level. Increased air circulation also can be predicted, with attendant decreases in local humidity compared to the high values normally found in wetlands (particularly in landscapes comprised substantially of relatively drier upland communities). Given the effects of edge distance on microclimate already predicted by longstanding theories from landscape ecology, one might expect to find greater effects of fires in small patches of wetland forests compared to large ones. We would expect these effects to produce a feedback to microclimate-mediated fire severity in future scenarios of drought-condition fires, with smaller patches exhibiting a stronger positive feedback between fire and microclimate than large ones.

A 2009 wildfire in Big Cypress National Preserve during an extended drought provided the opportunity to test predictions of edge-dependent fire feedbacks to microclimate in wetland forests. The landscape of Big Cypress, a mosaic of wetland and upland communities including wetland forest patches dominated by pondcypress (*Taxodium distichum* var. *imbricarium*), provided a range of sizes of forested wetland patches affected by fire. Following a year of microclimate measurements, our data support predictions of edge effects on diurnal temperature and humidity, and positive feedbacks in small patches. Findings in larger patches, however, did not conform to our expectations. We will present alternative theories that may explain our findings, and describe experiments currently in progress to test new hypotheses. We will discuss the potential impacts of altered microclimate on the effects of future wildfires that may affect wetland forests more frequently in the future as predicted human impacts on water supplies and climate shift patterns of fire occurrence.

Contact Information: Adam C. Watts, School of Natural Resources and Environment, University of Florida, 815 NW 17th Avenue, Gainesville, FL 32609, USA, Phone: 352-318-2471, Fax: 352-846-0841, Email: acwatts@ufl.edu

SMOLDERING CYPRESS SWAMP SOILS: MOISTURE EFFECTS AND IMPLICATIONS FOR FOREST STRUCTURE

Leda N. Kobziar[1], ***Adam C. Watts***[1], *Todd Z. Osborne*[1] and *James R. Snyder*[2]
[1]University of Florida, Gainesville, FL, USA
[2]U.S. Geological Survey, Ochopee, FL, USA

Extended and widespread droughts have contributed to headline-generating wildfires in recent years. Under extremely dry conditions wildfires can spread into areas with desiccated organic soils normally too wet to support combustion. The ground fires that can occur under these conditions pose a number of challenges. Aside from substantial human and societal costs, the combustion of soils high in organic matter can potentially cause a number of ecological effects.

The fuel available in desiccated organic soils, potentially representing hundreds to thousands of years of partially decomposed organic matter, may be far greater than that in the standing biomass of a mesic or wetland ecosystem. Therefore, carbon release from ground fires can be substantial. Soil-consuming fires also may produce significant hydrologic consequences in locations with low topographic relief. Where subtle changes in elevation can significantly affect hydroperiod, alterations in soil elevation from ground fires may produce significant changes in changes in ecological function. In landscapes with depressional wetlands, soil-consuming fires could change the volume of these isolated wetlands, with hydrologic consequences for the surrounding landscape. Indirect changes also may occur via subtle hydrologic changes due to local decreases in soil elevation: in cypress swamps, for example, increased hydroperiod as a result of elevation decrease due to peat fires plays a role in delayed mortality and can inhibit cypress regeneration, promoting conversion of swamps to marshes after severe fires. Because of their implications for hydrologic effects locally and carbon release of concern at greater scales, an improved understanding is needed of the effects of drought-condition ground fires on hydrology and carbon storage in soil pools.

This paper describes investigations of soil-moisture effects on smoldering combustion in the organic soil of isolated cypress swamps, using the low-relief landscape of Big Cypress National Preserve as a model system. We discuss the implications of our study of smoldering combustion in the organic soils of southern Florida for soil carbon pools at an ecosystem and landscape scale. We also describe the potential hydrologic effects of drought-condition fires, predicted to increase under scenarios of anthropogenic climate change, to the structure of widespread wetland forest patches, which presently constitute an important element of the greater Everglades regional ecosystem.

Contact Information: Adam C. Watts, School of Natural Resources and Environment, University of Florida, 815 NW 17th Avenue, Gainesville, FL 32609, USA, Phone: 352-318-2471, Fax: 352-846-0841, Email: acwatts@ufl.edu

FIRE EFFECTS ON NITROGEN CYCLE IN CALCAREOUS WETLANDS OF FLORIDA EVERGLADES

Xiaolin Liao*, Patrick W. Inglett, Benjamin Hogue, Cassandra Medvedeff* and *Kanika Sharma Inglett*
University of Florida, Gainesville, FL, USA

Prescribed fire is widely used as a primary restoration technique in various ecosystems and has great influences on nutrient cycles in ecosystem by changing the form, distribution and amount of nutrient as well as by changing species composition. A restored wetland (restored in 2000, high phosphorus) and a native calcareous wetland (reference site, low phosphorus) were burned on 4th May, 2010 in the Hole-in-the-Donut (HID) of Florida Everglades, where farmed marl prairie wetlands have been restored through complete soil removal to reduce nutrient levels. In each site, two 30m by 30m burn and control plots were set and soil properties were measured to evaluate the immediate (2 days), short (1month) and long time (around 1 year) changes of soil nitrogen cycles after the fire. Results showed that after the fire, soil total phosphorus (TP) was 20% to 30% higher in the burn plots compared to the control plots immediately after the fire in both restored and reference sites; and then after 1 year, the TP contents in the burn plots decrease to 10% of the values in the control plots. Accordingly, immediately after the fire, higher extractable nitrate/nitrite (NO_X-N) and ammonia (NH_4-N) were showed in the burn plots compared to the control plots in both restored and reference site. However, the increase of extractable nitrogen was greater in the low-P reference site, in which the extractable nitrogen in the burn plots was 2 times of that in the control plots immediately after the fire; in the high-P restored site, the values were only 20% to 40% higher in the burn plots compared to those in the control plots. These differences would indicate that in the low-P site, more P brought into the system by the fire could potentially facilitate the nitrogen cycle. After a longer time, the response of fire diminished and the extractable NO_X-N and NH_4-N returned to the original status. The effects of fire on nitrogen mineralization and N-related enzyme activities (Leucine-aminopeptidase, LAP and N-acetyl-β-D-glucosaminidase) were different in the restored and reference sites along the time. These results suggest that the fire effects on nitrogen cycle were different with different time scale.

Contact Information: Liao Xiaolin, University of Florida, 106 Newell Hall, Gainesville, FL, 32611, USA, Phone: 352-328-2872, Email:liaoxiaolin@ufl.edu

EXTREME EVENTS- FLOODING

SEDIMENTATION PATTERNS WITHIN THE ATCHAFALAYA BASIN AND MORGANZA SPILLWAY BEFORE AND AFTER THE LOWER MISSISSIPPI FLOOD OF 2011

***Edward R. Schenk*[1]**, *Dan Kroes*[2] and *Cliff R. Hupp*[1]
[1] US Geological Survey, Reston, VA, USA
[2] US Geological Survey, Baton Rouge, LA, USA

Sediment and carbon deposition and storage are important functions of forested bottomlands, yet documentation and interpretation of sedimentation processes in these systems remain incomplete. Our study was located in the Atchafalaya Basin and Morganza Spillway, Louisiana. The Atchafalaya Basin (Basin) is a distributary of the Mississippi River and contains the largest contiguously forested riparian wetland in North America. The Basin experiences high sedimentation in well hydraulically connected areas and hypoxia and sediment starvation in hydraulically isolated areas. The Morganza Spillway (Spillway) diverts water from the Mississippi River to the Atchafalaya Basin during exceptional floods (approximately 56,000 m^3/s). The Mississippi River experienced the second largest recorded flood in the spring of 2011 forcing the opening of the Spillway for the first time since 1973 resulting in record flows in the Basin.

In 2010 we established approximately 20 floodplain transects in areas that had previously been identified as highly depositional (previous study between 2000 and 2003). The sites were re-visited in early 2011, before the flood, and again in the fall of 2011 after the floodwaters had receded. Sediment cores were also taken in the Spillway at 10 locations with measurements of deposition at another 30 sites. Deposition rate, sediment texture, bulk density, and loss on ignition (LOI, percent organic material) were determined near or just above artificial markers (clay pads) located at each station in the Basin and on each core in the Spillway. Mean sedimentation rates ranged from slightly erosional to greater than 1 meter/yr. Mean percent organic material ranged from about 1% to 28%. Mean percent sand ranged from about 5% to 90%, and bulk density varied from about 0.4 to 1.3. Sites with low elevation (long hydroperiod), high hydraulic connectivity to multiple sources of sediment-laden water, and hydraulic damming (flow stagnation) featured the highest amounts of sediment trapping in the Basin; the converse in any of these factors typically diminished sediment trapping. The forebay of the Spillway trapped the majority of the sediment diverted from the Mississippi during the opening of the floodgates. Almost all remaining sediment that went through the structure was deposited within 3 km of the floodgates. The Atchafalaya Basin plays a substantial role in lowland sediment (and associated contaminant) storage, including the sequestration of carbon. These findings on local sedimentation patterns may aid in management of flow to control sediment deposition and reduce hypoxia.

Contact Information: Edward R. Schenk, National Research Program, US Geological Survey, MS430 12201 Sunrise Valley Dr. Reston, VA 20192, USA, Email: eschenk@usgs.gov

EXTREME EVENTS- HURRICANE

HISTORICAL ANALYSIS OF WETLAND SEDIMENTATION FROM TROPICAL CYCLONES IN COASTAL LOUISIANA

Andrew W. Tweel and *R. Eugene Turner*
Department of Oceanography and Coastal Sciences, Louisiana State University,Baton Rouge, LA, USA

Hurricanes Katrina, Rita, Gustav, and Ike deposited large quantities of sediment on coastal wetlands after making landfall. Various spatial interpolation methods were used to model the inorganic sediment deposition from each storm. The sediment deposition on coastal wetlands was an estimated 68 million metric tons (MMT) from hurricane Katrina, 48 MMT from hurricane Rita, and 21 MMT from hurricane Gustav. The spatial distribution of sedimentation within each storm event was also analyzed. Deposition reflected storm surge intensity, and decreased with distance from storm track and distance from the coast. Preliminary results indicate that there is a similar decay relationship to distance from the coast for all three storms, but that the relationship with distance to track is more variable. Total wetland deposition was proportional to storm intensity, and was used to investigate long-term tropical cyclone sedimentation rates in coastal Louisiana wetlands. These results highlight an important link between tropical cyclone events and coastal wetland sedimentation, and are an important component of sediment budgets for these coastal wetlands.

Contact Information: Andrew W. Tweel, Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, LA 70803 USA, Phone: 225-578-6700, Fax: 225-578-6307, Email: atweel1@lsu.edu

HYDROLOGY

DAILY STREAMFLOW PREDICTION OF A COASTAL FORESTED WATERSHED BY INDEPENDENTLY ESTIMATING STREAMFLOW MAGNITUDE AND SEQUENCE

H. Ssegane[1], ***D. M. Amatya***[2], *E. W. Tollner*[1], *Z. Dai*[3] and *J.E. Nettles*[4]
[1]University of Georgia, Athens, GA, USA
[2]Center for Forested Wetlands Research, USDA-FS, Cordesville, SC, USA
[3]University of New Hampshire, Durham, NH, USA
[4]Weyerhauser Company, Columbus, MS, USA

Commonly available methods for predicting streamflow of ungauged watersheds include statistical regionalization, where multiple regression analysis is used to correlate hydrological responses of watersheds to physical and climatic attributes, and use of regionalized hydrological model parameters, where physical characteristics of ungauged watersheds are related to optimized hydrologic model parameters of gauged watersheds. The above approaches predict streamflow time series and thus implicitly predict streamflow magnitude and temporal sequence concurrently. An alternative approach that has not been fully explored is the conceptualization of streamflow as a composite of two separable components (magnitude and sequence), where each component can be predicted separately and then combined. The magnitude can be modeled using the flow duration curve (FDC). The FDC estimates exceedance probability of time specific stream flows based on historical flow records of a watershed. Thus, the FDC is conceptualized as a hydrological system memory because it represents all flow magnitudes experienced by the watershed for the epoch under consideration. The streamflow sequence is defined as the timing or the temporal occurrence of streamflow magnitudes and, therefore, determines the day when a specific magnitude occurred. The approach has been successfully tested on watersheds of three Mid-Atlantic regions (USA) of Appalachian Plateaus, Piedmont, and Ridge and Valley, where the watersheds had minimum levels of surface storage (percent areal coverage under open water surface and wetlands) and urbanization.

This study tests the applicability of the approach on low-gradient, coastal plain forested watersheds with significant levels of surface storage including wetlands, where gauged watersheds are generally limited. The study site consists of two naturally drained forested wetland watersheds located at the US Forest Service Santee Experimental Forest (SEF) in coastal South Carolina with over 35 years of hydrological data. Daily streamflow magnitude is predicted using regionalized flow duration curve and use of drainage area scaling of flow of a gauged neighboring watershed (donor watershed). The streamflow sequence is predicted by transferring the flow temporal sequence of a neighboring watershed. The assumption behind transfer of streamflow sequence between neighboring watersheds is that geographic proximity may infer similarity of climate, watershed form and geology although previous work has shown that this is not always true. Therefore, timing of flow magnitudes of different flow regimes between neighboring watersheds is similar. The two components (magnitude and sequence) are combined using a shuffling technique (sorting) to generate predicted daily streamflow. The results of this approach are compared to simulations by distributed models such as MIKE-SHE and Hydrological Simulation Program-Fortran (HSPF) for its validation.

<u>Contact Information</u>: Herbert Ssegane, University of Georgia, USDA-FS, 3734 Hwy. 402, Cordesville, SC, 29434, Phone: 843-336-5604, Fax: 843-336-5068, Email: hssegane@fs.fed.us

SIMULATION OF NATURAL SYSTEM HYDROLOGY

M. Clay Brown[1] and *Winifred P. Said*[2]
[1]South Florida Water Management District, West Palm Beach, FL, USA
[2]Jupiter, FL, USA

During the past century, the cumulative effects of altered quantity, quality, timing and distribution of water resulted in significant habitat deterioration and loss within the greater Everglades. To reverse this trend and ultimately affect sustainable habitat while balancing the needs of the state's growing population, Federal and State entities have set the stage for hydrologic restoration initiatives.

Restoration strategies require an understanding of how the regional system hydrology interacts with topography, soils and plant communities. To understand how the south Florida ecosystem existed in an apparent dynamic equilibrium with naturally varying hydrologic conditions, studies were undertaken to develop a Natural Systems Model that represents how the south Florida hydrology and ecology functioned prior to drainage and development. Natural system modeling is designed and intended to be used, in combination with other adaptive management tools, to assist in restoration plan formulation and implementation.

Technological advances in hydrologic modeling at the South Florida Water Management District resulted in the development of the Regional Simulation Model (RSM). The RSM is a finite-volume computer model that simulates multidimensional and fully integrated groundwater and surface water flow. Application of the RSM to south Florida's Kissimmee-Okeechobee-Everglades and adjacent Big Cypress pre-drainage watersheds is referred to as the Natural System Regional Simulation Model (NSRSM).

The peer reviewed NSRSM v3.3 simulates the hydrology of approximately 12,000 mi^2 (7.7 million acres) of south Florida, including 5,000 mi^2 (3 million acres) of Everglades wetlands, as they existed before drainage (ca. 1850). Scenarios have been generated using recent climatic input (1965-2005). The water flows and levels in the pre-drainage Everglades uses a weighted average of the slough, ridge, and tree island landscape components are used as model input. The micro-topographic features of the landscape components are simulated using a stage-volume converter. Model sensitivity to this parameter is investigated and simulated water flows and levels are evaluated for consistency with pre-drainage Everglades reference ranges from peer reviewed literature.

Contact Information: M. Clay Brown, Hydrologic and Environmental Systems Modeling, South Florida Water Management District, MS7510, West Palm Beach, FL 33406 USA, Phone: 561-682-2256, Fax: 561-682-5750, Email: mcbrown@sfwmd.gov

USE OF LIDAR FOR WETLAND HYDROLOGIC ANALYSIS

Christina Uranowski[1] and ***B.J. Bukata***[2]
[1]Southwest Florida Water Management District, Brooksville, FL, USA
[2]Jones Edmunds & Associates, Inc., Gainesville, FL, USA

Water levels are recorded by Florida's Southwest Water Management District or water supply utilities at over 500 wetlands. However, stage data alone provide little insight into the flooding dynamics of these wetlands. Determining the hydrologic signatures using flooded-area frequency analysis could provide greater insight into their hydroperiod, function, or health and help guide management or regulatory considerations. To conduct this analysis, it is typically necessary to collect detailed topographic data, which would be extremely costly. This study explored the use of an alternative data source—publicly available District Light Detection and Ranging (LiDAR) data—to conduct a flooded-area frequency analysis for 12 forested wetlands.

Except for three of twelve wetlands, the vertical accuracy of the LiDAR to conventionally surveyed points was below the National Standard for Spatial Data Accuracy (NSSDA) specification of 0.09 or 0.18 meters. The individual wetland mean $RMSE_{(z)}$ for the 12 wetlands ranged from 0.05 to 0.18 meters with 1,052 to 4,839 LiDAR Class 2 mass points/hectare. However, only one out of 12 wetlands did not meet the NSSDA standard if the analysis incorporated the potential vertical error associated with conventional surveying techniques used to survey reference locations in the wetland which were subsequently compared to LiDAR mass points. The high topographic-point density created a detailed elevation surface of the wetland that improved the accuracy of the flooded-area analysis.

The project team used a LiDAR-derived normal pool contour to define the wetland perimeter, which allowed stage-area/stage-volume relationships to be developed for the 12 wetlands. Using these relationships and long-term water levels, flooded-area frequencies were generated for each wetland. The wetlands exhibit a hydroperiod with two distinct wet seasons and one distinct dry season although many of the wetlands never reached the normal pool elevation. Using the LiDAR-derived normal pool contour also led to the discovery that many wetlands previously classified by the District as isolated were connected with one or more adjacent wetlands at higher stages.

It appears that LiDAR could be an accurate and cost-effective source of wetland bathymetric data for District-monitored wetlands. This analysis could provide valuable insight into the hydrologic health of a given wetland and help guide management decisions.

Contact Information: B.J. Bukata, MS, PWS, Jones Edmunds & Associates, Inc., Gainesville, FL, 32641, USA; Phone: 352-377-5821; Fax: 352-377-3166; Email: bbukata@jonesedmunds.com

EFFECT OF WATER MANAGEMENT ON WATER SUPPLY TO EVERGLADES NATIONAL PARK: 1940 TO 2010

Kevin Kotun
National Park Service, Homestead, FL, USA

Water enters Everglades National Park (ENP) through a series of 89 bridges and culverts that allow water to flow under U.S. 41, (aka Tamiami Trail). This flow has been measured by the United States Geological Survey (USGS) since 1940 with funding from the National Park Service (NPS), the United States Army Corps of Engineers (USACE) and the USGS. Since 1940 there have been significant changes in water management infrastructure in South Florida, primarily as a result of implementing the Central and Southern Florida Project (C&SF). The structural and operational changes in water management have had significant influence on the quantity and spatial distribution of water.
This study analyzes the cause and effect relationship between water management and the spatial and temporal distribution of flow into the Park. Historically, the flow through the 89 bridges and culverts were grouped and reported as flow through only four flow sections. For this project, we compiled a database of flow through each of the individual bridges and culverts using the original field notes. These data provided the ability to discern changes in spatial distribution on a much finer scale. The data were then grouped into periods separated by significant changes in water management practices and analyzed for changes in the rainfall – runoff response; for example, the establishment of the eastern protective levee, the impoundment of the water conservation areas and construction of the south Dade conveyance system provide the most significant changes in runoff response. Other events such as the Turner River restoration and the establishment of the minimum deliveries schedule to ENP are also evident in the flow record. Analysis of flows into Water Conservation Area 3A and the Everglades Agricultural area complete the analysis and are used to help to explain some of the anomalies found in the data.

Contact Information: Kevin Kotun, South Florida Natural Resources Center, Everglades National Park, 950 N. Krome Avenue, 3rd Floor, Homestead, FL 33030, USA , Phone: 305-224-4224 , Fax: 305-224-4147 , Email: Kevin_Kotun@nps.gov

STANDARDIZED METHODS TO COMPARE HYDROLOGIC CONDITIONS IN DEPRESSIONAL FRESHWATER WETLANDS

Terrie M. Lee and *Geoffrey G. Fouad*
U.S. Geological Survey, Tampa, FL, USA

Standardized hydrologic evidence is increasingly needed to make comparisons between altered and natural wetlands, groups of wetlands, and regional wetland populations. Yet classical hydrologic comparisons applied to permanent water bodies such as lakes don't apply equivalently to seasonally-flooded wetlands, with flooded areas that vary in size, and disappear and reappear over the timeframe of hydrologic monitoring in unsynchronized cycles to other wetlands. Methods developed for studies of depressional wetlands in central Florida are presented including hydrologic comparisons of (1) flooded areas, (2) water budgets, (3) groundwater interactions, (4) depression storage, and (5) runoff areas and stream connectivity to headwater wetlands. These lines of evidence are combined with geologic evidence and vegetative and ecological assessments to demonstrate the hydrologic vulnerability of wetlands to wet and dry climate cycles, municipal well-field pumping, and land use changes.
The flooding histories of wetlands can be compared despite differences in wetland size by describing flooded area over time as a percentage of total vegetated area in each wetland. Wetland water-budget components are expressed as linear flux rates by dividing daily water volumes by the average flooded area in the wetland that day. Viewing linearized water-budget components as a sample population metric allows rates from discontinuous episodes of inundation to be aggregated and characterized statistically. Linear rates of wetland leakage, runoff, and climate fluxes can be compared across wetlands or in an individual wetland across time, without regard to the size of the respective flooded areas.
Depressional wetlands can collectively affect large land areas, especially in Florida, making spatially-distributed hydrologic evidence ideal for characterizing this resource. Mapping approaches to hydrologic assessment that rely on LiDAR-based microtopography are used to quantify water storage in depressional wetlands, define areas contributing runoff to wetlands, and delineate the small channels hydraulically connecting wetlands to streams. Mapping approaches are also used to describe the spatial distribution of upward flow in aquifers beneath headwater wetlands in stream basins. This evidence is used to examine the relationship between streamflow generated by headwater wetlands and discharging versus recharging groundwater conditions.

Contact Information: Terrie M. Lee, Florida Water Science Center, U.S. Geological Survey, 10500 University Center Drive, Tampa, FL 33612 USA, Phone: 813-498-5030, Fax: 813-498-5002, Email: tmlee@usgs.gov

ON THE CALCULATION OF THE FLUX OF MATERIALS THROUGH WETLANDS AND ESTUARIES UNDER OSCILLATORY MOTION

***Chunyan Li**, John White* and *Sibel Bargu*
Department of Oceanography and Coastal Sciences, School of the Coast and Environment, Louisiana State University, USA

Material transport through wetlands and estuaries under oscillatory motions caused by tides and cold fronts are often calculated by the use of average concentration values and average flow velocity or transport (e.g. volume flux). This method appears to be used often, regardless whether the flow is oscillatory. The reality is that the method works correctly for uni-directional flows only. When the flow is oscillatory, the flow has positive and negative values, while concentration is always none negative. The net material transport calculated by using the average flow (or net transport of water) and average concentration can be misleading. In this paper, we explain this simple mathematics with an example – we use data obtained from Barataria Pass over a 24 hour period in the summer of 2008. Between July 31 and August 1, 2008, we conducted a continuous 24-hour vessel-based survey. In this survey, we collected (1) data for flow velocity profiles across Barataria Pass, a 600-m wide tidal channel, using an acoustic Doppler current profiler, (2) data for temperature and salinity profiles using a CTD, and (3) water samples for nutrients, carbon, and suspended sediments. Two methods are used for the net material transport (flux of water, sediments, nutrients, and organic and inorganic carbons). We demonstrate the correct and incorrect methods by comparing the results, and explain the difference using the simple theory. Although the mathematics appears to be trivial, the incorrect method is however still used by some. This paper is aimed at some clarification and for an ending of the use of an incorrect method.

Contact Information: Chunyan Li, 331 Howe-Russell Geocomplex, Coastal Studies Institute, Louisiana State University, Baton Rouge, LA 70803, USA, Phone: 225-578-3619, lcx.lsu@gmail.com

ANALYSIS OF HYDROPERIOD IN ISOLATED WETLANDS ON WELL FIELDS IN THE NORTHERN TAMPA BAY REGION

Kim H. Haag and ***Patricia A. Metz***
U.S. Geological Survey, Tampa, FL, USA

Hydroperiods were compared at nine isolated well-field wetlands in the northern Tampa Bay region to determine whether reductions in well-field groundwater withdrawals increased the seasonal duration and spatial extent of wetland flooded area. Flooded area, expressed as a percentage of total wetland area, was used to provide a quantitative and comparable line of evidence for describing hydrologic conditions in wetlands of different sizes and locations. Flooded-area frequencies were quantified for periods with different groundwater withdrawal rates that bracketed reductions in well-field groundwater withdrawals. The data describing flooded area in the pre- and post-reduction periods were used to average-out the effects of year-to-year rainfall differences to reveal the effects of reduced groundwater withdrawals.

Only one of the nine wetlands experienced a hydroperiod similar to that observed at the reference wetlands, either before or after reductions in groundwater withdrawals. About 61-100 percent of the total wetland area was flooded about 40 percent of the time during the pre-reduction period and 45 percent of the time in the post-reduction period. The amount of time the wetland was dry decreased from about 40 percent in the pre-reduction period to about 25 percent in the post-reduction period. The median elevation of water levels in the Upper Floridan aquifer increased beneath this wetland by about 3-4 feet after reductions in groundwater withdrawals.

Four wetlands were mostly dry before reductions in groundwater withdrawals (less than 20 percent of the total wetland area was flooded for about 75 percent of the time), and had substantial increases in flooded area duration and extent after reductions in groundwater withdrawals (were dry for 25-45 percent less time). The median elevation of the potentiometric surface in the Upper Floridan aquifer was about 4-8 feet higher beneath these wetlands after reductions in groundwater withdrawals.

Four other wetlands were mostly dry before reductions in groundwater withdrawals and remained mostly dry after the reductions. The median elevation of the potentiometric surface of the Upper Floridan aquifer increased by about 2-5 feet beneath two of the wetlands, and did not increase beneath the other two wetlands after reductions in groundwater withdrawals. Subsidence, sinkhole activity, and the presence of high-permeability underlying sediments likely facilitated continued downward leakage and contributed to the lack of recovery at these four wetlands.

The ability to define the duration of seasonal flooding over multiple years and the spatial extent of flooding over the total wetland area integrates the effect of annual rainfall, which can be highly variable, and the effect of well-field groundwater withdrawals on groundwater levels below the wetlands. Hydrologic changes precede and ultimately lead to changes in wetland vegetation. Flooded-area analysis can provide a useful line of evidence to describe the important link between hydrology and wetland habitat.

Contact Information: Patricia A. Metz, USGS, 10500 University Center Drive, suite 215, Tampa, FL 33612 USA, Phone: 813-498-5031, Fax: 813-498-5002, Email: pmetz@usgs.gov

FACTORS THAT INFLUENCE THE HYDROLOGIC RECOVERY OF WETLANDS IN THE NORTHERN TAMPA BAY AREA, FLORIDA

P.A. Metz
U.S. Geological Survey, Tampa, FL, USA

Reductions in groundwater withdrawals from Northern Tampa Bay well fields were initiated in mid-2002 to improve the hydrologic condition of wetlands by allowing surface and groundwater levels to recover to previously higher levels. Following these reductions, water levels at some long-term wetland monitoring sites have recovered, while others have not recovered as expected. To understand why water levels for some wetlands have not increased, nine wetlands with varying impacts from well field pumping were examined based on four factors known to influence the hydrologic condition of wetlands in west-central Florida. These factors include the level of the potentiometric surface of the Upper Floridan aquifer underlying the wetland, recent karst activity near and beneath the wetland, permeability of the underlying sediments, and the topographic position of the wetland in the landscape.

The increase in the potentiometric surface of the Upper Floridan aquifer below the wetland-bottom elevation (a surrogate for the wetland water level) had the most influence on the hydrologic recovery of the study wetlands. Even wetlands influenced by karst subsidence (S-44 Cypress at Starkey Well Field), the increase in level of the potentiometric surface just below the wetland bottom limited the downward leakage potential and resulted in an increase in the flooded area and duration of the wetland hydroperiod. In contrast, two study wetlands affected by karst subsidence (W-12 Cypress and W-16 Marsh at Cypress Creek) remained mostly dry during the groundwater withdrawal reduction period, at which time the median distance of the potentiometric surface of the Upper Floridan aquifer was about 10 feet below the wetland-bottom elevation. Breaches or breaks in the underlying sediments or in the intermediate confining unit due to recent karst subsidence activity act as pathways for downward leakage. For these study wetlands, the leakage potential increased when the vertical separation between the potentiometric surface of the Upper Floridan aquifer and the wetland-bottom elevation increased.

Low permeability sediments and the absence of karst features underlying the wetlands had a positive influence on wetland recovery following the reductions in groundwater withdrawals. In these settings, intact low permeability subsurface layers help maintain water within and beneath the wetland, and limit the downward leakage potential to the Upper Floridan aquifer. An increase in the flooded area and the duration of the wetland hydroperiod was observed for wetlands in these settings

Compared to wetlands in a higher topographical position, those in a lower position had longer hydroperiods because of their greater ability to receive more runoff from higher elevation wetlands. For these study wetlands, surface-water connections to other isolated wetlands and surface-water bodies were established more easily through low-lying surface-water channels during wet conditions. In addition, wetlands in low-lying areas benefited from groundwater inflow when groundwater levels were higher than wetland water levels.

Contact Information: Patricia Metz, Florida Water Science Center, U.S. Geological Survey, 10500 University Center Drive, Suite 215, Tampa, FL, USA, Phone: 813-498-5031, Fax: 813-498-5002, Email: pmetz@usgs.gov

METHODS OF INTERPRETING HYDROLOGY DATA

Chris Noble
USACE, Vicksburg, MS, USA

Interpretation of hydrology data for wetland identification, delineation, creation, restoration, and mitigation was not clearly described in the Corps of Engineers Wetlands Delineation Manual (Environmental Laboratory 1987). Since that time the CORPS has attempted to provide clarification and guidance to application of wetland hydrology for delineation purposes. The Technical Standard for Water-Table Monitoring of Potential Wetland Sites (2005) and Regional Supplements to the 87 Manual have provided specific requirements for the collection and interpretation of hydrology for wetland identification and delineation. Wetland creation or restoration for the purposes of wetland mitigation is not required to follow the minimum requirements for the identification of wetland hydrology.

This presentation will discuss the various interpretations and applications of wetland hydrology requirements from various CORPS districts across the country.

Contact Information: Chris Noble, US Army Corps of Engineers, ERDC, Environmental Laboratory, Vicksburg, MS 39180, USA, Phone: 601-634-3482, Fax: 601-634-3205, Email: Chris.V.Noble@us.army.mil

WATER RESIDENCE TIME AND WATER QUALITY IN TAYLOR SLOUGH – EVERGLADES NATIONAL PARK, FL, USA

Estefania Sandoval*, René M. Price, Dean Whitman* and *Assefa M. Melesse*
Florida International University, Miami, FL, USA

The Everglades has experienced many alterations to its natural state due to urbanization and water management practices. The alterations have caused an increase in groundwater – surface water interactions, groundwater seepage outside of the Everglades, peat subsidence, and loss of tree islands to name a few. Efforts to improve the current state of the Everglades include the Comprehensive Everglades Restoration Plan (CERP), the largest restoration effort ongoing in the Everglades and the world. One of the main efforts of CERP includes increasing freshwater flow to Florida Bay via Taylor Slough. Several projects have been completed with the goal of increasing water flow in Taylor Slough with others reaching completion in the near future. A way to gain insight into the success of these restoration projects is by analyzing hydrological and geochemical conditions as many of these projects reach completion. The purpose of this research is to investigate the effects of restoration on the water balance, residence time, and water chemistry of Taylor Slough.

Changes in water residence time, major surface water ion concentration, nutrient data, and the dominant sources of ions in Taylor Slough are investigated from 2001 - 2011. Water residence time is calculated using the ratio of Volume/Influx with the influx including precipitation, surface water inflow, and groundwater discharge. Groundwater discharge is estimated via a water balance. Both the water residence time and water balance equations are calculated on a monthly time step from 2001 – 2011. Surface water samples obtained at Florida Coastal Everglades (FCE) Long-Term Ecological Research (LTER) sites within Taylor Slough are analyzed for anions (Cl^-, SO_4^{2-}) and cations (Na^+, K^+, Mg^{2+}, and Ca^{2+}) for the surface water chemistry. The samples are also analyzed for total and dissolved nutrients (N, P, and C). The analyzed water chemistry and nutrient data are compared and correlated with the water residence time values. The proportion of precipitation, groundwater discharge, and surface water inflow, as the major sources of ions into Taylor Slough is determined by calculating the product of the water budget equation value and chemical data for each source respectively. Stable isotope values are also obtained for the three major sources of water (rainfall, surface water, groundwater) to support the dominant inputs of water into Taylor Slough as identified by the water budget equation.

Preliminary results indicate water residence times in Taylor Slough to be one week or less during the wet season. Stable isotope and ion data indicate an increase in the influence of precipitation in the freshwater portion of the slough downstream of Taylor Slough Bridge. Near the coastline, major ions in both the surface water and groundwater increase due to seawater intrusion.

Contact Information: Estefania Sandoval, Department of Earth and Environment, Florida International University, 11200 S.W. 8th Street, Miami, FL 33199, USA, Phone: 305-348-0281, Email: esandova@fiu.edu

EVAPOTRANSPIRATION IN THE BIG CYPRESS NATIONAL PRESERVE, SOUTHERN FLORIDA, 2007–2010

W. Barclay Shoemaker
U.S. Geological Survey, Davie, FL, USA

Evapotranspiration (ET) was quantified over plant communities within the Big Cypress National Preserve (BCNP) using the eddy covariance method for a period of 3 years from October 2007 to September 2010. Plant communities selected for study included Pine Upland, Wet Prairie, Marsh, Cypress Swamp, and Dwarf Cypress. These plant communities are spatially extensive in southern Florida, and thus, the ET measurements described herein can be applied to other humid subtropical locations such as the Everglades. The 3-year mean annual ET was about 1,000, 1,050, 1,100, 930, and 900 mm (millimeters) at the Dwarf Cypress, Wet Prairie, Cypress Swamp, Pine Upland, and Marsh sites, respectively. Spatial differences in annual ET were considerable due to the recovery of the Marsh site from extensive forest fire and drought conditions. Temporal variability in annual ET was relatively small at sites that were well watered (Dwarf Cypress, Wet Prairie, Cypress Swamp, Pine Upland) over the 3-year study. In other words, locations that were well watered appeared to have similar annual ET rates. Monthly ET estimates exhibited seasonal variation. ET was generally greatest between March to October when solar radiation was relatively large, and least from November to February when solar radiation was small. Monthly ET was greatest in the spring and summer at the Cypress Swamp site, reaching rates as large as 140 mm. The large ET rates at this site coincide with the most active period of cypress growth during late spring and early summer. Cypress trees begin to senesce in late summer reducing transpiration. Net radiation and available energy explained most of the variability in ET observed at all five sites. Mean annual and monthly net radiation varied among the sites in response to cloud cover and the albedo of the land surface and plant community. Net radiation was greatest at the Cypress Swamp site, averaging about 130 W/m2 (watts per square meter) during the 3-year study. Net radiation was generally less at the Dwarf Cypress site, averaging about 115 W/m2 over 3 years. The Dwarf Cypress site apparently has the largest albedo, which likely is due to the sparse canopy and a highly reflective, calcareous, periphyton-covered land surface. Furthermore, mean annual net radiation was least in the first year of the study, which likely was due to greater cloud cover during a relatively wet year. In contrast, net radiation was greatest in the second year of the study, which likely was due to less cloud cover during a relatively dry year.

Contact Information: Barclay Shoemaker, U.S. Geological Survey, 7500 SW 36th Street, Davie, FL 33314, USA, Phone: 954-377-5956, Email: bshoemak@usgs.gov

DEVELOP A FINER RESOLUTION DEM TO SUPPORT HYDROLOGICAL MODELING AND ECOLOGICAL STUDY IN THE NORTHERN EVERGLADES FRESHWATER WETLAND

Zhixiao Xie
Department of Geosciences, Florida Atlantic University, Boca Raton, FL, USA

Accurate high resolution terrain data are essential to improve the realism of the predictive ability of hydraulic and hydrological models in lowland areas because lowland topography strongly influences hydrologic processes. An accurate high resolution DEM will benefit the ecosystem sciences and restoration efforts in the greater Everglades, especially the WCA1 subarea, which is characterized with bumpy micro-topography. This study integrates the USGS HAED elevation survey, the recently available SFWMD 2004 vegetation map, and the vegetation tag of HAED to develop a 50m resolution ground elevation model in WCA1. The DEM development adopts a divide-and-conquer strategy to divide the terrain into two vertical strata (lowland and highland) based on reclassified SFWMD 2004 vegetation map and interpolate them separately before mosaicing back into a whole DEM. For the lowland areas, the HAED data surveyed in highland (based on vegetation tag) were not used in interpolation; while the DEM in highland areas, after interpolating with all the HAED data, was further adjusted based on the association between vegetation types and hydroperiods. The DEM adjustment adopts a simple hydroperiod threshold approach to detect outliers and set adjustment target, and the adjustment does improve micro-topography spatial pattern. The developed DEM has a better validation accuracy, with a 7.7cm overall MAE and a 2.3cm improvement over the Jan. 2010 release EDEN DEM. The DEM development and adjustment approach described in this study could be easily extended to develop Everglades system-wide 50m resolution DEM once the 50m resolution vegetation map is completed for the whole Greater Everglades and to supply a more accurate foundation data for the Everglades sciences, restoration and long term management.

Contact Information: Zhixiao Xie, Department of Geosciences, Florida Atlantic University, 777 Glades Rd., Boca Raton, FL 33431, USA, Phone: 561-297-2852, Fax: 561-297-2745, Email: xie@fau.edu

HYDROLOGIC MODELING FOR ROLLING MEADOWS WETLAND RESTORATION IN POLK COUNTY, FLORIDA, USA

Tony Guan[1], ***Jing-Yea Yang***[2] and *Giles Rhoads*[1]
[1]ZFI &Construction, Inc., Orlando, FL, USA
[2]Environmental Consulting & Technology, Inc. (ECT), Fort Lauderdale, FL, USA

The South Florida Water Management District (District) owns an approximately 5,800 acre tract in Polk County, through which Catfish Creek drains from Lake Pierce to Lake Hatchineha. Lake Hatchineha is located in Central Florida along the eastern border of Polk County, just upstream of Lake Kissimmee. The tract has been separated into two (2) parcels and will be restored in phases. Phase I, also called Parcel B, consists of approximately 1,900 acres, of which 1,600 acres of former sod fields and marshland are proposed to be restored back to wetlands by reconnecting the parcel to Lake Hatchineha via breaching an existing perimeter berm.

The purpose of this study is to ensure that the berm breaches provide for no project-caused offsite flooding impacts for the 25-year (3-day) and 100-year (3-day) rainfall events under both the existing and future proposed regulation schedules for Lake Hatchineha. The hydraulic model, HEC-RAS Version 4.0 was used to simulate the watershed's primary stream network based on existing land use conditions. Water surface elevations were estimated through the hydraulic modeling. The river stages and flow rates along the study reach under various flow conditions were determined. The HEC-HMS model was used to simulate the precipitation-runoff and to combine simulated flow data from Catfish Creek for estimating the final water level in Parcel B wetland area. HEC-HMS Version 3.5 was also used to size the breaches along Lake Hatchineha to prevent adverse impacts on existing flood protection.

Modeling results indicated that the difference of peak flow and peak stage in Parcel B is not significant for the 25-year storm event among the three modeled scenarios. For the 100-year storm event, the connection between Parcel B and Lake Hatchineha through the berm breaches resulted in the water surface level in Parcel B to increase about 0.5 feet compared to the base run scenario. Large storm events could cause flooding to adjacent properties if the lake and Parcel B were connected through berm breaches under future proposed regulatory schedules for Lake Hatchineha. Further improvements to the current berm need to be performed for flood protection under this condition.

<u>Contact Information</u>: Jing-Yea Yang, Environmental Consulting & Technology, Inc. (ECT), 550 W. Cypress Creek Road, Suite 170, Fort Lauderdale, FL 33309, USA, Phone: 954-771-0444, FAX: 954-771-8118, Email: jyang@ectinc.com

INVASIVE SPECIES

PREDICTING *PHRAGMITES* EXPANSION IN THE LAURENTIAN GREAT LAKES

Martha. L. Carlson Mazur[1], *Kurt P. Kowalski*[1], *David M. Galbraith*[1], *Laura. L. Bourgeau-Chavez*[2], *Liza Jenkins*[2] and *Colin Brooks*[2]

[1]U.S. Geological Survey, Ann Arbor, MI, USA
[2]Michigan Tech Research Institute, Ann Arbor, MI, USA

The nonnative and invasive strain of *Phragmites australis* in North America forms impenetrable stands with thick detritus that help it to out-compete native flora and quickly degrade the functions and values of large areas of highly productive coastal wetlands. The enormous cost and effort to control mature *Phragmites* stands necessitates early treatment and improved strategies for limiting its spread. Resource managers, however, lack detailed maps of both existing *Phragmites* colonies and areas that may be vulnerable to *Phragmites* invasion in the future. On a local scale, invasion success of *Phragmites* has been related primarily to hydrologic alteration as well as shoreline development and nitrogen pollution, but a large-scale analysis of environmental drivers has not yet been performed. A thorough assessment of the species' current distribution and areas vulnerable to future invasion in the coastal zone of the Laurentian Great Lakes is needed to enable managers to prioritize control efforts and identify key monitoring areas for early detection.

Using multi-temporal radar imagery scenes (dual-polarized ALOS PALSAR) and extensive field verification, we mapped mature, monotypic stands of *Phragmites* (0.2 ha or larger) within a 10 km buffer of the US Great Lakes shoreline. Using the mapped distribution and environmental drivers from multiple spatial scales, we then assessed areas that may be vulnerable to *Phragmites* invasion with habitat suitability estimates from maximum entropy and boosted regression tree models. Whereas our results showed that some drivers (e.g., anthropogenic stress, proximity to agriculture, local soil characteristics) were related to *Phragmites* distribution for all lakes, we observed a differential response by lake basin for other drivers. For example, watershed nitrogen concentration appeared to have a greater influence on *Phragmites* distribution in Lake Huron than in the other lakes.

Such Information may be useful for developing a prioritized and coordinated approach for controlling *Phragmites* at local and basin-wide scales. These results will allow managers to develop control strategies that target key existing *Phragmites* populations, thereby reducing the likelihood of expansion. The resulting maps of vulnerable areas provide a powerful and flexible framework to detect new establishment and target control efforts accordingly. Therefore, these results are being made publically available as a web-based decision support tool.

Contact Information: Martha L. Carlson Mazur, Department of Earth and Environmental Sciences, Boston College, Devlin Hall 213, 140 Commonwealth Avenue, Chestnut Hill, MA 02467, USA, Email: martha.carlsonmazur@bc.edu

A COMPARISON OF THREE METHODS FOR DETECTING THE PRESENCE OF GREEN TREEFROGS (HYLA CINEREA) IN AN URBAN POND SYSTEM

Jacoby Carter[1] and *Sergio Merino*[2]
[1]U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, USA
[2]Fiver Rivers Services, LLC, US Geological Survey, National Wetlands Research Center, Lafayette, LA, USA

From 2005 to 2011, five ponds in Lafayette Louisiana were monitored for green treefrogs (*Hyla cinerea*). Monitoring was conducted once a week at each pond starting between late February and early April and ending between early August and mid October. Three methods were used to detect green treefrogs (GTF): (1) searching for and hand catching them at night (hand caught, 'HC'); (2) inspecting PVC pipes (pipe caught, 'PC') set out as artificial habitats during the day; and (3) frog call monitoring (call monitoring, 'CM') following North American Amphibian Monitoring Program protocols before proceeding to HC. Frogs caught using PC and HC were individually marked, measured for length and or weight, and released.

Frogs were PC most often early in the season (March-April) and then again late in the season (September-March). The percentage of recaptures for PC frogs in two consecutive weeks was high (often 50 or 100%) for any given pipe. This is compared to recapture rates generally less than 5% for HC frogs. The total number of frogs PC was generally low compared to HC, but this varied by season. Comparison of weeks where frogs were caught with one method but not the other (HC but not PC or visa versa) shows that PC worked better at the beginning of the season (early March) and HC worked better in August. CM often did not detect frogs even though PC and HC methods showed them to be present. This happened most often at the beginning and end of the sampling season.

The most reliable way of detecting the presence of GTFs is by hand catching at night. The low number of frogs caught by PCs and the high recapture rate suggests that estimates based on PC will be too low. Both PC and CM can be effective techniques for documenting seasonal presence of GTF, but timing of their use is important. PC and CM may not be effective throughout the activity season and their effectiveness is weather dependent. Pipes are most effective on cooler days and call monitoring on warmer days. While hand capture is most effective, it is also the most time and labor intensive. It can however be used for population estimation while the other two methods can not.

<u>Contact Information</u>: Jacoby Carter, U.S. Geological Survey, National Wetlands Research Center, 700 Cajundome Blvd., Lafayette, LA 70506, Phone: 337-266-8620, Fax: 37-266-8586, Email: jacoby_carter@usgs.gov

ACTIVITY PATTERNS OF NUTRIA (*MYOCASTOR COYPUS*) IN AN URBAN POND

Jacoby Carter[1] and *Sergio Merino*[2]
[1]U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, USA
[2]Fiver Rivers Services, LLC, US Geological Survey, National Wetlands Research Center, Lafayette, LA, USA

Hourly observations of nutria (*Myocastor coypus*) over 24 hour periods were conducted once a month to estimate population size and understand activity patterns. Our study site was Girard Park, Lafayette Louisiana, USA. The nutria habitat ('nutria zone') at Girard Park is comprised of a pond, a retention basin and the upland areas immediately adjacent to these two bodies of water. Girard Park has been continuously occupied by nutria for at least 10 years.

Under most circumstances nutria are not 'countable' through observation surveys because of their habitat and behavior. However, the circumstances at Girard Park are exceptional. The park has operational streetlights aiding in nighttime observations. Humans can be found in the nutria zone at any time of the day or night. Human activity peaks during the day and is generally at its lowest around 3 AM. Because of the constant human traffic and the fact that they are not hunted or harassed by park visitors, nutria are accustomed to the presence of humans and generally do not engage in avoidance behavior unless humans approach "too" close. Nutria will even approach people who are feeding the resident waterfowl for a handout. Together, these facts make counting nutria and observing their activity easy.

The primary food source for nutria was lawn grass. Their diet is supplemented by food items left over by visitors feeding the resident duck and geese populations. Nutria were active at night and were generally out of sight during the day. Daytime hiding places included drainage pipes and an island in the middle of the pond. Nutria counts peaked between 10 PM and 3 AM. Peak numbers on the counts varied between 10 and 30 with 20 being average.

The number of nutria counted at peak activity varied between 16 and 25. Few nutria were found dead and most of those found were adults. No predation events have been observed. Young nutria were present year round indicating nutria breed year-round. Young nutria can at times make up half of the population observed. We surmise therefore that either young nutria leave or there is a significant (unobserved) source of mortality for the population. Girard Park is connected through a system of drainage canals to both the Vermillion River downstream and urban and suburban wetlands upstream. There is a high concrete barrier on the retention basin that prevents nutria that leave from returning to the system. It is therefore likely that this 'isolated' population may provide a significant source population for other areas in the watershed.

Contact Information: Jacoby Carter, U.S. Geological Survey, National Wetlands Research Center, 700 Cajundome Blvd., Lafayette, LA 70506, Phone: 337-266-8620, Fax: 37-266-8586, Email: jacoby_carter@usgs.gov

COMPARING TWO MODELING APPROACHES TO PREDICTING ISLAND APPLE SNAIL RANGE EXPANSION IN THE SOUTHERN UNITED STATES

Jacoby Carter and *Christopher Wells*
U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, USA

Island applesnails (*Pomacea insularum*) are a new invasive species in the Gulf Coastal Plain of the United States. In other regions of the world they have caused extensive damage to rice agriculture and swamp ecosystems. Several studies have indicated that they have limited cold tolerance. We explored two different modeling approaches to predict their potential for range expansion in the Gulf Coastal Plain. One model was based on the Cold Hardiness Zones developed by USDA, and the second model was based on the number of days in January where the temperature does not rise above a threshold value. Both models predicted substantial range expansion under current climate conditions. Where the models differed we compared the predictions of the two approaches and the implications for management.

Contact Information: Jacoby Carter, U.S. Geological Survey, National Wetlands Research Center, 700 Cajundome Blvd., Lafayette, LA 70506, Phone: 337-266-8620, Fax: 37-266-8586, Email: jacoby_carter@usgs.gov

A REVIEW OF NUTRIA (*MYOCASTOR COYPUS*) HABITAT USE IN URBAN ECOSYSTEMS

Jacoby Carter[1], *Trevor Sheffles*[2], *Mark Sytsma*[2] and *Sergio Merino*[3]
[1]U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, USA
[2]Center for Lakes and Reservoirs, Portland State University, Portland, OR, USA
[3]Five Rivers Services LLC, USGS, National Wetlands Research Center, Lafayette, LA, USA

Using a combination of literature review and direct observations we characterize the habitat of nutria (a.k.a. coypu, *Myocastor coypus*) in urban ecosystems in North America and Europe. The minimum habitat needs for nutria include water that is deep enough to swim (1 meter deep) year round, a place to burrow, and a source of food. Urban environments where we have documented persistent nutria populations (present for over two years and indication of breeding) include ponds and lakes associated with parks and golf courses; and rivers, creeks, and un-concretized drainage ditches. All these aquatic areas are adjacent to foraging areas. Foraging areas may include emergent wetland plants, but more often are comprised of lawns. We have documented nutria eating lawn grass, acorns, floating vegetation such as duckweed (*Lemna* sp.), as well as emergent marsh grasses. While it has often been assumed that urban systems are at best corridors for nutria between wetland systems or even population sinks, our observations indicate that nutria urban systems can maintain viable nutria populations that serve as sources populations for the adjoining regions. Regional nutria control programs will need to address urban nutria populations as well as nutria populations in marshes and other large ‘natural’ wetland areas.

Contact Information: Jacoby Carter, U.S. Geological Survey, National Wetlands Research Center, 700 Cajundome Blvd., Lafayette, LA 70506, Phone: 337-266-8620, Fax: 37-266-8586, Email: jacoby_carter@usgs.gov

USING HABITAT AND CLIMATE MODELS TO PREDICT COYPU (*MYOCASTOR COYPUS*) INVASIONS

Jacoby Carter[1], *Trevor Sheffles*[2], *Catherine Jarnevich*[3] and *Mark Sytsma*[2]
[1]USGS, National Wetlands Research Center, Lafayette, LA, USA
[2]Center for Lakes and Reservoirs, Portland State University, Portland, OR, USA
[3]USGS, Fort Collins Science Center, Fort Collins, CO, USA

Like many invasive species with tropical or subtropical origins that have been introduced to temperate regions, coypu (a.k.a., nutria- *Myocastor coypus*) are range-limited in part by extreme cold weather events. When temperatures drop and stay below freezing for several days or longer coypu populations can become greatly reduced or die-out altogether. In both North America and Europe coypu were introduced over a greater area than where they are now found. A recent run of mild winters in the Pacific Northwest and the Chesapeake Bay regions of the United States have allowed coypu to move north and, in some cases, back to areas where they had apparently died out. We present a model that combines climate and habitat in a geographic Information system framework to predict where nutria populations are likely to expand and provide guidance on where to conduct early detection and rapid response.

Contact Information: Jacoby Carter, U.S. Geological Survey, National Wetlands Research Center, 700 Cajundome Blvd., Lafayette, LA 70506, Phone: 337-266-8620, Fax: 37-266-8586, Email: jacoby_carter@usgs.gov

ENVIRONMENTAL DNA DETECTION OF AQUATIC INVASIVE SPECIES: A MONITORING TOOLS FOR LOXAHATCHEE NATIONAL WILDLIFE REFUGE.

E. Diaz-Ferguson and *G. R. Moyer*
Department of Genetics, University of Georgia, GA, USA

Detection of invasive species requires the direct observation or capture of the focal species. Recent studies, however, have detected trace genetic material left behind from living organisms in their respective habitat (e.g, in the water column). This environmental DNA (eDNA) detection, as it has been coined, has great potential as a monitoring tool for aquatic invasive species. The main objective of our study was to develop and implement eDNA protocols for monitoring and early detection of two aquatic invasive species (bullseye snakehead and the African jewel fish) found near the Loxahatchee National Wildlife Refuge, Florida. Specifically, we developed two species specific mtDNA markers (*COI* and *Cytb*) for each species of concern. We also determined the minimum theoretical amount of DNA required for detection from water samples using quantitative PCR (qPCR). To date, we have successfully developed internal specific primers for both species and confirmed species specificity using negative and positive controls and sequencing of PCR products. We are currently assessing minimum detection probabilities for each species using known amounts of DNA via qPCR. Once detection limits are established, we will then determine the observed minimum detection probabilities for each of the above species in a laboratory setting with known numbers of each species and known volumes of water. These data will provide for a proof-of-concept for an early detection protocol by comparing theoretical and observed minimum detection probabilities. Results from this study should validate an important tool for early detection and monitoring of the bullseye snakehead and the African jewel fish in Florida's freshwater ecosystem.

Contact Information: Edgardo Diaz-Ferguson, Conservation Genetics Laboratory, Fish Technology Center, US Fish and Wildlife Service, 5151 Spring Street, Warm Springs, GA 31830, USA, Phone: 706-655-3382, Email: edgard03@uga.edu

NUTRIENT AND WATER LEVEL EFFECTS ON *PHALARIS ARUNDINACEA* AND *CAREX ACUTA*: A MESOCOSM EXPERIMENT

***Keith R. Edwards**, Miroslava Káplová* and *Jan Květ*
Department of Ecosystem Biology, Faculty of Science, University of South Bohemia, České Budějovice, Czech Republic

Phalaris arundinacea L. can be an aggressive species even where it is considered to be native. The species can dominate in nutrient-rich wet grasslands, resulting in low diversity conditions. In contrast, European wet grasslands dominated by *Carex acuta* , a common habitat in more extensively managed grasslands, tend to have higher diversity. A field study in the Třeboň Basin Biosphere Reserve (TBBR) showed that a nutrient-poorer section of a wet grassland had changed within a three year period from an almost monoculture of *P. arundinacea* to a slightly more diverse grassland with two co-dominant species (*P. arundinacea* and *C. acuta*) possibly as a result of the cessation of fertilization and mowing. Nutrient-richer areas remained as *P. arundinacea* monocultures. Based on the field results, a mesocosm experiment was established in 2009 to determine the effect of nutrient level and flooding regime on the growth and spread of these two common wet grassland species. Nutrient treatments consisted of Low (= 65 kg NPK*ha^{-1}*yr^{-1}) and High (= 300 kg NPK*ha^{-1}*yr^{-1}) additions, while there were three flooding regimes (saturated = water level -5 cm below soil surface; flooded = +10 cm above soil surface; spring flood = flooding for four weeks in spring with saturated conditions for the remainder of the growing season). Half of the pots were harvested in August 2010 and the remaining half the following August. Measurements included final plant height, above and belowground dry weight, number of daughter plants and plant nutrient (C, N) levels. Nutrient additions significantly increased stem height and aboveground biomass in *P. arundinacea* vs *C. acuta*. However, *P. arundinacea* was negatively affected by constant flooding, having significantly lower belowground and total biomass than *C. acuta*. Also, *C. acuta* was better at capturing nutrients (C, N) under long-term flooding. The results are in agreement with studies from North America showing that *P. arundinacea* is at a competitive disadvantage in nutrient-poorer conditions as well as when subjected to long-term flooding. These results may be important in controlling aggressive populations of *P. arundinacea* and for restoring more diverse wet grasslands.

Contact Information: Keith R. Edwards, Department of Ecosystem Biology, Faculty of Science, University of South Bohemia, Branišovská 31, 37005 České Budějovice, Czech Republic, Phone: +420-38-777-2259, Fax: +420-38-777-2368, Email: edwards@prf.jcu.cz

CRYPTIC INVASION IN A CHANGED CLIMATE – ECOPHYSIOLOGY AND GENE EXPRESSION OF COMMON REED FROM THE US GULF COAST

Franziska Eller and *Hans Brix*
Aarhus University, Department of Bioscience, Denmark

At the Atlantic coast of North America a native *Phragmites australis* (Common Reed) genotype has been almost completely replaced by *P. australis* genotypes originating in other continents (Saltonstall, 2002). Studies have shown that the native genotype has a lower nutrient demand and a less efficient photosynthetic uptake of CO_2 compared to the introduced ones (Mozdzer and Zieman, 2010). It is also likely, that introduced genotypes outcompeting native vegetation in salt marshes have a higher salinity tolerance than the native reed-types. The prospected global climate change predicts that temperature as well as atmospheric [CO_2] will increase significantly during the coming decades. This is likely to affect several plant ecophysiological processes and may also affect species' invasive behaviour. Increased [CO_2] may counteract salinity stress (Poorter and Perez-Soba, 2001) and may therefore affect the competitive ability of distinct reed-types differently.

The objective of this study was to assess to what extent two introduced genotypes of *P. australis* co-occurring at the Gulf Coast of America differ in selected ecophysiological traits and how these traits may be affected by a future climate with higher temperatures and elevated [CO_2]. Furthermore, differences in gene expression of the two genotypes were investigated. One of the genotypes studied was of European origin ("EU-type"). It is successfully spreading in the Mississippi River Delta and competing with the other investigated genotype, the "Delta-type", which is the dominant reed-type in the delta, originating from Africa and the Mediterranean region (Lambertini et al, personal communication).
Plants were grown in phytotrons at ambient and elevated temperature and [CO_2], and exposed to two levels of salinity in a factorial design. For gene expression analysis, quantitative RT-PCRs were conducted to determine the expression of different genes involved in photosynthesis and stress response.

The two invasive genotypes differed in their light-saturated rate of photosynthesis (P_{max}) throughout the treatments, with the Delta-type displaying the highest rates. The Delta-type also had the highest shoot-elongation rate. Salt treatment affected growth and biomass production negatively whereas a simulated future climate had a stimulating effect. An ameliorating effect of future climate conditions on salt stress was seen for both genotypes: several photosynthetic traits were considerably less affected by salinity under elevated [CO_2] and temperature. Expression of none of the investigated genes was significantly different between the two genotypes. Salt stress tended to increase expression of stress-related genes more in the future climate compared to the ambient treatment. The expression of genes related to photosynthesis did not differ significantly in the future climate and ambient treatment, acclimation being a likely explanation. Both genotypes have an increased potential for expanding their growth habitat under future climate conditions with the Delta-type being the marginally superior competitor.

Contact Information: F. Eller, Department of Bioscience, Aarhus University, Ole Worms Alle 1, 8000 Aarhus C, Denmark, Phone: +4587156574, Email: franziska.popko@biology.au.dk

ALTERATION OF RIPARIAN PLANT COMMUNITY STRUCTURE UNDER CLIMATE CHANGE SCENARIOS: THE EFFECTS OF TEMPERATURE AND HYDROPERIOD

***Neal Flanagan**, Curtis J. Richardson* and *Mengchi Ho*
Duke University, Durham NC, USA

Future climate scenarios predict increased surface water temperatures and a greater proportion of annual watershed hydrologic yield occurring during major storm events. We examine how predicted climate driven changes in hydrologic flux and temperature regimes of floodplain ecosystems affect plant communities in terms of their vulnerability to the establishment and spread of invasive species. Temperature and hydrology effects were evaluated using three experimental treatments (warm, cold and control) using a total of 13 wetland sites. We utilize demonstrated temperature contrasts of at least 5^{o}C between sets of surface-releasing and bottom-releasing dams to develop our warm and cold treatment sites, while control (ambient) sites are located in watersheds with no upstream dams. Sites downstream of dams experienced more "pulsed" hydroperiod than undammed sites with more frequent floods, shorter average duration of individual flood events, and more rapid rise in stage. We will present the results of statistical analysis of correspondence between plant community structure, temperature regime, hydroperiod, and local soil properties. Our results indicate the most important environmental variables explaining the structure of the riparian plant communities were temperature, various measures of hydroperiod and flood energy, followed by soil texture, soil organic matter, and nutrient availability. Our results will inform projections of temperature increases and increased storm flow events on the ability of existing floodplain communities to resist invasive species.

Contact Information: Neal E Flanagan, Duke Wetland Center, Duke University, Durham, NC 27708, USA, Phone: 919-613-8087, Fax: 919-613-8101, Email: nflanaga@duke.edu

EFFECTS OF NOVEL WATER REGIMES, INVASIVE PREDATORS, AND CONTAMINANTS ON POPULATION DYNAMICS OF WADING BIRDS (CICONIIFORMES) IN THE EVERGLADES OF FLORIDA, USA

Peter Frederick
University of Florida, Gainesville, FL, USA

Long-legged wading birds (Herons, egrets, ibises, storks and spoonbills) historically occurred in some of their largest colonies in the world in the Everglades of southern Florida, USA. These birds were an integral part of the nutrient dynamics and aquatic community ecology of this highly oligotrophic system, supported in part by a strong wet/dry seasonal cycle that allowed for concentration and high availability of fish and invertebrate prey. During the second half of the 20th century seasonal drying patterns and hydroperiods have become highly atypical, sometimes aseasonal, and spatially variable as a result of compartmentalized water management and drainage, with a concomitant decline of bird populations by over 90% and evidence of a general movement of the avian population to other parts of their range.

Reproduction by wading birds in this system is also highly dependent upon exceptionally low nest predation, primarily because access to colonies by raccoons (Procyon lotor) and other mammals is strongly limited by the presence of alligators (Alligator mississippiensis). Wading bird colonies are strongly associated with alligator presence, and our experimental studies have shown that wading birds strongly prefer sites with signs of alligator presence. However, captive-released Burmese Pythons (Python molurus) are now widespread in the Everglades and are known to prey on all species of wading birds, juvenile alligators, and small mammals. It is unclear how this novel predator may affect the suitability of nesting in this system and consequently the population dynamics of wading birds.

Beginning in the late 1980s, Everglades aquatic fauna became widely contaminated with methymercury (MeHg). Experimental exposures with Everglades-appropriate levels of MeHg have demonstrated that mercury can depress reproductive success by over 50%, manifested both as same-sex pairings (to 55% of males), decreased parental care, and highly altered endocrine expression. During the late 1990s, MeHg contamination decreased by 60 – 80% in wading birds, and since 1998, populations of breeding birds have consistently increased by 3 – 5X. This Information together suggests strongly that MeHg contamination may have strongly skewed reproductive potential of these birds, independently of hydrological effects. This work provides evidence that contamination can be a strong driver of demography, yet is often overlooked because of more obvious physical and biotic signals.

Contact Information: Peter C. Frederick. Department of Wildlife Ecology and Conservation, P.O. Box 110430 University of Florida, Gainesville, FL 32611, USA, Phone: 352-846-0565, Email: pfred@ufl.edu

NONNATIVE FISHES IN FRESHWATER CANALS OF THE FLORIDA EVERGLADES: IMPLICATIONS FOR BETTER MANAGEMENT

***D. A. Gandy*[1]**, *J.S. Rehage*[1] *J. Kline*[2], *K. R. T. Whelan*[3] and *R. Urgelles*[3]
[1]Florida International University, Miami, FL, USA
[2]Everglades National Park, Homestead, FL, USA
[3]National Park Service, Miami, FL, USA

Nonnative species pose a serious threat to the ecological integrity and biodiversity of natural ecosystems, including those found within protected areas. Presently in Everglades National Park (ENP), fourteen nonnative fishes are established, yet we know little about how they interact with native biota, their response to hydrological disturbance including restoration efforts, and their overall impact. A subset of these nonnative fishes are new invasions since 2000, several of them accompanying restoration projects. Additional invasions of nonnative fishes may be expected as the number of nonnative fishes established outside of the protected natural areas continues to increase. Ongoing research examines the impact of nonnative fishes on lower trophic levels and ecosystem processes, how their impact is mediated by hydrology, the potential for new invasion threats from bordering canals, and the alternatives for their containment.

This study is focused on examining the spatiotemporal dynamics of fish communities, both native and nonnative, in canals bordering ENP. Our research questions include the following: (1) What factors drive community structure in canals? (2) How do canals function as conduits for nonnative fishes? (3) How does the inclusion of nonnative fish species alter fish community structure? (4) How do we control & contain nonnative fishes that have invaded canals, but are not yet present in ENP marshes?
Fish communities in canals bordering ENP marshes are sampled via boat-mounted electrofishing. Fish communities appeared distinct among canals, with nonnative fishes composing between 8% and 70%. Habitat complexity and other abiotic factors seem to be influencing natives and nonnatives differently (e.g., littoral habitat structure). Because restoration efforts in this region will impact water management, there is a strong need to better understand how these canals function as habitat. In addition, canals are being used by restoration projects to deliver water to Everglades marshes often with little consideration of their role in the spread of nonnative taxa. Our research findings suggest a need for more effective management of these nonnative fishes while they are confined to the canal systems and should serve as a useful tool for restoring Everglades marshes.

Contact Information: D.A. Gandy, Earth and Environment Dept., Florida International University, Miami, FL 33199, USA, Phone: 305-348-0181, Fax: 305-348-6137, Email: dgand001@fiu.edu

BACK HOME WITH HYDRILLA: A MASSACHUSETTS TOWN AND THE GOOD FIGHT

Rob Gatewood
Town of Barnstable Conservation Division, Hyannis, MA, USA

Massachusetts' pioneer hydrilla infestation was well-established in 40-ha Long Pond by 2001. In 2002 the Town of Barnstable with assistance from the MA Lakes and Pond Program and the local lake association began a decade-long effort to eradicate the plant and prevent its spread to other ponds on Cape Cod. The town immediately closed the municipal boat landings and applied herbicide. Those practices have been repeated every year since 2002. Improvement has been measurable, but eradication elusive. In 2010, a new hydrilla infestation was discovered across town in 60-ha Mystic Lake. Unlike Long Pond, hydrilla in Mystic Lake was newly-arrived and patchy in distribution. The eradication strategy would be much different: no herbicide, no closure of the boat landing, more hands-on effort from volunteers. With assistance from the MA Lakes and Pond Program and the local lake association, hydrilla patches were hand-pulled and covered with benthic screens. Despite the early intervention, in summer 2011 hydrilla expanded its foothold. The Town of Barnstable continues to adapt to a reality of a long-term fight against this tenacious species.

Contact Information: Rob Gatewood, Town of Barnstable Conservation Division, Town Offices - 200 Main St., Hyannis, MA 02601, USA, Phone: 508-862-4093, Fax: 508-778-2412, Email: rob.gatewood@town.barnstable.ma.us

DETERMINING THE SOURCE(S) FOR *CICHLASOMA UROPHTHALMUS* (MAYAN CICHLID) IN SOUTH FLORIDA

***Elizabeth Harrison**, Timothy Collins* and *Joel C. Trexler*
Florida International University, Department of Biology, Miami, FL, USA

Invasive species are a major threat to biodiversity and ecosystem function, and are of increasing economic concern. Yet, ecologists have struggled to explain why some species succeed while others do not. One hypothesis is that a population with high genetic diversity should be able to adapt quickly to new environments, thus enhancing invasion success. The Mayan cichlid (*Cichlasoma urophthalmus)* is native to the Atlantic slope of Central America. It was first recorded in Everglades National Park in 1983 and is now well established throughout most of south Florida. I examined genetic structure of introduced and native populations of Mayan cichlids by examining nine mitochondrial and nuclear genes to evaluate the source and number of introductions. To date, we have collected 504 fish from within the Everglades, Mexico, Belize, Honduras and Guatemala. Travel to Belize is planned to collect additional samples from the native range. Preliminary results indicated six cytochrome b haplotypes that can distinguish between samples from Mexico, Belize and Honduras (native range), and the Everglades (introduced range). Mexico and Belize displayed shared and unique haplotypes while south Florida haplotypes are completely distinct. Genetic variation within Mexico, Belize, and within sites of south Florida, significantly contributed to total genetic variation of Mayan cichlids. Variation between the native and introduced ranges was highest. These results show that cytochrome b can help to identify source populations for Mayan cichlid introductions in south Florida and determine genetic relationships within and between the native and introduced ranges.

Contact Information: Elizabeth Harrison, Florida International University, 11200 SW 8th St., Miami, FL, 33199, USA, Phone: 305-763-9474, Email: lizharrison22@gmail.com

HOME RANGE, HABITAT USE, AND MOVEMENT PATTERNS OF NON-NATIVE BURMESE PYTHONS IN EVERGLADES NATIONAL PARK

M. Kristen Hart[1], *Michael S. Cherkiss*[1], *Frank J. Mazzotti*[2], *Ikuko Fujisaki*[2], *Skip Snow*[3] and *Michael E. Dorcas*[4]

[1]U.S. Geological Survey, Southeast Ecological Science Center, Fort Lauderdale, FL, USA
[2]University of Florida, Davie, FL, USA
[3]U.S. National Park Service, Homestead, FL, USA
[4] Davidson College, Davidson, NC, USA

Knowledge of the spatial ecology of invasive species is critical to allow for identification of key habitats occupied and to determine which native species may be affected. Designing conservation strategies that aim to control invasive species is a significant challenge, and radio telemetry offers promise for uncovering distinct areas that are important habitats. Non-native Burmese pythons (*Python molurus bivittatus*) are large-bodied constrictors reaching lengths up to 6m that are now established in Everglades National Park, a wilderness area also deemed a 'wetland of international significance'. During 2006-2009, we performed two radiotracking studies, one in which we translocated and tracked six adult pythons and another in which wetracked 16 wild-caught adult pythons in Everglades National Park. Study goals were to identify home ranges and core-use areas, as well as to explore correlations of individual movements with environmental parameters such as presence of surface water.

All six translocated pythons made relatively rapid, long distance movements towards their original area of capture, traveling up to 34.7km. The magnitude and rate of these movements appear to be unparalleled in many other snake studies. This large-scale movement and apparent ability to 'home' has not previously been documented in Burmese pythons. Tracking periods for the 16 pythons used in the second study ranged from 87 to 697 days, with a total of 5,119 days for all pythons (mean ±1 SD = 319.9 ± 184.3 days). We observed mean individual home ranges of 22.5 km^2 with overall low site-fidelity; all home ranges were within the Park boundary. Python core-use areas included slough and coastal habitat types, and pythons frequented areas with tree islands. Individual python core-use areas overlapped, forming 18 common-use areas. The longest movements of individual pythons correlated well with presence of surface water, but occurred during both wet and dry seasons. Until now, knowledge of python habitat use and movement in the Park has been limited. Our finding that multiple core-use areas are in relative proximity to roads provides not only a starting point for targeted control efforts, but also an opportunity for directed conservation of native species at risk in those sites.

Contact Information: M. Kristen Hart, Southeast Ecological Science Center, U.S. Geological Survey, Fort Lauderdale, Florida, USA, Phone: 954-650-0336, Fax: 954-475-4125, Email: kristen_hart@usgs.gov

MOVEMENT AND ACTIVITY OF INVASIVE BURMESE PYTHONS (*PYTHON MOLURUSBIVITTATUS*) DETERMINED THROUGH USE OF ACCELERATION AND GPS LOGGERS

M. Kristen Hart[1], *Michael S. Cherkiss*[1], *Nicholas M. Whitney*[2] and *Frank J. Mazzotti*[3]
[1] U.S. Geological Survey, Southeast Ecological Science Center,Fort Lauderdale, FL, USA
[2]Mote Marine Laboratory, Sarasota, FL, USA
[3]University of Florida, FLREC, Davie, FL, USA

Native to Southeast Asia, Burmese pythons are an established invasive species in South Florida.Habitat and dietary generalists, pythons can reach lengths greater than 6 meters and produce large clutches of eggs. Pythons have spread throughout Everglades National Park (ENP) and efforts are underway to develop methods to control the spread of this invasive exotic reptile. Such efforts include studies of Burmese python ecology, habitat use, movement, and activity patterns. These studies are critical for evaluating the impacts pythons have on native animal populations found within and adjacent to ENP. Until recently, knowledge of python habitat-use and movement (i.e., the extent and timing) in ENP has been limited. Radio-telemetry studies have shown that pythons can have large home ranges, move long distances, and use a variety of habitats including slough and coastal habitat types, and frequenting areas with tree islands and adjacent to roads.Eradication of Burmese pythons is no longer possible, but management is.Knowledge of the fine-scale spatial ecology and activity cycles and behavior of this invasive species in the wild are critical to allow for identification of key habitats occupied and to predict when pythons are most active. This Information will help managers to design appropriate strategies that aim to control this invasive species.

To uncover very fine-scale activity patterns of Burmese pythons that are at-large in the wild, we employed GPS technology to record movements of individual pythons multiple times a day in combination with acceleration data loggers (ADLs) which continuously record the body posture, temperature, and fine-scale body position and movements. We surgically implanted transmitters and loggers in the posterior half of each python's body, along with two VHF transmitters. We detected climbing and swimming behavior when performed for seconds at a time, and recorded a successful foraging event for one animal; the remains of a wading bird were found in its stomach shortly thereafter. The use of this technology allows for determining when pythons are most active, and the ADL's allow for ground-truthing the GPS logger data and when animals were most active. These tools show promise for deciphering python movements and habitat use in relation to activity patterns in wild-caught pythons.

Contact Information: M. Kristen Hart, Southeast Ecological Science Center, U.S. Geological Survey, Fort Lauderdale, Florida, USA, Phone: 954-650-0336, Fax: 954-475-4125, Email: kristen_hart@usgs.gov

PARALLEL UNIVERSES: REMARKABLE SIMILARITIES IN THE SIEGE OF INVASIVE SPECIES ON FLORIDA AND HAWAIʻI

Steven C. Hess[1] and *Lloyd L. Loope*[2]
[1]U.S. Geological Survey Pacific Island Ecosystems Research Center, Kīlauea Field Station, HI, USA
[2]U.S. Geological Survey Pacific Island Ecosystems Research Center, Maui Field Station, HI, USA

Florida and Hawaiʻi have unique insular and peninsular tropical and subtropical biotas shaped by long histories of isolation and slow rates of natural establishment by continental colonists. Advances in transportation have increased the rate of colonization and establishment of novel species, leading to a 'fast forward' in species invasions. While they now share a number of cosmopolitan invasive species such as feral pigs (*Sus scrofa*) and feral cats (*Felis catus*), there are also numerous, less widely distributed invasive species common to both states such as strawberry guava (*Psidium cattleianum*) and christmasberry or Brazilian pepper (*Schinus terebinthifolius*). In both cases, invasive trees have fundamentally changed the structure and function of large forested areas with few prospects for reverting back to natural conditions. Both states also have similar suites of invasive vertebrates including birds, herptiles, and large and small mammals, except that Hawaiʻi lacks many invasive aquatic vertebrates common to Florida, i.e., fish. The geographic range of many invasive species is restricted by elevation in Hawaiʻi, but Florida has a much more limited range of elevation and invasive species have proliferated in low-lying areas where hydrology has been intentionally altered. While these situations may be seen as mostly unfortunate, there are a number of transferable applications in the management of invasive species that may be mutually beneficial to both states. There are also opportunities to understand how the function of ecosystems is eroded by invasive species and apply knowledge of these processes to larger spatial scales. Specific areas where reciprocal Information transfer could be beneficial include: methods for local eradication and reducing the spread of little fire ants (*Wasmannia auropunctata*); the application of the Brazilian scale insect (*Tectococcus ovatus*) for the biological control of strawberry guava and several other agents for *Schinus*; and the implications of the internationally notorious Neotropical rust of Myrtaceae (*Puccinia psidii*), both for potentially severe adverse effects on endemic Hawaiian Myrtaceae, especially the dominant tree (*Metrosideros polymorpha*), as well as an adventive biological control agent for paperbark (*Melaleuca quiquenervia*) in Florida. The development of strategies to prevent establishment and to control the spread of invasive vertebrates in similar environments would also be mutually beneficial.

Contact Information: Steven C. Hess, U.S. Geological Survey Pacific Island Ecosystems Research Center, Kīlauea Field Station, PO Box 44, Hawaiʻi National Park, HI 96718, Phone: 808-985-6410, Fax: 808-967-8568, Email: shess@usgs.gov

PHRAGMITES AUSTRALIS EXPANSION IN A RESTORED BRACKISH MARSH DOCUMENTED AT DIFFERENT TIME SCALES

Rebecca J. Howard[1] and *Theodore D. Turluck*[2]
[1]U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, USA
[2]University of Louisiana at Lafayette, Department of Biology, Lafayette, LA, USA

Wetland restoration efforts in coastal Louisiana often include planting vegetation at sites where substrate conditions have been improved by engineering efforts. At one such site in the Barataria Basin of southeastern Louisiana dredged sediment from an adjacent waterway was added to restore a degraded brackish marsh in 2000. Plantings of *Phragmites australis* at the site in 2001 inadvertently included specimens of the invasive haplotype that is native to Europe and Asia. The plantings also included individuals of the gulf coast haplotype of *P. australis*, which may be native to this region. The study consisted of three sites with two planted areas, called units, at each site. Expansion of *P. australis* at the restored marsh was documented at three time scales. Growth over a short term of three months was examined during the first growing season after planting. Information on haplotype identity of the planted specimens was available, so differences between individuals of the Eurasian and the gulf coast lineages were examined. Expansion over an intermediate time scale was documented by plotting the occurrence of *P. australis* in the planted units over two years. Aerial imagery was used to determine overall increase in coverage of *P. australis* stands over the relatively long term of eight years since planting.

Little difference was found when growth of the two *P. australis* haplotypes was compared over the short term. Time, however, significantly affected growth response either as a main effect or by interacting with haplotype identity. Plots of expansion over two years indicated that the rate of spread differed among the six planted units. In each unit the cover of *P. australis* increased from less than 1 m^2 at the time of planting to about 74 m^2 over two years. In 2004, three years after planting, the two separate units at the sites were no longer discernable. Aerial imagery of two planted sites was available in 2009, eight years after planting, and total aerial coverage at these two sites was 3,245 m^2 and 3,453 m^2. For the five year period from 2004 to 2009, aerial cover of *P. australis* at these two sites increased 540% and 676%. Genetic analyses conducted in 2002 indicated that the Eurasian haplotype tended to displace the gulf coast haplotype at the site. Because the Eurasian haplotype characteristically forms dense monospecific stands, the functional value of this restored wetland may be compromised.

Contact Information: Rebecca J. Howard, U.S. Geological Survey, National Wetlands Research Center, 700 Cajundome Blvd., Lafayette, LA 70506, USA, Phone: 337-266-8639, Fax: 337-266-8586, Email: howardr@usgs.gov

NEXT GENERATION SEQUENCING, MOLECULAR TOOL DEVELOPMENT, AND GENETIC CHARACTERIZATION OF THE INVASIVE BURMESE PYTHON IN THE GREATER EVERGLADES ECOSYSTEM

Margaret Hunter[1] and *Kristen M. Hart*[2]
[1]U.S. Geological Survey, Southeast Ecological Science Center, Gainesville, FL, USA
[2]U.S. Geological Survey, Southeast Ecological Science Center, Davie, FL, USA

The invasive and exotic Burmese python is established and breeding in Everglades National Park (ENP) and provides additional challenges to the success of the Comprehensive Everglades Restoration Project (CERP). Pythons have the potential to occupy the entire footprint of the Greater Everglades and adversely affect the native resources, including endangered species populations, throughout the area. Previous studies found very little genetic diversity and lack of population division in the ENP python population; therefore, we developed additional nuclear microsatellite markers using next generation pyro sequencing techniques. Of the thousands of loci identified, we developed primers for 20 tri- and tetra-nucleotide repeats. In combination with seven previously available Burmese python primers, we developed eight microsatellite multiplexesto improve the throughput.

With these additional tools, we are characterizing the genetic diversity of pythons (including “core” and “periphery” samples)and calculating the size of the effective breeder population. Further,we are assessing ENP python population structure to determine whether breeding is occurring in a panmictic fashion throughout the population, or whetherdistinct breeding populations occur. Protocols will be developed to preparefor rapid analysis and interpretation of new genetic samples from “periphery” or areas adjacent to the Park. Additionally, gut contents will be genetically analyzed to identify the python prey species.

Contact Information: Margaret Hunter, Southeast Ecological Science Center, U.S. Geological Survey, Gainesville, Florida, USA, Phone: 352-264-3484, Fax: 352-378-4956, Email: mhunter@usgs.gov

ENDANGERED SPECIES RECOVERY VS. ERADICATION OF AN INVASIVE ECOSYSTEM ENGINEER: THE SURPRISING STORY OF THE INVASIVE *SPARTINA* PROJECT

Drew W. Kerr
San Francisco Estuary Invasive *Spartina* Project, Berkeley, CA, USA

The California State Coastal Conservancy and USFWS began the Invasive *Spartina* Project (ISP) in 2000 with the goal of reversing the spread of non-native cordgrass (*Spartina*) and eventually eradicating it from the San Francisco Bay estuary through a coordinated, baywide effort. Controlling this ecosystem engineer was a key first step in the South Bay Salt Pond Restoration Project that will return 15,000 acres of salt production ponds back to the ecosystem. Every tidal restoration site opened in the Bay over the last 25 years had been quickly invaded and dominated by *Spartina alterniflora* and its hybrids with the native *S. foliosa*, pushing the sites off the native marsh development trajectory resulting in low biodiversity monocultures.

Over decades of backcrossing, *S. alterniflora X foliosa* had formed a hybrid swarm of different morphologies and phenologies that were capable of exploiting all tidal marsh niches from channels to the high marsh ecotone. The invasion also threatened the mudflats used by more than one million migratory shorebirds on the Pacific Flyway, and clogged flood control channels large and small. However, one very important denizen of the Bay's marshes found welcome refuge in the thick, tall stands of hybrid cordgrass, the endangered California clapper rail (*Rallus longirostris obsoletus*). As the aggressive invasion engulfed more and more of the Bay's fragmented marshes through the 1990's, clapper rail populations at some sites soared beyond historical densities.

When Baywide *Spartina* control efforts began in 2005 after California registration of the aquatic formulation of imazapyr (Habitat®), the hybrid *Spartina* infestation had expanded to over 800 net acres affecting approximately 35,000 acres of tidal systems. By 2011, the hybrid *Spartina* footprint had been reduced to approximately 52 net acres. While the elimination of hybrid *Spartina* from intact marshes did not have a significant impact on clapper rail numbers, the removal of tall, dense stands of cordgrass where there was previously little habitat value did have the anticipated effect of returning the rail populations to pre-infestation levels. By 2011, winter call count surveys showed that even these declines had leveled out, with the population trends stabilizing over the past three years.

Passive revegetation had long been the standard approach to tidal marsh restoration in San Francisco Bay, a "breach it and they will come" perspective. But for unknown reasons, clapper rail numbers had dropped significantly even in areas of the Bay where no *Spartina* invasion had been treated; subsequently, USFWS required a substantial revegetation effort as a condition of ISP's Biological Opinion. Implementation began at 20 sites in 2011 focusing on *S. foliosa* reintroduction where it had been extirpated, planting *Grindelia stricta* at marshes where it was largely absent, and the establishment of a high-marsh ecotone.

<u>Contact Information</u>: Drew Kerr, San Francisco Estuary Invasive Spartina Project, 2612-A 8th Street, Berkeley, CA 94710, USA, Phone: 510-548-2461 ext. 203, Fax: 510-548-2460, Email: dwkerr@spartina.org

REFUGIA IN A NOVEL ECOSYSTEM: EVERGLADES SNAIL KITE IN FLORIDA

Wiley M. Kitchens[1], *Christopher Cattau*[2] and *Zach Welch*[3]

[1]U.S. Geological Survey, Gainesville, FL, USA
[2]University of Florida, Gainesville, FL, USA
[3]Florida Fish and Wildlife Conservation Commission, Ocala, FL, USA

The Everglades Snail Kite (*Rostrhamus sociabilis plumbeus*) is an endangered raptor whose current range in the U.S. is restricted to wetlands in south and central Florida. The population underwent precipitous population declines from 1999-2001 and again from 2006-2008, falling from approximately 3400 to 1500 to 1000 individuals. Population viability analyses have indicated high probabilities of quasi-extinction for the snail kite in the next 30 to 40 years, and the decline in the population growth rate has been associated largely with suppressed reproduction. Concurrent with the population decline of the snail kite has been an apparent decline of its major prey base, the Florida apple snail (*Pomacea paludosa*), throughout much of the kite's range. However, there has been a relatively recent explosive invasion of the exotic island apple snail (*Pomacea insularum*) in the Kissimmee Chain of Lakes (KCOL), particularly in Lake Tohopekaliga, where exotic snails have comprised approximately 95% of the kite's diet over the last seven years. Coincident with the invasion of exotic snails, there has been a major shift in the principal wetland units utilized by nesting kites. From 1998-2004 the KCOL supported approximately 26% of nesting throughout the range; however, after the invasion of the exotic snail, the nesting distribution shifted radically, and from 2005-2011 the relative frequency of nests in the KCOL more than doubled, constituting approximately 64% of all nests observed range-wide during this time period. The shift in the kite's breeding range corresponds closely with the distribution of the exotic snail, particularly in systems supporting dense stands of the invasive submerged aquatic *Hydrilla verticella*. The novel conditions in Lake Tohopekaliga, induced by hydrologic manipulations and plant management activities, have been described by Welch (2009), and recent observations have revealed that kites are employing new, adaptive foraging behaviors in this novel habitat. Recent data also indicate a potential recovery of reproductive capacity of the kite, with the number of successful nests (a principal vital parameter associated with population growth) increasing by a factor of two from approximately 100 to 200 throughout the range in 2011. This is the first indication of the kite's resiliency and adaptability to altered habitat resources, highlighting an endangered species' potential responses to novel conditions (i.e., the co-occurrence of two invasive exotics species).

Contact Information: Wiley M. Kitchens, Florida Cooperative Fish and Wildlife Research Unit, U. S. Geological Survey, McCarty Annex A, P.O. Box 110485, University of Florida, Gainesville, FL 32611, USA, Phone: 352-846-0536, Email:wiley01@ufl.edu

SYNERGISTIC EFFECTS OF INVASIVE SPECIES (*MELALEUCA QUINQUENERVIA*) AND MANAGEMENT PRACTICES ON NATIVE PLANT COMMUNITY RESILIENCE IN THE FLORIDA EVERGLADES

James J. Lange and *Brian W. Benscoter*
Florida Atlantic University, Davie, FL, USA

Invasive species can have profound impacts on native wetland plant communities and their ecology. The extent of these impacts can affect the capacity of communities to respond successfully to management practices. In the Everglades, *Melaleuca quinquenervia* is an aggressive, invasive tree that can displace native vegetation, often forming dense, closed canopy stands that have very little value to native wetland wildlife. Negative impacts of *Melaleuca* can increase with time through increased shading, altered hydrology, and substrate changes from massive litter production. Invasive species management of *Melaleuca* typically involves either aerial or ground spraying with herbicides, which can have possible detrimental effects on non-target native vegetation. The impacts of these removal practices on the long-term recovery potential of native wetland plant communities are not well quantified. We assessed the impact of management treatments (aerial vs. ground spraying) on native vegetation recovery trajectories along gradients of *Melaleuca* invasion severity (stand age, area, and litter depth) at the A.R.M. Loxahatchee National Wildlife Refuge to assess if management practices can have a detrimental effect on ecosystem resilience when thresholds of invasion are exceeded. We compared current plant community composition of both native and invasive species to baseline target data of native habitat composition from prior surveys to assess native community recovery under different management practices and levels of invasion. Understanding synergistic effects of invasion and treatment practices on ecosystem resilience will add insight into the immediate and legacy impacts of invasive species on wetlands, and provide tools for evaluating the benefits and risks of land management practices for native vegetation recovery.

Contact Information: James J. Lange, Environmental Sciences, Florida Atlantic University, 3200 College Ave., Davie, FL 33314, USA, Phone: 954-254-1020, Email: jlange1@fau.edu

COMMON REED (*PHRAGMITES AUSTRALIS*) STANDS IN FRESHWATER MARSHES: 'BIOLOGICAL DESERTS' REVISITED

Claude Lavoie and *the PHRAGMITES Research Group*
Université Laval, Québec, QC, Canada

The haplotype M of the common reed (*Phragmites australis* subsp. *australis*; Poaceae) is progressively invading freshwater marshes of the Great Lakes – St. Lawrence River watershed, creating new ecosystems up to hundreds of hectares in area. Since this plant is suspected of having negative impacts on biodiversity and ecosystem functioning, environmental managers in North America have often initiated herbicide based eradication programs. But do we really have data supporting the assertion that common reed stands in freshwater wetlands are biological deserts? Over the last ten years, the PHRAGMITES Research Group (Université Laval, Université de Montréal, McGill University) investigated the impacts of the common reed on plant and animal (fishes, amphibians, birds) biodiversity in Canadian freshwater marshes. Common reed reduces plant richness and diversity, but its impact on animals is, to date, very small. For some fish species, common reed stands are less suitable spawning grounds than other vegetation assemblages, but are nevertheless widely used by fishes for reproduction and feeding, especially during low water level periods. Amphibian and bird richness and diversity in common reed stands are similar to those of other wetland vegetation assemblages, although frog and bird populations in reed stands are somewhat different from a species composition point of view. In summary, common reed stands are by no means biological deserts, and to date there are few arguments supporting large-scale eradication programs. However, whereas having *some* common reed stands in a marsh is acceptable, having *only* common reed stands is another story. We hypothesize that once a certain proportion of the marsh has been invaded by the common reed, impacts on biodiversity become more tangible. This invasion threshold remains to be quantified. Environmental managers should therefore focus on preventing the emergence of new populations and on controlling the expansion of existing ones; the PHRAGMITES Group proposes several solutions to this end.

Contact Information: C. Lavoie, École supérieure d'aménagement du territoire et de développement régional, Université Laval, Québec, QC, G1V 0A6, Canada, Phone: 418-656-2131 ext. 5375, Fax: 418-656-2018, E-mail: claude.lavoie@esad.ulaval.ca

DOES HYBRIDIZATION CONTRIBUTE TO CATTAIL INVASION OF WETLANDS IN THE MIDWEST?

Steven E.Travis[1], ***Joy E. Marburger***[2] and *Rachel Tamulonis*[1]
[1]Department of Biological Sciences, University of New England, Biddeford, ME, USA
[2]Indiana Dunes National Lakeshore, National Park Service, Porter, IN, USA

Cattails (*Typha* spp.) are ubiquitous graminoids occurring in wetlands worldwide. Three known species, *Typha latifolia*, *T. domingensis*, and *T. angustifolia* (considered non-native by many), and a hybrid taxon, *Typha* x *glauca* occur in the US. Due to overlap of morphological characteristics, it is difficult to distinguish the hybrid taxon from its parental species. We applied species-diagnostic molecular techniques to evaluate both adult and seedbank populations in three national parks in the Midwest. Results at Sleeping Bear Dunes National Lakeshore indicated predominance of *T. latifolia*, but F_1 and backcross hybrids of *T. latifolia* and *T. angustifolia* also occurred. The seedbank reflected this pattern. A variety of native forbs, reeds, sedges, and grasses occurred in the seedbanks, with few other non-native species present. The results for Cuyahoga National Park and Pictured Rocks National Lakeshore indicated presence of only *T. latifolia* in both the adult populations and the seedbank. These parks will be reanalyzed with additional DNA markers, since the plant morphologies suggested some level of hybrid ancestry, and were therefore inconsistent with the genetic analysis. Hybridization is a contributing factor to increased cattail invasion of wetlands in the US. Management techniques to promote wetland plant biodiversity should consider the relative proportions of hybrid and non-native cattails at a site. Use of native plant seedbanks, herbicide treatment, plant installations from nurseries, and other restoration techniques can be applied to reduce invasive cattails and enhance biodiversity in Midwest wetlands.

Contact Information: Steven Travis, Department of Biological Sciences, 11 Hills Beach Road, Biddeford, ME 04042, USA, Phone: 207-602-2715, Email: stravis@une.edu

DIET OF INVASIVE BURMESE PYTHONS (*PYTHON MOLURUS BIVITTATUS*) IN SOUTHERN FLORIDA

***J. Frank Mazzotti*[1]**, *Kristen M. Hart*[2], *Michael S. Cherkiss*[2], *Michael R. Rochford*[1], *Skip Snow*[3], *Laurie Wilkins*[4] and *Carla Dove*[5]

[1]University of Florida, Davie, FL, USA
[2] U.S. Geological Survey, Southeast Ecological Science Center, Fort Lauderdale, USA
[3]Everglades National Park, Homestead, FL, USA
[4]Florida Museum of Natural History, Gainesville, FL, USA
[5]Smithsonian Institute Bird Lab, USA

Burmese pythons (*Python molurus bivittatus*) are an established invasive species in south Florida. One of the largest snakes in the world, Burmese pythons may reach lengths greater than 6 meters and have the ability to produce large clutches of eggs. Pythons have spread throughout Everglades National Park (ENP) and efforts are underway to develop methods to control the spread of this invasive exotic reptile. Such efforts include studies of their ecology, habitat use, movements, and activity patterns. In addition, examination of the diet of Burmese python is critical for evaluating the impacts pythons have on native animal populations found within and adjacent to ENP.

To evaluate impacts of pythons on native biological diversity, we examined python gut-content samples. Burmese pythons are known to be generalist predators that consume a wide variety of mammal and bird species, as well as reptiles, amphibians, and fish. By identifying prey species in the digestive tracts of Burmese pythons through examination of hair, bone, and teeth, to date we have identified 14 species of mammals, 5 species of birds, and one species of reptile in the gut contents. These species include several federally endangered Key Largo woodrats (*Neotoma floridana smalli*); one threatened species, the American alligator (*Alligator mississippiensis*); and two species of special concern, the limpkin (*Aramus guarauna*) and the white ibis (*Endocemus albus*). We have also found the remains of bobcat (*Lynx rufus*), and white-tailed deer (*Odocoileus virginianus*). Given the diverse dietary habits of the Burmese python, it is possible that other federally endangered or threatened species in Florida may be at risk as prey. In addition to the Key Largo woodrat, protected species believed to be at risk include the Florida panther (*Puma concolorcoryi*), mangrove fox squirrel (*Sciurus niger avicennia*), Key Largo cotton mouse (*Peromyscusgossypinusallapaticola*), wood stork (*Mycteria americana*), Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*), and American crocodile (*Crocodylus acutus*). Analyses of additional gut-content samples are ongoing.

Contact Information: J. Frank Mazzotti, Department of Wildlife Ecology and Conservation, University of Florida, Fort Lauderdale, Florida, USA, Phone: 954-577-6304, Fax: 954-475-4125, Email: fjma@ufl.edu

HABITATS INVADED BY EUROPEAN FROGBIT (*HYDROCHARIS MORSUS-RANAE*) IN LAKE ONTARIO COASTAL WETLANDS

***Brad M. Mudrzynski**, Douglas A. Wilcox* and *Aaron W. Heminway*
Department of Environmental Science and Biology, The College at Brockport, State University of New York, Brockport, NY, USA

European frogbit (*Hydrocharis morsus-ranae*), a native to Europe and northern Asia, was first introduced to North America in 1932 near Ottawa, Ontario, Canada and has spread throughout much of Lake Ontario and into many surrounding lakes, rivers, and ponds. This free-floating aquatic plant is capable of forming dense mats that choke out sunlight, alter dissolved oxygen and nutrient concentrations, and displace native flora. We sampled 34 Lake Ontario coastal wetlands during the summer of 2011 using 45 vegetation quads per wetland spread across submersed aquatic, emergent, and wet meadow vegetation zones and collected data on water quality, sediment depth, water depth, and detritus cover to test for correlations with European frogbit cover and frequency. European frogbit was present in 83.3% of riverine, 85.7% of barrier, 88.9% of lacustrine, and 85.3% of all wetlands sampled in Lake Ontario. While European frogbit cover was generally greatest in barrier wetlands, there were no significant differences in cover between the three hydrogeomorphic wetland types. European frogbit was most common and in the greatest cover within the emergent zone; however, it was capable of reaching 75% cover in the meadow zone if there was standing water. European frogbit was never greater than 20% cover in the submersed aquatic vegetation zone. Only one environmental variable, chloride ion concentration, was significantly correlated with frogbit frequency ($p = 0.015$, $r = -0.418$) and cover ($p = 0.009$, $r = -0.449$) in the emergent vegetation zone. No environmental variables were significantly correlated with frogbit cover across all zones; however, frogbit frequency was significantly correlated to total nitrogen concentration ($p=0.002$, $r = -0.398$) and transparency tube depth ($p = 0.026$, $r = 0.394$). While these results do not establish a cause and effect relationship that can be managed for control of European frogbit, they do suggest that wetland managers in the Great Lakes region focus prevention and monitoring efforts on wetlands that contain relatively low levels of chloride and nitrogen, and have relatively turbid waters.

Contact Information: Brad M. Mudrzynski, 108A Lennon Hall, 350 New Campus Drive, SUNY Brockport, Brockport, NY 14420, USA, Phone: 585-395-5763, Email: bmudrzyn@brockport.edu

NOVEL ECOSYSTEMS PERSIST FOLLOWING CONTROL OF THE INVASIVE GRASS *PHALARIS ARUNDINACEA*

Carrie Reinhardt Adams and *Philip Kauth*
Environmental Horticulture Department, University of Florida, Gainesville, FL, USA

Managing the transition from invasive plant control to native species establishment is complicated by our lack of knowledge of the drivers of management outcomes. Based on a multi-regional study of management in *Phalaris arundinacea*-dominated wetlands, we discuss the emergence of novel, hybrid, and historic systems resulting from restoration treatments. Control of this invasive perennial grass results in highly variable outcomes, perhaps related to landscape-level drivers (e.g. propagule pressure, and flooding), and site-level drivers (e.g. extant native vegetation species composition, seed bank composition, and soil nutrients). Extrapolation from this four-year dataset identifies degradation scenarios, defined by abiotic and biotic alteration of a site, that are likely to drive the outcome of management actions. Where *P. arundinacea* density is low and abiotic conditions are relatively unaltered, management may feasibly maintain a historic or hybrid system, wherein *P. arundinacea* is managed with little resource input and historic species composition persists. Where abiotic conditions are altered (elevated soil nutrients, increased frequency of flooding), a novel ecosystem results. Longer term observations of the outcome of management treatments are needed to determine the state of lands following *P. arundinacea* control.

Contact Information: Carrie Reinhardt Adams, Environmental Horticulture Department, University of Florida/IFAS, 107 Building 68, Gainesville, FL 32611, USA, Phone: 352-273-4502,; Fax: 352-3921413, Email: rein0050@ufl.edu

REDUCING THE RISK OF MISIDENTIFICATION OF *HYDRILLA*, *EGERIA*, AND *ELODEA* WITH DNA FINGERPRINTING

Nancy B. Rybicki[1], *Julie D. Kirshtein*[1] *Mary A. Voytek*[2]
[1]US Geological Survey, Reston, VA, USA
[2]National Aeronautics and Space Administration, Washington, DC, USA

DNA fingerprints provide tools to positively identify plant species from tiny fragments of fresh or dry plant tissue. We wanted to know if a simple species level taxonomic fingerprinting techniques could be developed for submerged aquatic vegetation (SAV) and used to reduce errors in identification. We tested the hypothesis that the use of fingerprinting would substantially improve current and past descriptions of SAV, and in turn improve our understanding of long term trends in invasive and native species distribution. We build upon existing molecular techniques (polymerase chain reaction (PCR)) and restriction fragment length polymorphism (RFLP) analyses to develop a fingerprinting protocol to discriminate among four related and morphologically similar species that are invasive in multiple continents, *Hydrilla verticillata* (monoecious and dioecious), *Egeria densa, Elodea canadensis,* and *Elodea nuttallii*.

We verified the technique on 105 herbarium and live samples. In applying the protocol we confirmed and corrected historic identifications that were based only on morphology. While *E. canadensis* is reported as common in the mid-Atlantic region of North America since the 1970s, and *E nuttallii* as rare, fingerprinting indicates the opposite is true. Further research is needed to investigate the potential displacement of *E. canadensis* with *E. nuttallii* in that region or elsewhere. We also confirmed new locations where the monoecious and dioecious *H. verticillata* biotypes had recently increased their range to the north in the USA. One herbarium samples labeled as *Elodea* was actually *H. verticillata* and showed it had invaded the Potomac River by 1976, pre-dating the published date of 1981. This study shows that once protocols are developed, molecular techniques are good tools for confirming identification, distribution, and recent pace of spread of invasive and non-invasive species. Molecular techniques in invasive species programs will aid in verification of species in order to optimize early detection efforts and can be of use after an introduction to reconstruct the initial introduction period, the invasion growth rate, and potential pathways.

Contact Information: Nancy Rybicki, National Research Program, US Geological Survey, MS430, National Center, Reston, VA 20192, USA, Phone: 703-648-5728, Fax: 703-648-5484, Email: nrybicki@usgs.gov

EFFECTS OF INTRODUCED *SPARTINA ALTERNIFLORA* ON THE BENTHIC AND AERIAL MACROINVERTEBRATES IN THE SALT MARSH

Chunfu Tong
State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai, China

Spartina alterniflora Loisel. which is native to the Atlantic and Gulf Coasts of North American, has been introduced to numerous locations all over the world. However, in last couple decades, in many of the introduced areas, including some locations in China, *Spartina alterniflora* has been reported to be an invasive species with some extremely negative effects on local ecosystems.

The macroinvertebrates in the aerial and the benthic habitats are key links in the food web of the salt marsh ecosystem. In order to test the effects of introduced *Spartina alterniflora* on benthic and aerial macroinvertebrates of the salt marsh, permanent sampling sites were set in different vegetation zones, including the native *Phragmites australis* and *Scirpus mariqueters* zones and the introduced exotic *Spartina alterniflora* zone. We conducted monthly surveys on the benthic macroinvertebrates in the different vegetation zones in 2006, and in the same areas on the aerial macroinvertebrates in 2007.

A total of 2603 specimens belong to 23 species of 4 phyla and 6 classes of the benthic macroinvertebrate were collected during the surveys. Vegetation type appeared to have significant effects on the number of species, abundance, biomass and diversity index values of the benthic macroinvertebrate (ANOVA, $p<0.05$). Contrary to what others have declared, *Spartina alterniflora* appeared to have some positive effects on the benthic macroinvertebrate. Some indicators, such as the biomass and Shannon-Wiener diversity index values of the benthic macroinvetebrate, in *Spartina alterniflora* zone were significantly higher than in the others.

A total of 3778 specimens belong to 49 species of 1 phyla, 2 classes and 11 orders of the aerial macroinvertebrate were collected in 2007. According to their trophic characteristics, we divided them into three functional groups: phytophagous, predatory-parasitic, and saprophagous. Among them, the phytophagous group had the highest species richness and abundance, and the saprophagous functional group had the lowest. Vegetation type appeared to have no significant effect on the functional group of the aerial macroinvertebrate (ANOVA, $p>0.05$). Furthermore, the introduced exotic species *Spartina alterniflora* had no significant negative effects, contrary to the existing results. Relative to the phytophagous group, although the number of individuals in the *Spartina alterniflora* zone was obviously lower than in the others, the number of species in the *Spartina alterniflora* zone was equivalent to those in the other zones.

From all the results above, we come to the conclusion that the effects of introduced exotic species *Spartina alterniflora* on the macroinvertebrates in the salt marsh varied among the benthic and the aerial habitats. Contrary to previously existing results, the effects of *Spartina alterniflora* can also be positive on some aspects. The mechanisms that control these findings need further investigation.

Contact Information: Chunfu Tong, State Key Laboratory of Estuarine and Coastal Research, East China Normal University, 3663 North Zhongshan Road, Shanghai 200062, P.R. China, Phone: 86-21-62232174, Fax: 86-21-62546441, Email: cftong@sklec.ecnu.edu.cn

CRYPTIC CATTAIL INVASIONS IN NORTH AMERICAN WETLANDS: IMPACTS TO BIODIVERSITY

Steven E. Travis[1] and *Joy E. Marburger*[2]
[1]University of New England, Biddeford, ME, USA
[2]National Park Service, Porter, IN, USA

Cattails (*Typha* spp.) are reed-like wetland graminoids that have undergone a massive, albeit cryptic, North American expansion over the past hundred years driven by a combination of environmental and evolutionary forces. Pollen records indicate the presence of native *T. latifolia* and *T. domingensis* dating back thousands of years in North America. While *T. latifolia* was widespread in the north, and *T. domingensis* in the south, both species appear to have coexisted alongside many other native wetland plant species until quite recently when they began to form novel and aggressive monocultures. This behavior has been fueled, at least in part, by the spread of a third cattail species, *T. angustifolia*, westward and southward from coastal portions of New England over the past 150 years. *Typha angustifolia* is known to supplant other wetland species, particularly under elevated nutrient levels, and to invade relatively deep, open water under stable hydrological conditions.

Recently, we used DNA markers to confirm that hybridization between *T. latifolia* and *T. angustifolia* is an additional factor contributing to cattail invasiveness in the Great Lakes region, and we are in the process of examining whether hybridization between *T. domingensis* and *T. angustifolia* is fueling similar invasions in the Everglades of Florida. Cattails may reproduce by either sexual or vegetative means, the latter being an especially prominent form of reproduction among invasive plants. Our work in the Great Lakes region has shown that hybrid cattails typically represent the largest clones in mixed *Typha* stands. As the age of these stands increases, as reflected in actual degree of mixing, clonal diversity also increases, thereby creating additional opportunities for outcrossing and potentially producing a ready source of viable seeds for the colonization of additional sites. In total, our work indicates that much of the Upper Midwest has been colonized by hybrid cattail, with the central Great Lakes, e.g. the upper peninsula of Michigan, serving as a noteworthy exception.

The magnitude of the North American cattail invasion has raised concerns over whether native cattail populations, as well as a host of associated wetland plant species, will be able to recover from the seed-bank if hybrids are physically removed. Thus, we also conducted an investigation of cattail seed-bank dynamics using DNA markers to compare the relative proportions of pure and hybrid cattails between adult and seedling populations, and found that even where the adult cattail populations consist of a mixture of *T. latifolia*, *T. angustifolia*, and hybrids, the majority of the seedlings germinating from the seed-bank are *T. latifolia*. In spite of the dominance of these marsh communities by cattails, cattails rarely dominated the seed-bank, with the majority of seeds representing a variety of other native North American wetland species.

<u>Contact Information</u>: Steven Travis, Department of Biology, University of New England, 11 Hills Beach Road, Biddeford, ME 04005, USA, Phone: 207-602-2715, Fax: 207-602-5956, Email: stravis@une.edu

PHYSIOLOGICAL STRESS EFFECTS INDUCED BY THE NON-NATIVE AFRICAN JEWELFISH ON NATIVE DOLLAR SUNFISH

***Vanessa Trujillo**, Philip K. Stoddard* and *Jennifer S. Rehage*
Florida International University, Miami, FL, USA

Interspecific aggression and territoriality by non-natives can exclude natives from preferred microhabitats when there is a high overlap of resource utilization. Prolonged social conflicts induced by non-native species can prove to be chronic stressors to natives, causing the stress response to become maladaptive. Sunfishes serve as essential predators in the swamps and seasonal wet prairies of the Big Cypress Swamp and Florida Everglades. The invasive African Jewelfish, *Hemichromis letourneuxi,* found in south Florida canals since the 1950s, are increasing their range through rapid expansion and have been found in the same microhabitats as native sunfishes. Jewelfish are aggressive and territorial, therefore it is predicted that they will be more successful in acquiring space and displacing native species. I propose a study to determine if invasive competitors cause more physiological stress effects than the presence of native competitors in native Dollar sunfish, *Lepomis marginatus.* The aims of this study are to 1) Determine if the presence of African Jewelfish change nest guarding in native Dollar sunfish relative to a native competitor, the Spotted sunfish, *Lepomis punctatus*, 2) Determine changes in ecosystem composition when African Jewelfish are present among Dollar sunfish and other native species & 3) Determine differences in cortisol levels of Dollar sunfish in the presence of African Jewelfish versus a native competitor. This study will provide evidence of physiological stress effects that invasive species have toward native Everglades' species and will aid in conservation efforts by highlighting a greater need for habitat restoration and invasive species regulation. Understanding the dynamics of stress effects imposed on native species by non-native species can potentially help decrease native species extinction. Future applications include looking at the ecological implications of non-native induced stress towards community structure, food web dynamics and ecosystem function.

Contact Information: Vanessa Trujillo, Department of Biological Sciences, Florida International University, 11200 SW 8th Street, Miami, FL 33199, USA, Phone: 904-316-7936, Fax: 305-348-1986, Email: nessa.trujillo@gmail.com

PHYTOTOXICITY OF SECONDARY METABOLITES PRODUCED BY *PHRAGMITES AUSTRALIS* IN SOUTH-EASTERN AUSTRALIA

Md. Nazim Uddin*, Domenic Caridi* and *Randall W. Robinson*

Ecology and Sustainability Group, School of Engineering & Science, Victoria University, Melbourne, Victoria, Australia

Phragmites australis is amongst the most widespread and invasive plant on the earth, occupying a wide variety of tidal and freshwater wetlands, marshes, ditches and roadsides worldwide. Allelopathy has been considered as a major driver for its invasion into natural ecosystems. To evaluate the phytotoxicity of *Phragmites australis* we conducted bioassays with aqueous extracts of different organs (leave, stem, root and rhizome) and litter (above-ground) decomposing materials using associated and model seeds in our laboratory. Our objective was to explore the allelopathic potentiality of *Phragmites* and its potential for invasion through chemical means. In germination bioassay studies, we used 5% (5-gm dry material/100ml distilled water) aqueous extracts from different organs and measured germination percentage and bio-chemical parameters (loss of membrane integrity, lipid per oxidation and cell respiration) of associated plant species (*Juncus pallidus* and *Rumex conglomeratus*). Both species were inhibited with the extracts of different organs but leaf and rhizome extracts had greatest potential effects. In dose-response (0, 1.25, 2.5, 5, 10, 15, 20% aqueous extracts) studies, the calculated LC_{50} (lowest concentration of aqueous extract required for 50% seed germination) was 4.68 and 11.25% for leaf and rhizome extracts on model seeds (*Lactuca sativa*) respectively. Based on our observed LC_{50} concentration and biochemical parameters assessments, the leaves were more toxic than rhizome.

In decomposition studies, three treatment series: litter alone (4gm/100ml distilled water), soil alone (100gm/50ml distilled water) and litter with soil (4gm litter/100gm soil) and two types of decomposition: aerobic and anaerobic conditions were maintained for 5-weeks in laboratory. The results indicate that the concentration of water soluble phenolics and dissolved organic carbon (DOC) were reduced sharply in the first two weeks and remained more or less constant during the remaining study period in aerobic conditions, but higher concentrations were observed in anaerobic conditions and the level fluctuated. The pH, electrical conductivity (EC), osmotic potential, specific ultraviolet absorbance (SUV) and ions (nitrate, nitrite, phosphate, sulphate and chloride) concentrations were measured in aqueous extracts and they varied with time and conditions of decomposition. It was found that aqueous extracts exhibited strong inhibitory effects on root elongation of *Lactuca sativa* at the beginning of decomposition with decreased effects at the end phases of decomposition. This study may prove useful in understanding the potential impacts of allelochemicals on recruitment of plants in wetlands that contain *Phragmites australis*. This study may go some way to explaining the long-term effects, particularly floristic simplification of wetlands due to the invasion of *Phragmites australis*.

Contact Information: Md. Nazim Uddin, Department of Ecology and Sustainability, School of Engineering & Science, St Albans Campus, Victoria University, Melbourne, Victoria, Australia, Phone: 61 3 9919 2601; Fax: 61 3 9919 2465, E-mail: mdnazim.uddin@live.vu.edu.au

AN ASSESSMENT OF A REPRODUCING POPULATION OF THE OUSTALET'S CHAMELEON (*FURCIFER OUSTALETI*) IN SOUTH FLORIDA

Joy Vinci[1], *Sara E. Williams*[1], *Jennifer K. Ketterlin Eckles*[2], *Dustin Smith*[3], *Frank J. Mazzotti*[1] and *Frank Ridgley*[3]

[1]University of Florida, Davie, FL, USA
[2]Florida Fish and Wildlife Conservation Commission, Boca Raton, FL, USA
[3]Zoo Miami, Miami, FL, USA

Florida is home to more nonnative wildlife than anywhere in the world and the majority of the species are found in South Florida near the Everglades. In 2010, a breeding population of a large chameleon species, the Oustalet's chameleon (*Furcifer oustaleti*), was documented in southern Miami-Dade County in an avocado grove. The Florida Fish and Wildlife Conservation Commission partnered with members from the Everglades Cooperative Invasive Species Management Area to conduct an assessment of the population in order to determine the likelihood of eradication and the possible effects on the native ecology of South Florida. Removal surveys have been conducted since July 2011 and data were collected on morphology, habitat use, fecundity, and recruitment. Fecal matter has been collected for a diet analysis. Several chameleons have been retained as study subjects by collectors involved with the project which has also served to inform on their behavior, diet, and medical issues. Early results indicate that this species is very fecund and well-adapted to life in an agricultural grove with a steady water supply. Their effect on the native flora and fauna is difficult to determine from this population but would not be expected to be significant. However, there are concerns about this and other species of chameleons being spread throughout Florida for collection for the pet trade and issues such as landowner/collector conflicts that could arise from this practice. A management plan that takes these social issues into consideration and looks for novel ways to stem this problem is being considered.

Contact Information: Joy J. Vinci, University of Florida, Ft. Lauderdale Research & Education Center, 3205 College Ave., Davie, FL, 33314, USA, Email: alphawav@ufl.edu

FUNCTIONAL BASIS FOR GEOGRAPHICAL VARIATION IN GROWTH AMONG INVASIVE SPECIES: THE CASE OF *LYGODIUM MICROPHYLLUM*

John C. Volin
University of Connecticut, Storrs, CT, USA

Several hypotheses have been proposed to explain why certain plants become invasive when introduced to a new environment. Some of the more commonly cited are the release from natural enemies, evolution of increased competitive ability, empty niche, and novel weapons hypotheses. Many of these hypotheses can be tested employing a biogeographical approach, which can contribute greatly to our understanding of both the role physiological adaptations play in plant invasiveness and of community ecology theory in general. Examining the functional basis for the geographical variation in growth has been an effective approach in the elucidation of the underlying reasons for the successful establishment and spread of the highly invasive plant *Lygodium microphyllum*.

Lygodium microphyllum, a climbing fern native to the Pantropics of the Old World, has been aggressively colonizing natural ecosystems in the Florida Peninsula for the last few decades. In our studies we examined edaphic factors potentially influencing the fern's invasiveness, specifically addressing the hypothesis that its behavior in Florida ecosystems can be explained in part by a release from natural belowground enemies. We also investigated phenotypic differences, expressed in similar growing conditions, between source populations from Florida and from the fern's native range in Australia, hypothesizing that the former would possess traits resulting in faster growth and superior competitive ability compared to the latter. We tested these hypotheses in four parallel studies, two in Australia and two in Florida. In each location we planted common garden studies, one in a native *L. microphyllum* wetland site in Australia and one in a recently colonized wetland site in Florida. In addition, on both continents, using soils from *L. microphyllum* sites, we performed control pot studies in order to gain a more mechanistic explanation for potential differences between continents. To facilitate comparisons between the two control studies, a common sand culture was included in each. Fern growth rate and its principal determinants were compared among treatments in which soil was altered through either sterilization or nutrient amendment, or both. Relative growth rate (RGR) was generally stimulated by nutrient amendment and sterilization. The overall effect of sterilization, however, was muted under high nutrient conditions, except for the population originating from the same region as the soil used in the Australian study. Regardless of nutrient treatment, plants in this population had a significantly greater RGR in sterilized than in non-sterilized soil. Our results indicate that the invasiveness of *L. microphyllum* in Florida may be partially explained by release from natural soil-borne enemies, but likely not from an evolution of increased competitive ability.

Contact Information: John C. Volin, Department of Natural Resources and the Environment, University of Connecticut, Storrs, CT 06269, USA, Phone: 860-486-0137, Fax: 860-486-5408, Email: john.volin@uconn.edu

DID *PHRAGMITES AUSTRALIS* INVASION IN THE GREAT LAKES BEGIN IN 1988 RATHER THAN 1999?

Douglas A. Wilcox
The College at Brockport, State University of New York, Brockport, NY, USA

Water-level fluctuations are critical for maintaining the diversity and resultant habitat value of Great Lakes wetland plant communities. However, activation of the seed bank can also provide an opportunity for invasive species to displace native species. Beginning in 1999, a major invasion of *Phragmites australis* was observed in many wetlands of the upper Great Lakes when growing season peak water levels decreased by 0.7m or more following high lake levels in 1997. Timing of the invasion process is not clear, however, as *Phragmites* propagules had to be present to exploit the exposed soils. I analyzed a data set from Dickinson Island on the St. Clair River delta collected in 1988-1991, 1996 during a previous lake-level decline to document prior *Phragmites* growth, as well as overall seed-bank response. Above-ground biomass was determined for all plants each year in randomly placed quadrats in a 5-ha area exposed when lake levels decreased by 0.65m from 1986 to 1988. An initial increase in plant diversity in 1988 was gradually lost as canopy-dominating *Typha angustifolia* and *Phragmites* increased. The next cycle of high and subsequent low lake levels will be required to open the canopy again and expose the sediments for another round of germination from the seed bank. Although *Phragmites* did not expand greatly until after the decline from the 1997 high, it likely inoculated the area with viable seed during the previous low. Life- history characteristics of *Phragmites* may help explain why major invasion occurred starting in 1999 but not in 1988, despite similar decreases in lake level. However, a more straightforward conclusion is based on topography. Because post-1997 lake levels were lower than those post-1986, they exposed a greater area for *Phragmites* colonization from seed; lake levels also remained low for a longer time. Differences in bathymetry below the 1986 and 1997 lake-level elevations likely played a role in greater post-1997 spatial expansion of *Phragmites* at other sites in the Great Lakes also. The next high lake level is overdue and will likely be required to displace *Phragmites*, but the effect will be temporary.

Contact Information: Douglas A. Wilcox, Department of Environmental Science and Biology, The College at Brockport, State University of New York, 350 New Campus Drive, Brockport, New York, 14420, USA, Phone: 585-395-5963, Fax: 585-395-5969, Email: dwilcox@brockport.edu

SEA LEVEL RISE - COASTAL WETLANDS

SALTWATER INTRUSION ALTERS NITROGEN AND CARBON EXPORT FROM A RESTORED COASTAL PLAIN WETLAND, NORTH CAROLINA, USA

Marcelo Ardón[1], *Emily S. Bernhardt*[2], *Ashley Helton*[2], *Amy Burgin*[3], *Robert Payn*[4] and *Geoffrey Poole*[4]

[1]Department of Biology, East Carolina University, Greenville NC, USA
[2]Biology Department, Duke University, Durham NC, USA
[3]School of Natural Resources, University of Nebraska-Lincoln NE, USA
[4]Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT, USA

Sea level rise and decreased precipitation will increase the probability of saltwater intrusion into formerly freshwater wetlands. Saltwater intrusion changes the chemistry of surface water and soil solution by increasing sulfate concentrations and ionic strength of water. These chemical changes can alter the availability and chemical species of carbon (C) and nitrogen (N) through both microbial metabolic and physicochemical pathways. Availability and chemical species of C and N can change through microbial metabolic pathways as the availability of electron donors and acceptors is altered by saltwater intrusion, particularly due to increased SO_4^{2-} concentrations. Physicochemical pathways include ion pairing with seawater anions, blockage of sediment cation exchange sites, and flocculation. Over five years we examined carbon (DOC) and nitrogen (NO_3^-, NH_4^+, and TDN) export from the Timberlake Observatory for Wetland Restoration (TOWeR), a large (440 ha) restored wetland in the coastal plain of North Carolina. In three out of the five years we documented drought-induced saltwater intrusion during fall and winter. Episodes of saltwater intrusion decreased DOC export by half and increased NH_4^+ export by 7x. Decreases in DOC export were driven both by changes in the concentration of DOC in surface water and decreased water export. Laboratory assays indicated that flocculation in response to saltwater could partially explain decreases in DOC concentrations observed in the field. Increased NH_4^+ export was due to higher concentrations during periods of increased salinity. Other studies have found increased NH_4^+ flux from sediments in response to increased salinity due to ion pairing and blockage of sediment cation exchange sites. Our ongoing laboratory microcosms suggest similar mechanisms are driving increased NH_4^+ flux from sediments in our site. Our results indicate that in order to understand the consequences of saltwater intrusion on ecosystem fluxes of C and N it is important to examine both microbial metabolic and physicochemical pathways. Understanding the response of coastal plain wetlands to saltwater intrusion is necessary to understand the potential for fertilization of downstream estuaries from increased NH_4^+ export.

<u>Contact Information</u>: Marcelo Ardón, Department of Biology, East Carolina University, Greenville, NC 27858, USA, Phone: 252-328-6307, Email: ardonsayaom@ecu.edu

EFFECTS OF SALTWATER INTRUSION ON TIDAL FRESHWATER MARSH SURFACE ELEVATION AND VEGETATION; AN EXPERIMENTAL STUDY IN CHESAPEAKE BAY

Leah Beckett and *Andrew H. Baldwin*
University of Maryland, College Park, MD

Global climate change affects coastal marshes in a variety of ways. Changes in precipitation and river discharge, as well as drought and sea-level rise, resultant of climate change may have devastating effects on coastal marshes of Chesapeake Bay. Of particular interest is the increasing salinity in oligohaline and tidal freshwater marshes as droughts decrease freshwater inputs and saltwater intrudes up-estuary. Saltwater intrusion has a variety of effects on marsh surfaces including increases in flooding, salinity and sulfates. These factors cause an increase in vegetation stress and mortality, and may also cause a shift in community composition towards more salt tolerant species. Vegetation stress and mortality may result in a decrease in surface elevation as soil respiration rates increase and living root networks break down. An *in situ* saltwater intrusion experiment was conducted in Jug Bay, a tidal freshwater marsh of the Patuxent River, a tributary of Chesapeake Bay. Surface elevation tables were installed in 2007 and baseline measurements were taken in June, 2008. Paired experimental plots were developed with half of each plot receiving freshwater inputs, and later, a freshwater well, the other halves of each plot receiving saltwater treatments through drip irrigation, and later salt wells. Treatments began in April 2008 and continued during the growing seasons through November 2011. Seedling recruitment, vegetation cover and composition were monitored throughout the duration of the study, as well as rates of surface elevation change and accretion. Rates of elevation change and shallow subsidence did not differ between treatments. Results of vegetation monitoring are forthcoming. These results are not in agreement with previous studies that suggest marsh decomposition rates are accelerated by saltwater and sulfate intrusion, leading to an expected drop in surface elevation.

Contact Information: Leah Beckett, University of Maryland, College Park MD, 20742 United States, Phone: 301-405-1228, Email: leahbeckett5@gmail.com

GETTING THE MOST FROM SURFACE ELEVATION TABLE-MARKER HORIZON (SET-MH) INSTALLATIONS

***Alice Benzecry*[1],** *Leah Beckett*[2], *Donald R. Cahoon*[3], *Ellen Kracauer Hartig*[4], *Danielle Kreeger*[5], *James C. Lynch*[6], *Beth A. Middleton*[7], *Denise J. Reed*[8] and *Charles T. Roman*[9]

[1]Fairleigh Dickinson University, Teaneck, NJ, USA
[2]University of Maryland, Maryland, USA
[3] United States Geological Survey, Patuxent Wildlife Research Center, Beltsville, MD, USA
[4]New York City Department of Parks & Recreation, New York, NY, USA
[5]Partners for Delaware Estuary, Maryland, USA
[6]National Park Service, Washington DC, USA
[7] United States Geological Survey, National Wetlands Research Center, Lafayette, LA, USA
[8]University of New Orleans, New Orleans, LA, USA
[9]National Park Service and University of Rhode Island, Narragansett, RI, USA

Experienced as well as newer Surface Elevation Table-Marker Horizon (SET-MH) users will discuss how they are using this instrument as a key tool in assessing the long-term health and viability of coastal marshes. SET-MH practitioners will offer lessons learned, covering a range of topics such as sampling designs, deep and shallow SETs, time needed to obtain meaningful results, using cryogenic cores, and new developments.

Included will be the advantages, commitments and logistics needed in getting SET-MH monitoring going in a community's salt marshes. The panelists will describe the Information gathered from investing the time, effort and funds for placing SETs in the landscape. The purpose will be to share Information with others on SET use for research, conservation, stewardship, and restoration goals.

The SET device, increasingly used nationally and internationally in coastal marshes, has become a standard in understanding a marsh's capacity to respond to stressors including sea level rise. The session will therefore be of interest to salt marsh researchers and managers who want to know what tools are available for long-term marsh monitoring assessments. Invited panelists include academic researchers, representatives from government agencies and environmental advocacy groups.

Contact Information: Alice Benzecry, Ph.D, Associate Professor, Fairleigh Dickinson University, School of Natural Sciences H-DH4-03, 1000 River Rd. Teaneck, NJ 07666 USA, Voice 201-692-2385, Fax 201-692-7349, e-mail: benzecry@fdu.edu

SALINIZATION OF *MELALEUCA*-DOMINATED WETLANDS OF THE GIPPSLAND LAKES, AUSTRALIA

Paul Boon
Victoria University, Melbourne, Australia

The Gippsland Lakes are the largest navigable waterway in Australia. They consist of three large, shallow, coastal lagoons (combined area: 360 km^2), fed by seven rivers that together drain one-tenth of the State of Victoria (south-eastern Australia). The lagoons are surrounded by extensive saline, brackish and freshwater wetlands dominated either by coastal saltmarsh or by Swamp Paperbark *Melaleuca ericifolia* and Common Reed *Phragmites australis*. The complex of lagoons, wetlands and lower reaches of the rivers is listed under the Ramsar Convention as the Gippsland Lakes Ramsar site (area: 617 km^2). Before European colonization (*c*.1840), the Gippsland Lakes were mostly fresh and linked to the sea only by a small, intermittent opening at their northern end. A permanent entrance was cut to the Southern Ocean in 1889 to facilitate navigation, and this resulted in a drop in average lake levels of *c*.0.8 m, chronic intrusions of seawater via the now-permanent link to the ocean, and progressive salinization of the formerly freshwater lagoons and fringing wetlands. The ecological consequences have been severe and include marked shifts in floristic composition and plant condition. Since the 1980s the dominant management response has been to maintain high water levels in the fringing wetlands in order to limit intrusions of saline water, but the resultant permanent inundation has also had adverse ecological consequences, including the inability of *Melaleuca ericifolia* to recruit sexually, decreases in foliage cover of adult plants, and low floristic diversity in the understory. Over the past 10 years we have undertaken a multi-disciplinary project to rehabilitate the largest of the wetlands in the Gippsland Lakes, Dowd Morass. One-third (500 ha) of the morass was subjected to a controlled draw-down of water levels and pre-existing hydrological/salinity conditions were maintained in the remaining 1,000 ha to provide control and reference sites in a BACI-type experimental design. Gradient analyses showed that within-wetland microtopography interacted with the altered wetting and drying cycles to generate three distinctive water regimes, differentiated largely by the spatial extent of exposed sediment and duration of the dry period. Water-level drawdown promoted sexual recruitment in some plant species (including *Melaleuca*) and the survival of those cohorts then depended on the duration of the ensuing dry period; in contrast, plant species richness and condition of adult plants continued to decline in areas that remained permanently flooded. Progressive salinisation of sediments and surface waters further reduced the effectiveness of the hydrological intervention and dramatically affected species richness and cover of aquatic vegetation, neither of which recovered fully when fresher conditions returned. The capacity of wetland vegetation to respond to a drawdown cycle following chronic inundation and salinization was constrained by biotic (e.g. salinity) and abiotic factors (e.g. depauperate seed bank). Thus reinstating a dry phase in chronically inundated, salinized wetlands is complex and risky, and may not effectively improve vegetation condition in the short term. Moreover, the threat to wetland condition posed by chronic salinization and inappropriate water regimes is likely to increase markedly with climate-change induced sea-level rise.

Contact Information: Paul Boon, Institute for Sustainability & Innovation, Victoria University, PO Box 1442, MCMC, Melbourne, Victoria 8001, Australia, Email: paul.boon@vu.edu.au

ASSESSING THE ROLE OF TIDAL INUNDATION IN DETERMINING THE SPATIAL STRUCTURE OF A SOUTHEASTERN US SALT MARSH

Tracy. L. Buck and *Erik M. Smith*
North Inlet-Winyah Bay National Estuarine Research Reserve, Georgetown, SC, USA

To assess the impacts of rising sea level on salt marsh plant community structure, the North Inlet-Winyah Bay National Estuarine Research Reserve has established permanent monitoring transects within two *Spartina alterniflora* dominated sites in a sub-basin of the North Inlet estuary (South Carolina, USA). Established in 2007 and located within the Crabhaul Creek basin, each of the sites contains three transects of 8-10 permanent plots that span the elevation gradient from creekbank to upland forest edge. The location of these sites along a chronosequence of salt marsh development provides an ideal setting for 1) quantifying the role of tidal flooding (frequency and duration) in determining the spatial structure of edaphic properties and vegetative communities along the marsh platform; and 2) assessing the long-term effects of sea level rise on plant community zonation and horizontal migration rates. Routine measurements at each sampling plot include repeated fine-scale elevation measurements using RTK-GPS, measured sediment dynamics through SETs (sediment elevation tables) and sediment tiles; edaphic factors (% organic content, bulk density, grain size distribution, elemental analysis); porewater salinity, nutrient, sulfide, and dissolved organic carbon (DOC) concentrations, groundwater level, plant species composition, stem density and canopy height. A NOAA tide gauge at the downstream edge of the basin allows for the calculation of frequency and duration of tidal inundation at each permanent plot.

While the two sites differ in total transect length, both sites are similar in elevation range (~1m) and exhibit clear vegetation zonation typical of southeastern US salt marshes. However, the broader downstream site has a more diverse plant community with a well-developed mid-marsh meadow community and a broad high marsh community dominated by *Juncus roemerianus*, while the upstream site is predominantly *S. alterniflora* with an abbreviated high marsh community. Both canopy height and stem density of *S. alterniflora* show pronounced site differences, inter-annual variability and clear variation as a function of mean inundation period. Sediment characteristics such as bulk density and organic content show reversed patterns along the elevation gradients between sites. Percent clay and silt are significantly negatively correlated with elevation while percent sand shows a significant positive correlation with elevation. Higher concentrations of porewater constituents such as NH_4, PO_4 & H_2S are found at the upstream site whereas the downstream site shows higher concentrations of porewater salinity and DOC. Overall, cluster analysis and principal components analysis indicate that elevation and/or inundation period alone are not sufficient to explain plant community zonation patterns, but rather that zonation is a complex function of the combined effects of elevation, inundation, porewater chemistry and sediment characteristics.

Contact Information: Tracy Buck, North Inlet-Winyah Bay NERR, Baruch Marine Field Lab, 2306 Crabhall Road, Georgetown, SC 29440 USA, Phone: 843-904-9027, Fax: 843-546-1632, Email: tracy@belle.baruch.sc.edu

HOW DOES SALTWATER INTRUSION ALTER ANAEROBIC MICROBIAL METABOLISM IN A FRESHWATER WETLAND?

Amy J Burgin[1], *Valerie A. Schoepfer*[1], *Ashley M. Helton*[2], *Marcelo Ardón*[3], *Emily S. Bernhardt*[2], *Robert A. Payn*[4] and *Geoffery C. Poole*[4]

[1]School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, USA
[2]Biology Department, Duke University, Durham NC, USA
[3]Biology Department, East Carolina University, Greenville NC, USA
[4]Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT, USA

Freshwater wetlands are increasingly undergoing salinization through a variety of hydrologic mechanisms, including drought-induced saltwater intrusion and sea-level rise. The introduction of saltwater represents a profound chemical shift from a predominantly freshwater state: increasing salinity alters the availability of certain nutrients from within the site (e.g., nitrogen or carbon) while the salt water itself is an external source of marine-derived chemicals (e.g., salt and sulfate). These chemical changes shift the availability of electron donors and acceptors for many forms of anaerobic microbial metabolism, including iron and sulfate reduction and methanogenesis. We examined the effects of salt water on anaerobic microbial metabolism at two scales: 1) by measuring rates of anaerobic metabolic processes in a coastal plain freshwater wetland before and after a saltwater intrusion event, and 2) by using controlled, slurry-based assays manipulating salinity (0, 2, 4 ppt), nitrate (0.5, 1, and 3 mg/L NO_3^--N) and sulfate (5, 50, 500 mg/L SO_4^{2-}) in a fully-factorial experiment to discern the individual chemical effects on specific anaerobic processes. Our study site was the Timberlake Observatory for Wetland Restoration (TOWeR), a large restored coastal plain wetland (North Carolina, USA) wherein drought-induced saltwater intrusion has been documented in three of the previous five years, including our study year (2011). We collected soil samples from 10 sites across hydrologic (wet, intermittent and dry) and saltwater (150 µS – 5 mS) gradients during early saltwater intrusion (late June 2011) and after ~2 months of intrusion (September 2011). Soil cores were sectioned by depth (0-15 cm total depth in 3-5 cm sections) and were analyzed for iron reduction potential, sulfate reduction rates and methanogenesis potential. Methanogenesis potential was generally higher in September compared to June, and was always greatest in the surficial sediments (0-3cm). Methanogenesis potential generally decreased with increased exposure to salt water, whereas sulfate reduction rates increased ~10x near the saltwater source. Preliminary analysis of our manipulative slurry-based assay experiment suggests that the addition of salt (as NaCl) doubles methanogenic activity, which is in turn suppressed by the addition of NO_3^-. Increased methane production under increased salt exposure has been documented by other researchers, though the mechanism and potential ecosystem-level implications of this pattern remain unresolved. Our future work will seek to better understand how increased saltwater exposure will affect microbial methanogenic activity and ecosystem methane fluxes, in addition to other forms of anaerobic microbial metabolism.

Contact Information: Amy Burgin, School of Natural Resources, University of Nebraska-Lincoln, 3310 Holdredge St., Lincoln, NE 68583-0974 USA, Phone: 402-472-3491; Email: aburgin2@unl.edu

AN APPROACH FOR ESTIMATING SALT MARSH RESILIENCE TO SEA-LEVEL RISE

Donald R. Cahoon
U.S. Geological Survey, Patuxent Wildlife Research Center, Beltsville, MD, USA

Developing a capacity to assess and manage the vulnerability of coastal wetlands to accelerations in sea-level rise requires an appropriate framework for integrating four key factors: the geospatial relationship between marsh elevation and sea level, trends of vertical development, the critical processes controlling vertical development, and models to forecast change. This approach requires the measurement of: 1) elevation capital (the position of the wetland relative to the lowest elevation at which emergent plants survive), 2) current accretion and elevation trends, 3) the environmental factors and biotic and physical processes controlling accretion and elevation trends, and 4) future elevation responses to accelerated sea-level rise. Step 1 provides a geospatial framework, or starting point, for evaluating wetland responses. Step 2 provides rates of change using the surface elevation table – marker horizon (SET – MH) method, but the trends are of limited value unless put in context of the geospatial framework. Step 3 provides Information on key drivers of elevation change needed to develop management options. Step 4 integrates data from steps 1-3 to forecast future wetland vulnerability and develop management options. The four steps will be unique for every wetland. Each step requires intensive data collection, particularly step 3 if there are numerous critical processes to evaluate, although steps 1-3 can be undertaken simultaneously to save time. We applied the approach to the highly degraded Jamaica Bay salt marshes and provide examples of each step in the process as well as the implications for management.

Contact Information: Donald R. Cahoon, U.S. Geological Survey, Patuxent Wildlife Research Center, Beltsville Lab, c/o BARC-East, Building 308, 10300 Baltimore Avenue; Beltsville MD 20705, Phone: 301-497-5523, Email: dcahoon@usgs.gov.

BIOGEOCHEMICAL EFFECTS OF SALTWATER INTRUSION AND INCREASED INUNDATION ON EVERGLADES PEAT SOIL

Lisa G. Chambers[1], *Stephen E. Davis*[2], *Tiffany Troxler*[3], *Joseph Boyer*[3], *Alan Downey-Wall*[3] and *Leonard Scinto*[3]

[1]Soil and Water Science Department, University of Florida, Gainesville, FL, USA
[2]Everglades Foundation, Palmetto Bay, FL, USA
[3]Southeast Environmental Research Center, Florida International University, Miami, FL, USA

The mangrove wetland communities that dominate the coastal Everglades (Florida, USA) overlie >1 m of carbon-rich peat soil and serve as a globally important carbon sink. With sea level rising at approximately 3 mm y^{-1}, these intertidal systems are exposed to increased inundation and potentially higher salinity seawater than in the past. Changes in water level and salinity can affect soil microbial activity by altering redox potential, electron acceptor availability, the intensity of osmotic stress, and consequently, the rate of carbon cycling. This study quantified the effects of greater tidal inundation and higher salinity on the rate of organic carbon loss in a peat soil from lower Shark River Slough, southwest Everglades. Twenty-four field replicate intact peat monoliths (15.4 L) were collected in perforated buckets in August, 2011. Soils were taken to an outdoor tidal mesocosm facility in Key Largo, FL where they were randomly assigned to one of four treatment combinations: control water level or increased inundation (+7.6 cm); and ambient salinity (15-20 ppt) or elevated salinity (30-35 ppt). Carbon dioxide production (at day low tide, night low tide, rising tide, and falling tide) methanogenesis (at low tide), porewater nutrients (DOC, NH_4^+, NO_x, SRP), and redox potential were routinely monitored during the 3-month study. On average, elevated salinity accelerated the rate of CO_2 flux by 53%. Increased inundation decreased CO_2 flux by about 12%, while the combined effect of increased inundation and elevated salinity was a roughly 21% decrease in the rate of CO_2 flux. Despite low redox potential (-300 mV), methane production was minimal, but slightly greater in the soils exposed to increased inundation and ambient salinity treatment (27.4 mg CH_4-C m^{-2} d^{-1}). Dissolved OC production averaged 12.5 ± 0.5 mg L^{-1} for all treatments except the increased inundation, elevated salinity treatment, which produced 57% more DOC than the other 3 treatments. In terms of total organic C cycling, elevated salinity increased the rate of total C loss by 53%, increased inundation decreased the rate of loss by 8%, and the combined effect of elevated salinity and increased inundation resulted in the lowest rate of total C loss-- 18% less than the control. This study illustrates the critical role of sulfate reduction in carbon cycling and the importance of soil accretion in maintaining optimal levels of tidal inundation in coastal wetlands exposed to rising sea level.

Contact Information: Lisa Gardner Chambers, Wetland Biogeochemistry Lab, Soil and Water Science Department, 106 Newell Hall, PO Box 110510, University of Florida, Gainesville, FL 32611 USA, Phone: (352) 392-1803, Email: lisagardner@ufl.edu

COMPETITION VERSUS FACILITATION: TESTING MULTIPLE STRESS GRADIENT EFFECTS ON SALT MARSH AND MANGROVE INTERACTIONS

***Glenn A. Coldren**, C. Edward Proffitt, Donna J. Devlin* and *Kathryn A. Tiling*
Florida Atlantic University at Harbor Branch Oceanographic Institute, Fort Pierce, FL, USA

The stress gradient hypothesis (SGH) provides predictions for the dominant effect (e.g., facilitative or competitive) between two interacting plants. These predictions may be improved by considering the type of plants (e.g., stress tolerant or competitive), type of gradients (e.g., resource or non-resource) and number of gradients involved. These hypotheses may provide insight into the effect of salt marsh species on mangrove species, particularly in transitional latitudes where both species may co-dominate or where mangroves may be sparse and rare. We conducted two studies to test these predictions. The first study experimentally tested the effect of intertidal flooding depth on the interaction between salt marsh species diversity and mangrove growth. We planted four salt marsh species (*Spartina alterniflora, Spartina patens, Sesuvium portulacastrum, Distichlis spicata*) into four species richness levels (1 to 4), with one planted *Rhizophora mangle* propagule. All naturally recruiting salt marsh species and mangroves (e.g., *Avicennia germinans, Laguncularia racemosa*) were also followed throughout the study period. This study found that the effect of salt marsh varied over an intertidal depth gradient and over time, with initial effects opposite of traditional SGH predictions. Over time the effects became more consistent with the SGH, with competition at low stress and neutral effects at moderate and high stress, although no facilitation was observed in these later growth stages. The second study tested the effect of multiple naturally occurring stress gradients on natural salt marsh and mangrove populations occurring throughout Florida, which ranges from temperate to tropical. We observationally inspected interactions between these co-occurring salt marsh and mangrove species over naturally varying stress gradients (e.g., salinity, herbivory, organic soil content, etc.), including potential cold stressors due to latitudinal differences. Further, we created experimental salt marsh removal plots at each site (prior to winter to capture potential latitudinal cold stress effects) to further examine the role of presence and absence of salt marsh on interactions with mangroves over these naturally occurring stress gradients. Preliminary results indicate that salt marsh presence may dampen the effect of several stressors for at least one mangrove species, *Avicennia germinans*.

Contact Information: Glenn A. Coldren, Department of Biology Sciences, Florida Atlantic University, c/o Harbor Branch Oceanographic Institute, 5775 Old Dixie Hwy, Fort Pierce, FL 34946 USA, Phone: 772-485-1338, Email: gcoldren@fau.edu

CLIMATE CHANGE IMPACTS ON THE WETLANDS OF TABASCO, MEXICO

L. Gama[1], *R. Collado-Torres*[1], *C. Pacheco-Figueroa*[1], *J. Valdez-Leal*[1], *H. Diaz-Lopez*[1], *C. Villanueva-Garcia*[1] *y M. Arturo Ortiz*-Perez[2] and E. *Moguel-Ordoñez*[1]
[1]Universidad Juarez Autonoma de Tabasco, Villahermosa, Tabasco, Mexico
[2]Instituto de Geografia, UNAM, DF, Mexico

The State of Tabasco is located on the south coast area of the Gulf of Mexico. It is suffering an important lost of natural ecosystems due to different natural and human effects. This region is also exposed to important threats related to climate change. The climate is warm and humid with abundant rains in summer, and this mangrove region is one of the wettest, with a total of almost 1,600 mm per year. Because of their biological characteristics, the wetlands located here are considered the most important wetlands of Mexico. Oil exploitation, cattle breeding and agriculture are the main economic activities and responsible for an important lost of natural landscapes that result on a lack of resources and alternatives for local poverty communities of the area. The objective of this research was to study global warming effects on this region, and to generate potential future sceneries. A landscape map based on a geomorphological classification was configured to contrast changes on coast from 1984 and 2003. An historical review of the land use, as well as natural phenomenon's like sea shore variation were perform to find out their effects on the different ecosystems. A historical review of the hydrology, and land use, was done to have a base line for the study. Each landscape unit was characterized, as well as the spatial distribution of all its components. Results show that the area is situated in a vast plateau with occasional floods. Intrusions of salt water during the dry season allow mangroves in this region to grow up to 30 km inland however the strong effect of salinization of soils is affecting different production activities. Road infrastructure without planning, urban growth and oil exploitation infrastructure has cause important impacts especially on the hydrodynamic and coastal areas reducing sedimentation process. Local fisheries, deforestation for agricultural purposes and cattle grazing, and industrial pollution are currently the major threats. The data regarding sea shore erosion shows a lost that goes from centimeters to meters in some parts of the coast of Tabasco on different segments. Sea level increase sceneries show an important future alteration to wetlands of this area.

Contact Information: L. Gama, Division Academica de Ciencias Biologicas, Universidad Juarez Autonoma de Tabasco, Av. Universidad S/N, Zona de la Cultura, Col. Magisterial, Villahermosa, Centro 86040, Mexico, Phone: (52) 993 3581500, Email: lillygama@yahoo.com

ENCOUNTERING CULTURE IN RESTORATION: UNDERSTANDING CULTURAL TENSIONS IN THE FLORIDA EVERGLADES AND BEYOND

Rebecca I. Garvoille[1] and *Laura A. Ogden*[2]

[1] PhD Candidate in Anthropology, Florida International University, Miami, FL, USA

[2] Associate Professor, Florida International University, Miami, FL, USA

Governments and development organizations across the globe are increasingly embracing the restoration of degraded wetland environments as a climate change adaptation strategy and as an environmental necessity. Yet, restoration projects in wetland environments are frequently the site of cultural tensions between different stakeholder groups. Drawing on fieldwork in the Florida Everglades, this presentation focus on how anthropological research including in-depth interviews with relevant stakeholder groups and social survey research can provide novel insights into the tensions and conflicts surrounding ecological restoration within wetland environments.

Often, different social groups have contrasting and complex socio-historical relationships with wetlands targeted for restoration, and these socio-historical ties can translate into incongruous visions for wetland restoration. In-depth interviews coupled with survey research shed light on the key points of cultural contention associated with different wetland restoration projects, and document how different stakeholder groups envision successful restoration. This data can assist restoration decision-makers and practitioners in evaluating the cultural and social justice issues associated with different wetland restoration projects, and help diffuse the conflicts around these issues, which could otherwise delay restoration efforts.

My presentation will present examples from an anthropological research project for the Florida Coastal Everglades LTER Human Dimensions research group called “Defining Restoration Success” that focuses on documenting different stakeholder visions of success for Everglades restoration, and from my dissertation research on the historical roots of environmental struggles over wetland restoration in the Florida Everglades. My presentation will demonstrate how environmentalists and traditional users have fundamentally different visions for the ecological restoration of the Florida Everglades, and discuss how an anthropological research approach is applicable to mapping out cultural tensions in other wetland environments undergoing ecological restoration.

Contact Information: Rebecca I. Garvoille, PhD Candidate in Anthropology, Department of Global and Sociocultural Studies, Florida International University, Modesto A. Maidique Campus - SIPA 340, Miami, FL 33199 USA, Phone: 954-330-7412, Email: rgarv001@fiu.edu

THE IMPACT OF CHANGING SALINITY ON AQUATIC ECOSYSTEMS: WHY THE LAST PAGE ONLY TELLS PART OF THE STORY.

Peter A. Gell and *Keely Mills*
Centre for Environmental Management, University of Ballarat, Mt. Helen, Vic, Australia

Aquatic ecosystems are subjected to considerable pressures from catchment changes driven by land clearance and productive agriculture. Also, they are impacted by hydrological change from the regulation of rivers systems and abstraction of water to service primary industries and communities. Further, the water balance across catchments varies on account of climatic cycles and trends. Southeast Australia is the most heavily developed region of the continent and its rivers are highly regulated. While it is subjected to a highly variable climate, the region has also experienced a long term drying trend that is expected to continue under climate change scenarios.

The clearance of groundwater recharge zones and allocation of surface water for irrigation agriculture lead to elevated water tables across the region. These were widely expressed when ground water tables rose rapidly in response to a La Niña event in the mid 1970s. Where these groundwaters were saline, severe and extensive soil, and wetland, salinisation was experienced. Since 1997 Australia has suffered under a severe drought that has limited river flows, reduced lake water levels and concentrated salts. This, compounded with water abstraction, has reduced the freshwater contribution to estuaries changing their hydrodynamics.

The ecological character of an aquatic system is often presumed and often relies on short term data or anecdote. Paleoecological evidence is an additional, and increasingly used, method of gaining extended, independent evidence for wetland condition and change. Among the best bioindicators for changing salinity from fossil remains preserved in sediments are diatoms. Across south-eastern Australia almost 200 lakes and estuaries have been investigated with respect to their salinity history. In many instances, paleosalinity reconstructions can be aligned, in time, with other evidence of system response such as stable isotopes, fossil pollen and plant and macroinvertebrate remains.

The evidence from these records reveals that the natural ecological character of wetlands are often presumed, and that they have changed considerably since European settlement, but often well beyond the instrumental record or memory. Salinisation is evident from early in European settlement while other, naturally saline, sites turned fresh from reduced tidal influence or after receiving diverted drainage waters. In a large Ramsar-listed wetland, several drivers of change shifted the state of the wetland over several decades leading to a severely degraded condition. More recently, wetlands that have accumulated liberated sulphur salts have become exposed through drought, leading to rapid shifts to acidified conditions. While many have shown resilience to long term climate variations, in all cases the combination of climate and catchment factors have driven the wetland outside their historical range of variability.

Contact Information: Peter A. Gell, Centre for Environmental Management, The University of Ballarat, Mt. Helen, Vic, 3353, AUSTRALIA, Phone +61 353276155, Fax +61 353279240, Email: p.gell@ballarat.edu.au

SIMULATING THE INFLUENCE OF SALTWATER INTRUSION ON COUPLED ELEMENT CYCLES IN COASTAL PLAIN WETLANDS

Ashley M. Helton[1]*, Geoffrey C. Poole*[2]*, Emily S. Bernhardt*[1]*, Robert A. Payn*[2]*, Clemente Izurieta*[3] and *Amy J. Burgin*[4]

[1]Biology Department, Duke University, Durham NC, USA
[2]Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT, USA
[3]Computer Science Department, Montana State University, Bozeman, MT, USA
[4]School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, USA

Saltwater intrusion within historically freshwater coastal wetlands is expanding due to sea-level rise and more frequent drought conditions. Saltwater intrusion changes the flux of solutes (e.g., sulfate) into wetlands, which alters biogeochemical cycling by introducing potential new interactions between biogeochemical cycles (e.g., sulfur and nitrogen) and a new suite of microbial metabolic pathways (e.g., sulfate reduction and sulfide oxidation). However, the rate and character of these changes are uncertain. We developed a simulation model of linked oxygen, carbon, nitrogen, sulfur, and iron cycling to explore the potential range of wetland biogeochemical processes both before and after salt water intrusion events. The model is based on fundamental principles of stoichiometry and thermodynamics, and assumes that microbial assemblages will use the suite of metabolic pathways that maximize microbial growth, given the available electron donors and acceptors and the stoichiometric ratio of carbon and nitrogen required for building biomass. We implemented the model under three differing redox scenarios and based model inputs on observed solute concentrations from coastal wetlands experiencing saltwater intrusion. The first scenario includes only carbon, nitrogen and oxygen microbial pathways. The second scenario adds both iron and sulfur cycling, and is representative of pathways likely occurring after a saltwater intrusion event. The third scenario also adds alternate anaerobic microbial pathways: anaerobic oxidation of methane (AOM) and anaerobic oxidation of sulfide (AOS), which are likely important microbial processes under some anoxic conditions, but are not typically considered in biogeochemical models. We compare model results to preliminary assays of wetland soils, and explore potential patterns of microbial trace gas production. Modeled interactions among elemental cycles vary depending on the redox conditions specified in the model scenario. Variability in simulated electron donor and acceptor availabilities changes the distribution and magnitude of biogeochemical pathways, which alters carbon and nitrogen cycling as well as trace gas (e.g., methane) emissions. This modeling approach provides a tool for hypothesis-based exploration of complex interactions among multiple elemental cycles within wetlands under changing climatic conditions.

Contact Information: Ashley Helton, Box 90338, Department of Biology, Duke University, Durham, NC 27708; Email: amh72@duke.edu; Phone: 919-660-7262

PREDICTING THE IMPACTS OF SALTWATER INTRUSION ON ECOSYSTEM DYNAMICS IN TIDAL FRESHWATER FLOODPLAIN FORESTS IN COASTAL GEORGIA

Ellen R. Herbert[1], *John M. Marton*[1], *Mihee Jun*[2], *Erika R. Elswick*[3] and *Christopher, B. Craft*[1]

[1]School of Public and Environmental Affairs, Indiana University, Bloomington, Indiana, USA
[2]Institute of Health and Environment, Gyeongsangnam-do, Republic of Korea
[3]Department of Geological Sciences, Indiana University, Bloomington, Indiana, USA

Tidal freshwater floodplain forests provide numerous benefits including carbon (C) sequestration and water quality amelioration via nitrogen (N) and phosphorus (P) retention; however they are significant sources of greenhouse gasses, particularly methane (CH4). Tidal forests are vulnerable to saltwater intrusion resulting from sea level rise (SLR) and climate change and anthopogenically driven reductions in freshwater flows. We used a combination of field surveys, laboratory incubations and model simulations to predict the impacts of saltwater intrusion on ecosystem processes in tidal forests.

We used the Sea Level Affects Marshes Model (SLAMM v6.1) with a salinity sub-model parameterized for the Altamaha River, GA to simulate changes in the distribution of estuarine ecosystems in 2100 under a 1 m SLR scenario. Accelerated SLR is predicted to disproportionately affect tidal forests in the Altamaha, reducing their acreage by 9% (484 ha), through a combination of persistent saltwater intrusion and increased inundation. Predictions of future climate change suggest that the Altamaha will experience increasingly frequent periods of drought-induced low flows resulting in periodic saltwater intrusion further into the freshwater reaches.

Experimental studies indicate that salt water intrusion will degrade tidal forests by increasing mineralization of soil organic matter and releasing soil NH4-N, potentially aggravating eutrophication of estuaries downstream. In laboratory incubations of soils from three healthy tidal forests (Altamaha, Ogeechee, Satilla) and an “unhealthy” tidal forest experiencing saltwater intrusion (South Newport), healthy tidal forest soils adsorb NH4-N and PO4-P (5.2-10.7 mg NH4-N m-2; 2.3-4.4 mg PO4-P m-2), while the unhealthy tidal forest soils released NH4-N (7.11-67.5 mg m-2) but adsorbed PO4-P at comparable rates to healthy tidal forests. In a second experiment, we simulated short-term saltwater intrusion by incubating soils from 3 tidal forests with saltwater. Saltwater caused healthy tidal forest soils to release NH4+ and dissolved inorganic carbon (DIC) to the water column and increased PO4-P sorption. The amount of NH4+ and DIC released and PO4-3 sorbed increased with salt concentration and frequency of inundation with saltwater.

Saltwater intrusion also has implications for greenhouse gas production and C mineralization. Incubations of healthy tidal forest soil slurries with saltwater showed that increasing salinity depresses CH4 production. CO2 and N2O production and denitrification did not show relationships with salinity. CO2 production was positively correlated with reduced sulfur, a proxy for sulfate reduction, in all three rivers. However, reduced sulfur did not generally correlate with salinity. Pre-treatment sulfur pools varied significantly between the three rivers and indicated that the past history of saltwater intrusion may impact how tidal forests respond to modern saltwater intrusion events. Collectively, these results suggest that the impacts of saltwater intrusion on tidal forests will reduce the overall extent of these ecosystems and reduce the ability of remaining tidal forests to provide valuable ecosystem services like N removal. However, it remains unclear how saltwater intrusion will impact greenhouse gas production and C cycling in tidal forests.

Contact Information: Ellen R. Herbert, School of Public and Environmental Affairs, Indiana University, Bloomington, IN 47401 USA, Phone: 812-856-7491, Fax: 202-354-4810, Email: erherber@indiana.edu

PLANT CHEMISTRY IN A FRESHWATER WETLAND EXPERIENCING SALT WATER INTRUSION

K.N. Hopfensperger[1], *C. Kowal*[1] and *A.J. Burgin*[2]
[1]Northern Kentucky University, Highland Heights, KY, USA
[2]University of Nebraska-Lincoln, Lincoln, NE, USA

We collected data in June 2011 from a coastal freshwater wetland experiencing both salt water intrusion and agricultural nutrient runoff. Tissue from dominant plant species and soil cores were sampled along transects with wet to dry moisture gradients. We predicted that species would differ in their C/N ratios and the amount of oxygen they deliver to the substrate. Plant delivery of oxygen to the sediment could thus influence iron chemistry in the soil. The plant tissues were dried and ground and plant roots were separated from the soil cores for analysis. Iron plaque was extracted from the root surfaces and analyzed using inductively coupled plasma. We found more iron plaque on roots of sedges/rushes/grasses than on roots of broad-leaved plants ($F=3.64$, $p=0.05$); however, we did not find a difference along the moisture gradient. The sedges/rushes/grasses also contained the most iron in their root tissues ($F=3.81$, $p=0.04$); although, only one submerged species was sampled, and it contained 10 times more iron in its tissues than other plant types. The tissue C/N ratio of the dominant rush species, Juncus effusus, increased along the salinity gradient with more carbon found upstream in the wetland. When examining plant community data, we found plant communities were most strongly related to tissue iron concentration and soil moisture gradients. The data we collected is just the beginning to understand not only how salt water intrusion may influence plant communities, but how plant communities in return may affect biogeochemical processes in a marsh with changing salinity.

Contact Information: Kristine N. Hopfensperger, Department of Biological Sciences, Northern Kentucky University, 1 Nunn Drive, Highland Heights, KY 41099 USA, Phone: 859-572-5305, Fax: 859-572-5639, Email: hopfenspek1@nku.edu

IMPACTS OF SHORT-TERM SALINITY INTRUSION AND POST-INTRUSION CONDITIONS ON OLIGOHALINE WETLAND VEGETATION AND SOILS

Whitney M. Kieh and *Irving A. Mendelssohn*
Louisiana State University, Baton Rouge, LA, USA

Storm-induced salinity intrusion can lead to necrosis and loss of aboveground vegetation in low-salinity wetlands due to salinity stress. Because of recent storm impacts in the northern Gulf of Mexico and expected changes in storm frequency and intensity due to global climate change, much emphasis has been put on studying the effects of saltwater intrusion into low-salinity coastal wetlands. However, little effort has gone into studying the mechanisms that might affect recovery. Because large storm events can have significant impacts on the physical structure and hydrology of coastal wetlands, they have great potential for changing plant community structure and function. Post-storm conditions such as nutrient status, flooding regime, storm sediment deposition, and post-intrusion salinity may be important drivers in determining the degree and rate of recovery of the resultant plant community.

The aim of our investigation was to assess the interactive effects of flooding regime, sediment addition, and herbivory on the recovery of oligohaline wetland vegetation after short-term salinity intrusion. Although herbivory is not directly related to storm occurrence, the importance of herbivore pressure in shaping wetland plant communities in the Mississippi River Delta Complex has been demonstrated in previous studies and may interact with post-storm conditions to impact recovery. The results of this study suggest that greater flooding negatively impacts plant diversity and is an important determinant of relative plant dominance in wetlands recovering from short-term salinity intrusion. Soil physico-chemical variables such as porewater sulfide concentration and redox potential were also impacted by flooding regime, with greater sulfide concentration under highly flooded conditions in the absence of sediment addition. To further examine the importance of flooding in driving post-storm plant community structure and function, a greenhouse mesocosm experiment was implemented to assess recovery. We found that flooding had a significant negative impact on plant diversity and cover, and had a positive impact on *Sagittaria lancifolia* density, dominance, and growth rate.

The results of our investigation indicate that flooding is an important determinant of olighaline wetland plant communities. Elevated flooding negatively impacts plant diversity, essentially converting a once-diverse wetland to a monospecific stand of less productive plants. These results have significant implications for the health and stability of Mississippi River Delta wetlands and their recovery from mega-disturbances such as storm-induced salinity intrusion. Extensive canal dredging has drastically altered the hydrological connectivity of Louisiana’s wetlands, resulting in elevated and prolonged flooding in many areas impounded by dredge spoil. Prolonged flooding of such marshes may have long-term consequences on ecosystem goods and services that the landscape provides. The results of this study further elucidate the need for a better understanding of controls on post-storm wetland recovery and drivers of change in impacted wetlands.

Contact Information: Whitney M. Kiehn, Department of Oceanography and Coastal Sciences, Energy, Coast and Environment Building, Louisiana State University, Baton Rouge, LA 70803 USA, Phone: 770-861-6161, Fax: 225-578-5328, Email: wpate1@tigers.lsu.edu

A NEW SUBSIDENCE CURVE FOR MISSISSIPPI RIVER DELTA TIDE GAUGES AND ITS IMPLICATIONS FOR COASTAL RESTORATION

Alexander S. Kolker[1], *Mead A. Allison*[2] and *Sultan Hameed*[3]
[1]Louisiana Universities Marine Consortium, Chauvin, LA, USA
[2]University of Texas at Austin, Austin, TX, USA
[3]Stony Brook University, Stony Brook, NY, USA

It is widely recognized that rates of relative sea level rise (RSLR) in Mississippi River Delta (MRD) are among the highest rates on Earth, and that this subsidence plays an important role in the massive wetland loss that has occurred along its coastline. However, there exists considerable disagreement over the magnitude of these rates of subsidence, and how they vary over time. Here we report a new method of tide gauge analysis, based on an understanding of the dynamical drivers of sea level change that removes most of the eustatic and interannual variability in the tide gauge record at Grand Isle, LA, thereby providing a history of subsidence for this site. Results show that rates of subsidence at Grand Isle, LA fit a quasi-parabolic pattern, which start at 3.52 ± 2.79 mm yr^{-1} in the 1947-1952 period, reach their maximum of 15.83 ± 3.06 mm yr^{-1} in the 1965-1970 period and then decline to -1.54 ± 6.20 mm yr^{-1} in the 2001-2006. Temporal patterns in subsidence are closely coupled to temporal patterns of oil and gas withdrawal and rates of wetland loss in south Louisiana. These findings suggest that current rates of subsidence may be at the low end of many projections, suggesting that restoration of the large areas of the MRD is possible, particularly if large quantities of sediments can be trapped in the nearshore zone. Given these conditions, the greatest future threats to wetlands the MRD may come from climate change, and not subsidence.

Contact Information: Alexander S. Kolker, Louisiana Universities Marine Consortium, DeFelice Marine Center, 8124 Highway 56, Chauvin, LA 70334 USA, Phone: 985-851-2837, Fax: 985-851-2874; Email: akolker@lumcon.edu

USING MODERN HURRICANE WIND DATA TO SUPPLEMENT HYDRODYNAMIC HINDCAST AND FUTURECAST MODELS

M. Dennis Krohn[1], *Eric D. Swain*[2], *Catherine A. Langtimm*[3] and *Thomas J. Smith, III*[3]
[1] U.S. Geological Survey, Coastal and Marine Science Center, St. Petersburg, FL, USA
[2] U.S. Geological Survey, Florida Water Science Center, Ft. Lauderdale, FL USA
[3] U.S. Geological Survey, Southeast Ecological Science Center, Gainesville, FL USA

A USGS integrated modeling effort is examining the consequences of short-term events like hurricanes and long-term Sea Level Rise trends on vegetation change in the Everglades. A major focus is to use hindcasts to improve the reliability and robustness of the eco-hydrology models; the data-poor hindcast models are commonly a better analogy for futurecasts than data-rich sources for recent events. We are attempting to adapt modern hurricane wind fields as suitable input for hindcasts. The goal is not to recreate the historic wind fields, but to see what types of general questions can be answered from approximated wind fields: what is the effect of having a variable wind field in the hindcast; a constant wind field; or no wind field at all?

Hindcasts were run using the BISECT (BIscayne SouthEastern Coastal Transect) hydrodynamic model over seven-year intervals. The interval from 1926-1932 corresponds to the earliest air photo coverage of historic vegetation and includes the Great Miami Hurricane of 1926. Initial runs of the hindcast showed no effects of the 1926 hurricane. Since the relevant input sources for the model had been destroyed by the hurricane, estimated storm rainfall parameters were input into the model from general hurricane properties and anecdotal historical records. The resultant hindcast then showed hydrologic patterns consistent with other historic hurricanes.

To understand the potential impact of wind fields from the 1926 hurricane, modern wind fields from Hurricane Wilma in 2005 were compiled and resampled for the hindcast. Seven hourly-gridded wind field measurements from 10:30 – 16:30 Z on 10/24/2005 were taken from Surface Wind Analysis portal of NOAA's Hurricane Research Division (HRD); the data were plotted, rotated, and rescaled to a 4 x 4 mega-grid covering the southern Florida peninsula with cells approximately 33 km x 22 km. The resultant hindcast using the modern proxy wind field showed that the variable wind field approximation made a significant improvement to the model as opposed to a constant wind field or no wind field. An unexpected observation from the hindcast is a long-term impact on groundwater salinity, which is currently under investigation.

While our primary purpose was to improve the reliability of the hindcast model, an additional benefit of the schematic wind fields is that they can be integrated into futurecast storm scenarios. The current Wilma scenario would rank as a hurricane with an extremely wide eye that impacts a broad area. Additional scenarios from other well-documented hurricanes, such as Andrew in 1992, will be available as options in futurecast models.

Contact Information: M. Dennis Krohn, U.S. Geological Survey, Coastal and Marine Science Center, St. Petersburg, FL 33701 USA, Phone: 727-803-8747 x3062, Fax: 727-803-2030, Email: dkrohn@usgs.gov

SEASONAL WATER CHEMISTRY AND SPECTRAL REFLECTANCE IN COASTAL MANGROVES

***David Lagomasino*[1,2]**, *Rene M. Price*[1,2], *Petya K. Campbell*[3] and *Dean Whitman*[1]
[1]Florida International University, Department of Earth and Environment, Miami, FL
[2]Florida International University, Southeast Environmental Research Center, Miami, FL
[3]NASA, Goddard Space Flight Center, Biospheric Sciences Branch, Code 614.4, Greenbelt, MD

The threat of rising sea levels, a predicted drier climate, and increased water demand may accelerate the landward migration of salt water intrusion within south Florida, which will ultimately have an effect on the coastal wetlands. The large spatial expanse and remoteness of the Everglades makes it difficult to access and expensive to collect samples. Satellite remote sensing can be a cost effective method to determine changes in the environment on a regional scale. Furthermore, changes in leaf optical reflectance properties may be used as an indicator of surface and subsurface water chemistry. The objective of this research is to identify relationships between spectra-derived biophysical indices of several mangrove species with the ionic and nutrient concentrations in the porewater, surface water, and groundwater of the mangrove ecotone. This method may provide a means to monitor nutrient and ionic concentrations in the surface and groundwater along the coastal zone on monthly, seasonal, and decadal time scales. Measurements of water chemistry, field-level leaf spectra and satellite data were used to develop a linear model to help predict water chemistry on a regional scale in the coastal mangroves of south Florida from multispectral remote sensing images. Water samples were collected from surface water, groundwater and porewater and analyzed for ionic (e.g., Cl^-, SO_4^{2-}, Na^{2+}, Mg^{2+}, K^+, and Ca^{2+}) and nutrient (e.g., TOC, TN and TP) concentrations. Leaf-level spectra-derived biophysical indices were calculated to assess various relationships between the mangrove spectral signatures and water chemistry at a total of 13 stations; 9 located in tall mangroves (3 species) and 4 located in dwarf mangroves (1 species). Samples were collected approximately every 3 months over the course of 2011. Landsat 5TM images were used to explore regional scale trends on annual and decadal timescales. Seasonal patterns were identified for both leaf-level and satellite reflectance data and correspond to the wet and dry seasons in south Florida. Strong correlations are exhibited between particular biophysical indices (e.g., EVI, NDVI) and ion concentrations at the field and satellite level. Surface water chemistry was successfully calculated using Landsat 5TM data. These relationships are primarily dependant on wavelengths in the green (550nm), red (680nm), and near-infrared (780-900nm) wavelengths. Stronger correlations exist when mangrove species are separated by type, indicating different mechanisms associated with water stress for the individual species. Correlations between nutrients and mangrove spectra demonstrate complex relationships, suggesting physiological differences of nutrient uptake caused by salinity-related stress.

<u>Contact Information</u>: David Lagomasino, Department of Earth and Environment, Florida International University, 11200 SW 8th Street, Miami, FL 33199 USA, Phone: 305-348-0281, Email: dlagomas@fiu.edu

SALINITY CHANGES BIOGEOCHEMISTRY AND ECOSYSTEM FUNCTIONING; ON THE ROLES OF SODIUM CHLORIDE, SULFATE, AND NUTRIENTS

Leon P.M. Lamers
Radboud University Nijmegen, Nijmegen, the Netherlands

The ecophysiology of organisms is severely challenged by changes in salinity, causing a biodiversity minimum in the brackish range, as described by Remane (1958). Particularly fluctuations in salinity cause physiological problems for organisms, including microorganisms. In terms of biogeochemical cycling, not only is salinity (mainly determined by sodium and chloride, NaCl) important, but also the increased availability of sulfate (SO_4^{2-}), which serves as an alternative terminal electron acceptor for anaerobic decomposition and generates sulfide (H_2S). Changes in Na^+, Cl^- and SO_4^{2-} severely affect carbon fluxes, but also fluxes of nitrogen (N) and phosphorus (P).

This means that changes in salinity initiate a cascade of biological and biogeochemical changes by three major paths: toxicity (Na^+, Cl^- and H_2S), decomposition rates and nutrient availability. In this paper, I will show the interacting effects of these pathways, and their effects on the functioning of wetland ecosystems.

Contact Information: Leon P.M. Lamers, Department of Aquatic Ecology & Environmental Biology, Institute for Water and Wetland Research, Radboud University Nijmegen, Heyendaalseweg 135, 6525AJ Nijmegen, the Netherlands, Phone: +31 243653014, Email: L.Lamers@science.ru.nl

HYDROPATTERNS AND RAINFALL DURING THE 2009-2010 HYDROLOGIC YEAR (JUNE TO MAY) PROVIDE INCITE INTO HOW A RESTORED EVERGLADES MIGHT RESPOND TO SEA LEVEL RISE.

Jerome J. Lorenz*, Peter E. Frezza* and *Michelle Robinson*
Audubon of Florida, Tavernier, FL, USA

A major argument against proceeding with the costly Everglades Restoration Plan is that the Everglades will be lost to sea level rise if current predictions are realized. Proponents of the restoration plan argue that restoration will protect the Everglades by raising water levels along the coastal wetlands, thereby blocking salt water intrusion. Mean sea level data at Key West since 1913 were acquired from the NOAA website. The 2009-10 hydrologic years (June 1 to May 31) for the Everglades coastal wetlands experienced the highest mean sea level on record (based on Key West data). These records also indicate that monthly mean water levels were at, or near the maximum ever recorded for the period of June 2009 through February 2010 with the exception of July 2009. Hydrologic monitoring on the periphery of Florida Bay also reflects high water in the marine environment. The unprecedented high sea level surrounding the Everglades in 2009-10 allows for an examination of a sea level increase of 3.5cm above the mean for the decade 2000-10. We have been collecting physical and ecological parameters in the coastal mangrove wetlands of the Everglades since 1990. Rainfall data indicate that the 2009-2010 dry seasons was one of the rainiest on record and was well above the long term mean in terms of seasonal rainfall. This rainfall, coupled with water management practices resulted in higher flow toward the coastal wetlands. We believe that high freshwater flows associated with the 2010 dry season are reflective of dry season flows that would occur in a restored Everglades. The record mean sea level and the record dry season rainfall presented an opportunity to explore how a restored Everglades might respond to sea level rise. We present hydrological and ecological results from our long term data collection comparing 2009-2010 to hydrologic years dating back to 1990-91 in an effort to explain how the coastal systems of a restored Everglades might respond to sea level rise.

Contact Information: Jerry Lorenz, Tavernier Science Center, Audubon of Florida, Tavernier FL 33070, USA, Phone: 305-852-5218, Email: jlorenz@audubon.org

CARBON SEQUESTRATION IN MANGROVES AND SALT MARSHES IN SOUTH EAST QUEENSLAND

***Catherine E. Loveloc**, Ruth Reef* and *Matthew Hayes*
School of Biological Sciences, University of Queensland, St Lucia, QLD 4067, Australia

Mangroves and salt marshes are important habitats for carbon (C) sequestration in the coastal zone but variation in rates of C sequestration and the factors controlling sequestration are poorly understood. We assessed C sequestration in Moreton Bay, South East Queensland in mangrove forests and salt marshes that span a range of environmental settings and flora, including mangroves and salt marsh on the eastern, oligotrophic sand islands and on the eastern side of Moreton Bay and the nutrient enriched, western side of the bay adjacent to the city of Brisbane. We found that rates of C sequestration were similar among mangrove forests but C sequestration on the oligotrophic sand islands, dominated by *Juncus kraussii,* had the highest rate of C sequestration while the western salt marshes, which were dominated by *Sarcocornia quinqueflora,* had the lowest rate of C sequestration. Over all habitats and sites C sequestration was significantly positively correlated with the C to phosphorus ratio of the soils, although the relationship was variable. Our data suggest C sequestration varies among and within habitats, varies with plant species and that nutrient pollution has a negative effect on C sequestration.

Contact Information: Catherine Lovelock, University of Queensland, University of Queensland St Lucia, 4072, Australia, Phone: 61733654302, Email: c.lovelock@uq.edu.au

DEVELOPMENT OF SAMPLING PROTOCOLS FOR THE SURFACE ELEVATION TABLE

***James C. Lynch*[1]**, *Donald R. Cahoon*[2] and *Philippe Hensel*[3]
[1]U.S. National Park Service, Northeast Coastal and Barrier Network, Washington, DC, USA
[2]U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, MD, USA
[3]NOAA, National Geodetic Survey, Silver Spring, MD, USA

The Surface Elevation Table (SET) has been in use for over 20 years and has become a standard tool for the long-term monitoring of elevation change in wetland environments. It is now used in 25 states and the District of Colombia in the U.S., and in over 25 countries worldwide. Consultants, researchers and government agencies are now actively using this technology in support of their research and monitoring efforts. The northeast region of the National Park Service, in collaboration with colleagues from the U.S. Geological Survey and National Oceanographic and Atmospheric Administration are writing a protocol document containing guidelines on the installation and monitoring of SET's in wetland environments. This document will discuss the sampling design of SET studies, the installation of SET benchmarks, and the collection and analysis of SET and marker horizon data. Detailed instructions will be provided for all of the various aspects involved in setting up and monitoring SET sites. Other topics such as hydrology monitoring and surveying will also be discussed. This document intends to provide clear and concise guidelines for groups planning on using these techniques in their studies.

<u>Contact Information</u>: James C. Lynch, National Park Service, 4598 MacArthur Blvd, NW, Washington, DC 2007 USA, Phone: 410-924-5412, Email: james_lynch@nps.gov

EFFECT OF HYDROLOGIC CONDITIONS AND SEDIMENT TRANSPORT ON WETLAND PATTERNING

***Mehrnoosh Mahmoudi*[1]**, *Fernando Miralles – Wilhelm*[2] and *Reinaldo Garcia*[3]
[1]Department of Earth and Environment, Florida International University, Miami, FL, USA
[2]Southeast Environmental Research Center, Florida International University, Miami, FL, USA
[3]Department of Civil and Environmental Engineering, Florida International University, Miami, FL, USA

Wetlands around the world have been historically drained for land development, recreational, and agricultural purposes. Often these extensive usages result in degradation of wetland features, which impact wetland ecology, biology, and biodiversity. An example of such degradation is seen as loss of the ridge and slough features and their connectivity in the highly controlled Everglades of South Florida. Understanding hydrologic conditions and sediment transport, involved in ridge and slough landscape formation, stability, and maintenance is crucial in restoration efforts. Previous studies hypothesized that a positive feedback mechanism between hydrology, plant productivity, and nutrient input controls ridge and slough formation and stability. However, this positive feedback cannot explain the lateral growth. Recent studies suggest that sediment transport is one of the key factors that control ridge and slough formation and stability. They also suggest that the substantial pulse flow is required for sediment resuspension, which may not occur under the present day managed system. Their findings however do not account for the effect of extreme events or pulse flows during short periods of time, and do not capture the effect of surface water/groundwater interaction on sediment resuspension and deposition.

A physically based numerical model of sediment transport has been developed as an extension to FLO – 2D integrated surface water/groundwater model. The developed model has been used to simulate the effect of sediment transport and surface water/groundwater interactions on spatial and temporal variation of bed elevation in the ridge and slough landscape, and to explore how these processes may affect the formation, maintenance and stability of the ridge and slough landscape patterns observed in wetlands. Sensitivity analysis was performed to assess how the model responds to changes in flow conditions and groundwater head elevation. Water samples were taken from several locations within a flowing macrocosm of Loxahatchee Impoundment Landscape Assessment (LILA) before, and after extreme rainfalls, and during a series of manually generated pulse flow. Suspended sediment concentration was measured in the lab. These data along with other data such as water depth and velocity, and groundwater head, were collected to support and validate the developed model. Bed elevation is been measured using site topography from available LiDAR data.

Results from the model development and numerical simulations from this research will provide an improved understanding of how wetland features such as ridges may have formed and degraded by changes in water management that resulted from increasing human activity in wetlands such as The Florida Everglades, over the past decades

Contact Information: Mehrnoosh Mahmoudi, Florida International University, College of Arts and Science, Department of Earth and Environment, 3000 NE 151 St, Suite AC1-331, Miami, Florida, USA, Phone: 305-919-5141, Email: nmahm001@fiu.edu

MITIGATING AND ADAPTING TO GLOBAL SEA LEVEL RISE IN THE GULF OF MEXICO

Valsin A. Marmillion and ***Sidney Coffee***
America's WETLAND Foundation

Scientific studies predict that coastal communities in the Gulf of Mexico will continue to experience increasingly powerful, destructive coastal storms in addition to relative sea level rise driven by land subsidence and climate change. Based on these threats, localized resiliency parameters and action plans are urgently needed that will enable communities to adequately prepare for the future.

The America's WETLAND Foundation's "BLUE RIBBON RESILIENT COMMUNITIES" project works to transform coastal communities in Texas, Louisiana, Mississippi, Alabama and Florida into "resilient" communities. Resilient communities have the ability to adapt to and influence the course of environmental, social, and economic change and they will be critical to the region's long-term viability and success in the face of impending threats from natural and man-made disasters.

The "BLUE RIBBON RESILIENT COMMUNITIES" project is assessing local vulnerabilities and empowering each community to envision, plan and act to ensure resiliency and sustain cultural, economic and ecological values. The initiative will strengthen the local voice and provide more authentic solutions to envisioning their future.

All of the 11 forums will have been convened by June 2012. During this session, we will share how these 11 communities in Louisiana, Texas, Mississippi and Alabama are planning for a resilient future as we reveal findings and recommendations that have resulted from individual interviews, focus groups and facilitated discussions with local stakeholders, community leaders and scientific advisors. While some issues are discreet to particular communities, there are issues common to all that will likely influence policies and actions in the region.

Contact Information: Valsin A. Marmillion and Sidney Coffee, America's WETLAND Foundation, 365 Canal Place, Ste. 1475, New Orleans, LA , 70130, USA, Phone: 562.429.3821, Fax: 562.429.3831, Email: lnoble@americaswetalnd.com

FORECASTING COASTAL CHANGE UNDER SEA LEVEL RISE: A MID-ATLANTIC CASE STUDY

S. Kyle McKay[1,2], *Austin V. Davis*[2], *Jay J. Ratcliff*[3] and *Kelly Burks-Copes*[2]

[1]Environmental Laboratory, U.S. Army Engineer Research and Development Center
[2]Odum School of Ecology, University of Georgia
[3]Coastal and Hydraulics Laboratory, U.S. Army Engineer Research and Development Center

In the next century, coastal military assets, capabilities, and operations will be directly affected by inundation due to sea level rise and resulting changes in wave energy and storm surge. Furthermore, geomorphic evolution and subsequent changes in the ecological community could magnify these direct impacts. We present a case study of the potential geomorphic change that may occur due to sea level rise at Naval Station Norfolk, Virginia, United States. We begin by reviewing Mid-Atlantic coastal ecosystems and the relationship between geomorphic and ecological processes which function synergistically to maintain these systems. Geomorphic evolution of the system is forecasted using the Sea Level Affecting Marshes Model (SLAMM) for a 100-year time period with five incremental levels of sea level rise ranging from zero to two meters. Model sensitivity was assessed relative to three relevant parameters: (1) coastal protection strategy, (2) physical process rates, and (3) regional differences associated with land development. For a highly developed and urban Norfolk site, results indicate that dry land, swamp, and beach/shore are likely to decrease, and marsh, flat, and open water are likely to increase. The model sensitivity analysis indicates the SLAMM is highly sensitive to management decisions regarding the protection of land while minimally sensitive to physical process inputs. While models are valuable tools for examining the potential effects of sea level rise, this analysis highlights the need to address model sensitivity and uncertainty in long-term forecasts of coastal change.

Contact Information: S. Kyle McKay, Environmental Laboratory, U.S. Army Engineer Research and Development Center, 1660 S. Lumpkin St. #10, Athens, Georgia, 30606, USA, Phone: 601-415-7160, Fax: 601-634-3912, Email: Kyle.McKay@usace.army.mil

THE SALT MARSH-MANGROVE ECOTONE AND VULNERABILITY OF SUBTROPICAL COASTLINES TO SEA-LEVEL RISE

Karen L. McKee and *William C. Vervaeke*
U.S. Geological Survey, Lafayette, Louisiana 70506 USA

The salt marsh-mangrove ecotone represents an important transition between tropical and temperate climate zones globally. A shift from herbaceous to arboreal growth forms might alter wetland capacity to accommodate sea-level rise (SLR) through effects on mineral sedimentation or biomass contributions to soil volume. This study focused on a plant community in the rapidly subsiding Mississippi River Delta Plain composed of *Avicennia germinans* (black mangrove) and *Spartina alterniflora* (smooth cordgrass). The black mangrove reaches its northernmost limit in this region where it expands into and replaces salt marsh during freeze-free intervals. Seasonal, small-scale disturbances (wrack burial, drought, freezing temperatures) are common and may promote vegetation shifts as well as soil elevation changes. The aim of this study was to compare elevation dynamics in stands dominated by these species and to determine effects of plant mortality on elevation trajectories. Eighteen plots were established equidistant from the shoreline and at similar elevations in monospecific stands of both species as well as in mixed stands. Plots were instrumented with surface elevation tables and randomly assigned to control or disturbance treatments. Disturbance treatments were applied as follows: Canopies of *A. germinans* were damaged by freezing (with liquid nitrogen); *S. alterniflora* stands were covered with wrack (plant debris), and species mixtures received both treatments. Plots were monitored for a total of 4.8 years. Live aboveground cover was highest in *A. germinans* plots, intermediate in mixed plots, and lowest in *S. alterniflora* plots. Percent live cover was much lower in disturbed plots compared to controls 12 months after treatment. There were no significant effects, however, of disturbance on trajectories of elevation change, vertical accretion, or shallow subsidence. Small-scale disturbances such as wrack burial or moderate freeze damage, which frequently occur in this habitat, thus may have an insignificant effect on elevation trajectories in this sedimentary setting. Shallow benchmarks, which allowed measurement of root-zone movement, indicated shallow-subsurface contraction in most plots. Thus, vertical gain was due mainly to sedimentation on the soil surface, but this was insufficient to match relative SLR (subsidence plus eustatic rise). The elevation deficit (relative SLR minus elevation change) in this plant community averaged 4.1 mm yr^{-1} (monospecific stands: 4.5–5.0 mm yr^{-1}, mixed stands: 2.6 mm yr^{-1}). These results illustrate the vulnerability of this ecosystem to submergence but also suggest that species shifts due to climate change or other factors will not likely increase the risk of wetland loss. These findings are relevant for understanding and predicting vulnerability of subtropical coastlines to SLR as well as informing restoration plans for the Mississippi River Delta.

Contact Information: Karen L. McKee, National Wetlands Research Center, U.S. Geological Survey, 700 Cajundome Blvd., Lafayette, LA 70506 USA, Phone: 337-266-8662, Fax: 337-266-8586, Email: mckeek@usgs.gov

THE DROWNING OF A COASTAL ESTUARY: HOW HURRICANES AND SEA-LEVEL RISE ALTERED BIG SABLE CREEK

Paul R. Nelson[1] and *Tom J. Smith III*[2]
[1]Jacobs Technology/USGS Southeast Ecological Science Center, St. Petersburg, FL, USA
[2]USGS Southeast Ecological Science Center, St. Petersburg, FL, USA

Between 1928 and 2006, 10 tropical cyclones impacted Florida's Southwest coast. Sea level rose steadily at 2mm yr^{-1}, according to the Western Hemisphere's longest sea-level record at Key West (since 1846). These two factors transitioned Big Sable Creek from a small series of tidal creeks to a highly channelized network of creeks, mudflats and mangrove islands. Without adequate seed recruitment and sediment supply (leaf litter, root debris, and occasional storm deposits), the mangroves that occupy this region will retreat inland or die off.

Big Sable Creek is located on the northwest coast of Cape Sable within Everglades National Park, home to many endangered and threatened species. This area, a mangrove coastline and part of a network of coastal, riverine, and marsh study sites, is the focus of a 13-year study that includes the emplacement of Surface Elevation Tables (SETs), feldspar marker horizons, permanent vegetation plots, and surface and ground water wells. Additionally, the use of historical charts and aerial photographs helped identify coastal habitat change over a 78-year period. In some areas, inland retreat measured in excess of 300 meters. Narrow stream channels (~6m) gradually converted to mudflats (some >50,000 m^2). Three major hurricanes (Labor Day 1935, Donna 1960, and Wilma 2005) made landfall within this region. The resulting storm surges, wind damage, and sediment deposition initiated the conversion from coastal mangrove forest to mudflats. Increased sea level and a strong tidal amplitude (~2m) prevented sediment accumulation and seed recruitment. Not surprisingly, initial analysis of the SET data indicates an erosional environment.

Cape Sable is home to several endangered species including Roseate Spoonbills, diamondback terrapins, and the American crocodile, and the coastal mangroves provide crucial nursery habitat and protection for numerous species. The continued monitoring of the Big Sable Creek estuary is essential in determining species response to habitat change and assisting resource managers with future conservation planning.

Contact Information: Paul R. Nelson, Jacobs Technology/USGS Southeast Ecological Science Center, St. Petersburg, FL ,33701, USA, Phone 727-803-8747, Fax: 727-803-2031, Email: prnelson@usgs.gov

SALTWATER INTRUSION INTO TIDAL FRESHWATER MARSHES DRIVES SHIFTS AT ALL LEVELS OF ECOSYSTEM ORGANIZATION

Scott C. Neubauer[1], *Rima B. Franklin*[2] and *Michael F. Piehler*[3]
[1]University of South Carolina, Baruch Marine Field Laboratory, Georgetown, SC, USA
[2]Virginia Commonwealth University, Richmond, VA, USA
[3]University of North Carolina, Institute of Marine Sciences, Morehead City, NC, USA

Saltwater intrusion into tidal freshwater marshes has effects at all levels of the system, from plant and microbial communities to biogeochemical transformations to ecosystem processes. From Jun 2008 through Nov 2011, in situ manipulations in a *Zizaniopsis miliacea* (giant cutgrass)-dominated tidal freshwater marsh in South Carolina, USA raised porewater salinities from freshwater to oligohaline levels and/or subtly increased the amount of water flowing through the system. In general, plant communities responded negatively to salinization. Throughout the growing season, salinization consistently reduced species richness by at least 50% (ca. 3-6 vs. 9-14 species per 61 x 61 cm plot). Nearly all common plant species at the site were present at lower densities, or were absent entirely, due to elevated salinity. A notable exception was *Z. miliacea*, which increased in density in the saltwater-exposed plots (~45 vs. ~25-30 plants m^{-2}). However, *Z. miliacea* plants tended to be shorter under higher salinities. Other measured species showed more robust growth (greater height, # leaves, and/or leaf size) in freshwater conditions and were virtually absent in saltwater-exposed plots. Molecular analysis of near-surface soils revealed significant salinity-related differences in the communities of bacteria and archaea. Further, elevated salinity led to shifts in the populations of sulfate reducers and methanogens, microbes that carry out specific biogeochemical transformations. In surface soils, long-term brackish water additions depressed rates of potential methanogenesis (by roughly two orders of magnitude) and anaerobic CO_2 production (by 60-80%) relative to freshwater conditions. Whole-core incubations showed a similar pattern in that soil O_2 demand was 4-6 times higher in freshwater versus salinized soils. Further, long-term exposure to elevated salinities in this tidal freshwater marsh led to denitrification rates that were 74-84% lower than rates in freshwater-exposed plots, indicating that saltwater intrusion not only affects carbon cycling but also impacts biogeochemical nitrogen transformations. The impacts of salinization on individual components of the tidal freshwater marsh system are reflected in ecosystem-scale processes. Across the entire study, elevated salinity decreased annual rates of gross ecosystem production by ~30% (the magnitude of the effect varied slightly from year-to-year). Similarly, rates of ecosystem respiration (consisting of both CO_2 and CH_4 emissions to the atmosphere) were considerably lower due to the elevated salinity. Early during the study, salinization decreased net ecosystem production (i.e., the balance between gross production and respiration) by roughly 50% but this effect disappeared in later years. Currently, it is not known if this interannual variability is driven by larger-scale environmental factors (e.g., climate, river flow) or if it reflects acclimation of the ecosystem to the stressor of saltwater intrusion.

Contact Information: Scott C. Neubauer, Baruch Marine Field Laboratory, University of South Carolina, PO Box 1630, Georgetown, SC , 29442, USA, Phone: 843-904-9030; Fax: 843-546-1632, Email: scott@belle.baruch.sc.edu

PROJECTED CLIMATE-INDUCED MANGROVE FOREST RANGE EXPANSION IN THE SOUTHEASTERN U.S.: THE ROLE OF WINTER TEMPERATURES

Michael J. Osland[1], *Nicholas Enwright*[2], *Mary S. Ellison*[1], *Richard H. Day*[1] and *Thomas W. Doyle*[1]

[1] U.S. Geological Survey, Lafayette, LA, USA

[2] Five Rivers Services, LLC, U.S. Geological Survey, Lafayette, LA, USA

In the southeastern U.S., winter severity greatly influences the distribution and abundance of salt marshes and mangrove forests in tidal saline wetland habitats. Mangrove forests are sensitive to freezing temperatures and are currently found only in warmer portions of Florida, Louisiana, and Texas. Salt marshes are more dominant along colder coastlines where winter severity precludes mangrove survival. Yet, future climate projections for the region forecast warmer winter temperatures which could lead to mangrove forest range expansion and salt marsh displacement along parts of the Gulf of Mexico and southeastern U.S. Atlantic coast. In this study, we quantified the relationship between recent (1970-2000) winter temperatures and mangrove forest presence and abundance in the southeastern U.S. We also evaluated the potential for future (2070-2100) mangrove forest range expansion based upon climate projections for the region. Our results identify temperature thresholds for salt marsh-mangrove forest interactions and highlight areas of the southeastern U.S. that may be vulnerable to climate-induced mangrove forest range expansion in the future.

Contact Information: Michael J. Osland, U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA 70506 USA, Phone: 337-266-8664, Email: mosland@usgs.gov

PLANNING FOR INLAND MIGRATION OF COASTAL WETLANDS DUE TO SEA LEVEL RISE IN LOUISIANA

Heidi Beck[1], *Alicia Bihler*[2], *Melissa Kemm*[1], ***Sam Pardo***[2] and *Douglas Perron*[1]
[1]Duke University, Beaufort, NC, USA
[2]Duke University, Durham, NC, USA

Louisiana contains over a third of coastal wetlands in the contiguous US but has seen a drastic reduction in total wetland area in the last century. This loss is especially troubling for coastal Louisiana where wetlands play a vital role in protecting and supporting the state's economy and culture. Under natural conditions, wetland areas will move upland with rising sea level or sinking land. However, engineered structures and shore armoring such as levees, seawalls, and bulkheads impede this process. Advanced planning for wetland migration is needed to keep communities and infrastructure out of harms way from encroaching open water and to mitigate future wetland loss. This project will investigate the potential for wetland migration in Louisiana through 1) the mapping and analysis of coastal wetland migration and 2) an examination of policy options relevant to wetland migration.

Wetland migration analysis will compare three parishes—Lafourche, St. Mary, and Vermilion—using the Sea Level Affecting Marshes Model (SLAMM). Local rates of erosion, accretion and subsidence will be modeled with constant global sea level rise projections to identify areas that are suitable for inland migration of coastal wetlands. This spatial data will be combined with economic and land use data to further evaluate the suitability of the land for wetland migration.

In the wake of Hurricane Katrina, the state of Louisiana recognized the need to integrate hurricane protection and wetland restoration efforts. This shift in policy is a marked improvement in coastal management, yet it currently overlooks the important process of wetland migration. In the policy analysis we will review national, state, and parish policies relevant to wetland migration, including local land use, sea level rise, floodplain management and wetland mitigation. Specific recommendations will be made with the goal of developing an equitable and efficient wetland migration policy capable of complementing and improving current coastal management plans.

Contact Information: Sam Pardo, Nicholas School of the Environment, Box 90331, Duke University, Durham, NC , 27708-0331, USA, Phone: 914-830-4589, Fax: 919-684-8741, Email: samuel.pardo@duke.edu

SEASONALITY AND DISTURBANCE EVENTS IN THE CARBON ISOTOPE RECORD OF *PINUS ELLIOTTII* TREE RINGS FROM BIG PINE KEY, FLORIDA

Carrie E. Rebenack[1], *William T. Anderson*[1] and *Paolo Cherubini*[2]
[1]Florida International University, Southeast Environmental Research Center, Miami, FL, USA
[2]WSL, Birmensdorf, Switzerland

The South Florida coastal ecosystem is among the world's subtropical coastlines which are threatened by the potential effects of climate change. A well-developed localized paleohistory is essential in the understanding of the role climate variability/change has on both hydrological dynamics and disturbance event frequency and intensity; this understanding can then aid in the development of better predictive models. High resolution paleoclimate proxies, such as those developed from tree-ring archives, may be useful tools for extrapolating actual climate trends over time from the overlapping long-term and short-term climate cycles, such as the Atlantic Multidecadal Oscillation (AMO) and the El Niño-Southern Oscillation (ENSO). In South Florida, both the AMO and ENSO strongly influence seasonal precipitation, and a more complete grasp of how these cycles have affected the region in the past could be applied to future freshwater management practices.

Dendrochronology records for the terrestrial subtropics, including South Florida, are sparse because seasonality for this region is precipitation-driven; this is in contrast to the drastic temperature changes experienced in the temperate latitudes. Subtropical seasonality may lead to the complete lack of visible rings or to the formation of ring structures that may or may not represent annual growth. Fortunately, it has recently been demonstrated that *Pinus elliottii* trees in South Florida produce distinct annual growth rings; however ring width was not found to significantly correlate with either the AMO or ENSO. Dendrochronology studies may be taken a step beyond the physical tree-ring proxies by using the carbon isotope ratios to infer Information about physiological controls and environmental factors that affect the distribution of isotopes within the plant. It has been well established that the stable isotope composition of cellulose can be related to precipitation, drought, large-scale ocean/atmospheric oscillations, and disturbance events. Because slash pine growth is dependent on water availability, a chronology developed using carbon isotopes may provide greater insight into plant stress over time and ultimately may lead to better correlations with climate oscillations.

The work presented here is the result of a carbon-isotope study of four slash pine trees from Big Pine Key, Florida. Initial $\delta^{13}C$ data show seasonal stomatal activity in the trees and indicate the timing of possible disturbance events.

Contact Information: Carrie E. Rebenack, Department of Earth and Environment, Florida International University, 11200 S.W 8th Street, PC344, Miami, FL, USA, 33199, Phone: 305 348-6528; Fax: 305 348-3877, Email: crebe001@fiu.edu

MEASURING MARSH SURFACE ELEVATION CHANGE: PATTERNS AND PROCESSES, TRENDS AND TIMING

Denise J. Reed

University of New Orleans, New Orleans LA, USA

Methods to measure marsh surface elevation change have been used for several decades. These approaches, focusing on the change in position of the marsh surface relative to a 'fixed' point, must be distinguished from field techniques designed to measure sediment deposition (e.g., sediment traps, the accumulation of material on the marsh surface (e.g., marker horizons), and rates of vertical soil development (e.g., ^{137}Cs dating). Most insight into vertical processes is gained by using a number of techniques – however, the intensity of field work and/or laboratory analyses needed to execute a number of approaches across a range of sites, means that this type of study is rare. The advantage of SET measures of marsh surface elevation change is that once the investment of time and resources in initial deployment is made, subsequent measurements are easy and can be conducted over long period and insights can be gained even when measurements are episodic. Elevation change measurements are often supplemented by one or more other measurements of soil development, as resources allow.

In coastal Louisiana, SETs deployment began at select study sites in the early 1990s. Several of these early sites were tracked for more than a decade. Regular measurements, especially when repeated at the same time of year to control for variation in hydrology and growing season, provide Information on inter-annual or inter-seasonal variability which can be correlated, at least broadly, with seasonal changes in plant growth, hydrologic forcing, and/or sediment delivery. The role of hurricanes is delivering material to marshes, and contributing positively to elevation change, has been identified through seasonal sampling around the peak of the storm season. Post storm tracking of marsh surface elevation has allowed subsequent lowering of the initial storm related increase to be tracked which would not be possible with other measures of storm related sediment inputs, e.g., sediment traps.

Interpreting changes in marsh surface elevation detected with SETs requires ancillary data collection. In particular, as elevation change reflects a change in soil volume, not weight or density, contributing factors, such as plant root contributions to organic matter, must also be quantified in terms of volume. While such studies are resource intensive, their periodic association with long term measures of marsh surface elevation change, allow individual studies, especially if repeated, to be put in a longer term context of marsh evolution.

Contact Information: Denise J. Reed, Dept. Earth & Environmental Sciences, University of New Orleans, New Orleans, LA, USA, 70148, Phone: 504-280-7395, FAX: 504-280-7396, Email: djreed@uno.edu

THE CHALLENGE OF STEADY STATE COASTAL LAW IN THE TIME OF RISING OCEANS

Edward P. Richards
Louisiana State University Law Center, Baton Rouge, LA, USA

The climate is changing and the ocean has been rising for decades. Ocean rise over the past 100 years has inundated hundreds of square kilometers of coastal Louisiana and made all coastal areas, including New Orleans, more susceptible to flooding.

The legislative response in the Gulf Coast and southern Atlantic states denies that the ocean is rising and that this rise is likely to accelerate. Even politicians who believe in climate change support laws and fund projects that only make sense in a steady state world. The best example is the National Flood Insurance Program (NFIP). Passed in response to flooding after Hurricane Betsy, the NFIP was intended to impose land use restrictions on coastal development in return for affordable flood insurance in high risk areas. Politics made it impossible to enforce the land use restrictions. The NFIP became the major driver of high risk coastal and floodplain development.

Ocean rise on the Louisiana coast is amplified by significant coastal subsidence, yet the legislative response has been to build more and bigger levees and to encourage repopulation of the highest risk areas after they are flooded by major storms. With levees blocking their retreat, coastal wetlands are progressively destroyed as the ocean rises. This is countered with coastal restoration projects that can only work in a steady state world.

This mismatch between law and reality arises because the law protects the status quo. The law usually trails events, slowly accommodating to change over time. The law recognizes that land might be gained and lost when a river changes course, because that has been a problem ever since people started living near rivers. But the progressive and irretrievable loss through inundation is new to the law, so there is no model for imposing legal order and stability on the effects of ocean rise. Politically, the inundation of coastal communities is the greatest possible threat to elected officials: hard choices are followed by the loss of voters as communities are relocated or inundated. It should not be surprising that the political response is to deny the threat of ocean rise and to fund temporizing projects that provide short-term reassurances.

This presentation will discuss the intrinsic resistance of the legal system to honest coastal science and effective adaptation to ocean rise. This structural resistance to the acceptance of a dynamic world, and the particular threat of ocean rise, is the major legal impediment to the protection of wetlands, endangered species, culture, and human life. Coastal scientists play a critical role in informing the public about the need for legal change and in fighting against short term solutions that will exacerbate long term risk. Don't count on the lawyers to do it for you.

Contact Information: Edward P. Richards, Louisiana State University Law Center, 1 Campus Drive, Baton Rouge, LA, USA, 70803, Phone: 225-578-7595, Fax 225-579-5935, Email: richards@law.lsu.edu

FORECASTING SALT MARSH RESPONSES TO SEA LEVEL RISE USING THE ELEVATION CAPITAL CONCEPT

Charles T. Roman[1]*, Donald R. Cahoon*[2]*, James C. Lynch*[3] and *Kelly C. Medeiros*[4]
[1]National Park Service, Narragansett, RI, USA
[2]U.S. Geological Survey, Beltsville, MD, USA
[3]National Park Service, Washington, DC, USA
[4]National Park Service, Wellfleet, MA, USA

Salt marsh surface elevation must keep pace with sea level rise. When relative sea level rise is greater than marsh surface elevation increase, marshes gradually become submerged, often resulting in conversion of vegetated marsh to mudflat or open water. Using the Surface Elevation Table-Marker Horizon (SET-MH) method, the National Park Service in cooperation with the USGS have been monitoring salt marsh elevation change and surface accretion processes at Cape Cod National Seashore (MA), Fire Island National Seashore (NY), and Gateway National Recreation Area (NY/NJ) for over a decade. As expected, the findings among sites are variable. Some marshes are keeping pace with relative sea level rise, while others are in an elevation deficit. Factors associated with this observed variability (e.g., hydroperiod, sediment supply, bioturbation) will be discussed. The concept of elevation capital is presented as a method for coastal managers to apply SET data toward forecasting the long-term status of salt marshes under a regime of rising sea levels. Examples are provided of marsh platforms that are low in the intertidal zone and may be less capable of tolerating increased flooding associated with accelerated rates of sea-level rise (low elevation capital); marshes high in the intertidal zone may have a longer time-frame before the effects of submergence become apparent (high elevation capital).

Contact Information: Charles T. Roman, Northeast Region, National Park Service, University of Rhode Island Bay Campus, Narragansett, RI, USA, 02882, Phone: 401-874-6886, Fax: 401-874-6887, Email: charles_roman@nps.goV

THE EFFECT OF SALTWATER INTRUSION ON COUPLED IRON AND SULFUR CYCLING IN A COASTAL FRESHWATER WETLAND

Valerie A. Schoepfer and *Amy J. Burgin*

School of Natural Resources, University of Nebraska, Lincoln, NE, USA

Saltwater intrusion, a consequence of global climate change, dramatically alters coastal freshwater chemistry. One aspect of this change is increased sulfate concentrations, the introduction of which can modify ambient nutrient cycling. Increasing sulfate stimulates microbial sulfate reduction, which produces toxic sulfide. Reducing conditions in wetland soils and the presence of reduced iron promote the formation of stable iron and sulfide complexes (FeS), thereby reducing sulfide toxicity. In the Timberlake Wetland (North Carolina, USA), saltwater intrusion is seasonal, lasting 3-6 months through summer when precipitation and subsequent freshwater discharge is lowest. Our study asks: How does periodic saltwater intrusion affect coupled iron and sulfur cycling in a freshwater coastal plains wetland? Iron and sulfate reduction rates were quantified from a 10 sites representing a range of hydrologic (wet vs. dry) and salinity (150 µS to 5 mS) conditions both before and during an intrusion event (June and September, 2011). Additionally, we used IRIS (Indicator of Reduction In Soils) methodology to characterize sulfate reduction at the same 10 sites. IRIS employs iron oxide painted PVC sheets, which are inserted into the soil. As sulfide is produced via sulfate reduction, it binds with the iron forming black FeS; the black, FeS patterns allow for a visual representation of sulfate reduction rates. Preliminary analysis indicates an increase in the areal extent and density of FeS in sites near the salt water source, indicating increased rates of sulfate reduction in response to salt water intrusion. Further analysis using imaging software will provide a quantitative measurement of sulfate reduction to correlate to the slurry-based techniques. IRIS methods have a number of advantages over slurry-based methods including: 1) a more visual and less laborious descriptor of sulfate reduction, 2) a larger surface area, better for capturing soil heterogeneity, and 3) an in situ method of observing microbial reduction rates. Comparing these two methods will enhance our understanding of the chemical changes involved with saltwater intrusion. Furthermore, understanding the interactions between iron and sulfur cycling contributes to our knowledge of how coastal freshwater wetlands will respond to impending salinization periodic saltwater intrusion events as well as eventual via sea level rise.

Contact Information: Valerie Schoepfer, School of Natural Resources, University of Nebraska, Lincoln, NE, USA 68503, Phone: 860-908-9155, Email: valerie.schoepfer@huskers.unl.edu

DETECTING LONG-TERM COMMUNITY SHIFTS IN RESPONSE TO SEA LEVEL RISE AND EVERGLADES' RESTORATION

Kristie S. Wendelberger[1], *Jimi Sadle*[2], *Sonali Saha*[3] and *Jennifer H. Richards*[1]
[1]Florida International University, Miami, FL, USA
[2]Everglades National Park, Homestead, FL, USA
[3]The Institute for Regional Conservation, Miami, FL, USA

Coastal communities in Florida are threatened by increased salinity from sea level rise (SLR) while simultaneously the Comprehensive Everglades Restoration Plan (CERP) is attempting to restore freshwater flows to these areas. Everglades National Park harbors 43 critically imperiled species, 21 of which are threatened by SLR; rare species richness tends to be negatively correlated with salinity in these habitats.

When the complexities of SLR and CERP are added to a vegetation matrix driven by elevation, salinity, inundation, and rainfall, it is difficult to know when a community is undergoing long-term shifts in species abundance and composition resulting from changes in salinity regime or is fluctuating normally. To form a realistic conservation action strategy in the face of large-scale change, land managers need to prioritize species under greatest extinction threat. With this Information, they can decide how to allocate resources and funding, making the best decisions to preserve the greatest amount of biodiversity.

We address these issues in three ways: Creating a baseline map of coastal plant communities through remote sensing technologies. We are using WorldView-2 satellite 2x2m resolution data with 8 multi-spectral bands to map plant communities in a 122km^2 area around coastal Flamingo, Everglades National Park.

We are testing if salt-tolerant species (halophytes) eco-engineer their environment elevating soil salinity to the detriment of salt-sensitive glycophytes. Halophytes can continue transpiring under increased saline conditions that cause glycophytes to close their stomata resulting in decreased glycophyte productivity; this allows halophytes to out-compete co-occurring glycophytes and become more abundant. In a greenhouse experiment, we are evaluating the ability of halophytes to increase soil salinity under varying halophyte/glycophyte densities; our results will inform predictive models assessing plant community change due to increased salinity levels.

Assessing which life history stages are most vulnerable to increasing salinity levels for 6 coastal plant species found in buttonwood forests and HH. We are looking at the effects of 0ppt, 5ppt, 15ppt, 30ppt, and 45ppt salinity levels on seed germination, the first three months of seedling establishment, and one year old juveniles. This Information will assist park managers in monitoring community shifts due to increased/decreased salinity levels from either SLR or CERP, respectively.

Contact Information: Kristie S. Wendelberger, Florida International University, 11200 SW 8th ST, Department of Biology, OE 167, Miami, FL 33199 USA, Phone: 919-257-9154, Email: kwendelberger@yahoo.com

RESPONSE OF TIDAL FRESHWATER MARSH PLANT AND MICROBIAL COMMUNITIES IN THE DELAWARE RIVER ESTUARY TO SEA-LEVEL RISE AND SALT-WATER INTRUSION

Nathaniel B. Weston
Villanova University, Villanova, PA, USA

Tidal freshwater marshes (TFMs) in many estuarine systems will experience both sea-level rise and salt-water intrusion as global climate changes. Altered flooding depth, increasing ionic strength, and higher sulfate concentrations will influence both plant and microbial processes in these marshes, which will in turn impact C cycling and potentially alter rates of vertical accretion. To evaluate the response of TFMs to sea-level rise and salt-water intrusion, a field manipulation was conducted in the Delaware River Estuary where intact TFM mesocosms were placed on marsh 'organs' which simulated sea-level rise by lowering the elevation of the marsh mesocosms relative to the marsh platform. Four organs were constructed along the estuarine salinity gradient (maximum salinities of 0, 0.5, 4 and 10) to evaluate the coupled impact of sea-level rise and salt-water intrusion on tidal freshwater marsh processes. Along with TFM mesocosms, the marsh organs were also populated with mesocosms from the adjacent marsh to evaluate the response of marshes throughout the Delaware River estuary to sea-level rise. Plant species composition and biomass along with CH_4 and N_2O gas emission rates have been monitored over two growing seasons (2.5 years), and soil microbial process rates (methanogenesis and sulfate reduction) and porewater biogeochemistry were determined on a subset of mesocosms in mid-summer of two years.

Tidal freshwater marsh plant species composition and biomass respond strongly to both flooding depth and salt-water intrusion. *Spartina alterniflora* salt-marsh grass responds positively to 10-20 cm of increased flooding. In contrast, the high-biomass TFM plants (*Bidens aristosa, Amaranthus rudis* and *Polyganum* species) respond negatively to increases in flooding depth. Increased flooding depth in TFM mesocosms therefore resulted in a shift to more inundation-tolerant species (*Nuphar lutea and Peltandra virginica*) and lower overall plant biomass. Salt-water intrusion resulted in markedly lower plant biomass in the first growing season, and shifts in species composition to more salt-tolerant plant species (*Zizania aquatic* and *Spartina alterniflora*) in the second growing season. The transition to salt-tolerant plant species was limited, however, as maximum biomass in the freshwater marsh mesocosms experiencing salt-water intrusion in the 2nd year remained far below the *in situ* biomass in the salt- and brackish-marshes. The succession from TFM to salt-marsh appears further limited by increased flooding, with relatively little growth of salt-tolerant plants in TFMs mesocosms experiencing both salt-water intrusion and increased flooding.

Microbial sulfate reduction and methanogenesis were, surprisingly, not significantly correlated with plant biomass, indicating a decoupling of organic matter production and microbial decomposition processes in TFMs following salt-water intrusion and sea-level rise. Sulfate reduction was highest in the brackish and salt-marsh sites, and salt-water intrusion into TFMs significantly increased rates of sulfate reduction. Methanogenesis did not decrease following salt-water intrusion, and rates of methanogenesis increased with greater flooding depth. These results suggest that, despite lower inputs of plant organic matter, microbial organic matter decomposition increased following sea level rise and salt-water intrusion. Sea-level rise and salt-water intrusion may therefore reduce C sequestration and limit the vertical accretion potential of TFMs.

Contact Information: Nathaniel B. Weston, Department of Geography and the Environment, Villanova University, Villanova, PA 19085 USA; Phone 610-518-8009; Fax 610-519-3338; Email: nathaniel.weston@villanova.edu

SEA LEVEL RISE - SALINITY GRADIENTS

SOIL SURFACE ELEVATION CHANGE ALONG A TIDAL FRESHWATER FORESTED WETLAND TO MARSH TRANSITION

Nicole Cormier[1], *Camille L. Stagg*[1], *Ken W. Krauss*[1], *William H. Conner*[2] and *Donald R. Cahoon*[3]
[1]U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, USA
[2]Clemson University, Baruch Institute of Coastal Ecology and Forest Science, Georgetown, SC, USA
[3]U.S. Geological Survey, Patuxent Wildlife Research Center, Beltsville, MD, USA

Many tidally influenced freshwater forested wetlands in the southeastern United States are currently undergoing dieback and decline from saltwater intrusion and altered freshwater flow. Increasing sea-level and climatic variability also enhances tidal coupling within freshwater wetlands that, over time, cause additional stress resulting in dieback of tidal swamps, with eventual conversion to marsh. Maintenance of soil surface elevation is important to this dynamic, and scientists have hypothesized that soil surface elevation is compromised by saltwater intrusion into freshwater forested wetlands by directly reducing root growth in non-halophytic forest vegetation and by facilitating organic matter mineralization with greater sulfate loading to interstitial waters. To monitor these changes, we established replicate landscape transects along the Savannah River (Georgia) and Waccamaw River (South Carolina). Transects were arranged along gradients of degradation associated with both increasing tidal influence and interstitial salinity, and includes healthy (salinity <0.5 ppt), moderately degraded (0.5-2.0 ppt), and highly degraded (>2.0 ppt) forested wetlands along each river, as well as an oligohaline marsh (3.4-3.7 ppt). We documented sedimentation and elevation change along this gradient for each river transect over a 2 year period by focusing on surficial vertical accretion, root zone processes (0.5-0.7 m), and deep soil processes (3-16 m). Surface elevation relative to both deep and shallow benchmarks decreased within the forested wetland zone, which included healthy and degrading forests along the salinity gradient. In contrast, the oligohaline marsh showed an increase in soil surface elevation over time, attributable in part to the restoration of shallow root growth as herbaceous marsh plants became more vigorous. Surface accretion was lowest in the healthy forests, highest in the marsh, and intermediate in both forests experiencing salinity intrusion. Overall, we confirmed that surface elevation reductions occur with greater incursion of salinity into tidal freshwater forested wetlands, thus increasing the vulnerability of degraded forested wetland sites to submergence. But, marshes appear to have an inherent ability to restore soil surface elevations after transition from forested wetlands.

Contact Information: Nicole Cormier, U.S. Geological Survey, National Wetlands Research Center, 700 Cajundome Boulevard, Lafayette, LA 70506 USA, Phone: 337-266-8838, Fax: 337-266-8586, Email: cormiern@usgs.gov

WATER BUDGET, CLIMATE VARIABILITY, AND PREDICTING SALINITY FOR EASTERN FLORIDA BAY

Erik Stabenau and *Kevin Kotun*
National Park Service, Homestead, FL, USA

An increase in upstream freshwater flow to the marine transition zone of Florida Bay to reduce salinity levels in the coastal basins is an important goal of the Comprehensive Everglades Restoration Plan (CERP). CERP salinity performance measures for the coastal system are useful to evaluate the impacts of upstream flow restoration on seasonal salinity levels within the basins of Florida Bay. However, predicting the success of such projects is challenging, since cycles and trends in salinity in the natural system may be larger than salinity changes attributed to restoration alternatives being evaluated. The goal of this analysis is to determine the drivers of the seasonal variation and long-term trends in salinity and predicting how those drivers may influence salinity through the projected timeframe for CERP implementation.

Since 1990, salinity values in eastern Florida Bay have shown wide variations on annual to interannual time scales. Prior to 1995, salinity ranged from euhaline to hypersaline conditions, while in 1995-1996, eastern Florida Bay experienced mesohaline conditions likely due to greater precipitation and freshwater discharge. While salinities were higher on average in 1990 than today, from 1994 through the present there has been an increasing trend in mean salinity. In addition, there is larger interannual variation in the range of salinity observed during the tropical wet or dry season cycles.

Extensive monitoring in the region has allowed the development of a water budget which was then used to investigate the relative importance of the individual components on salinity in eastern Florida Bay. One critical issue is to determine if the increase in salinity is a secular trend or part of a cyclical process, and the likely outcome of each scenario. Trend related features, such as long-term changes in canal operations in the C-111 and related structures in the marsh or sea level rise in the marine environment may affect residence time within and exchange rates between basins and affect salinity. Cyclical features, such as annual cycles in precipitation and freshwater flow, experience changes in magnitude and timing due to connections with multi-year climate cycles. Recent advances in the understanding of these global drivers of local sea-level and regional precipitation patterns may improve our ability to understand the relative importance of the individual drivers of salinity variation. We will present predictions for the future salinity conditions in eastern Florida Bay, identify features that may be used to improve those predictions, and discuss their limitations.

Contact Information: Erik Stabenau, South Florida Natural Resources Center, National Park Service, 950 N. Krome Ave., Homestead, FL, 33030-4209, USA, Phone: 305-224-4209, Email: Erik_Stabenau@nps.gov

THE EFFECT OF SALTWATER INTRUSION ON BELOWGROUND DECOMPOSITION

Camille L. Stagg[1]*, Nicole Cormier*[1]**,** *Ken W. Krauss*[1] and *William H. Conner*[2]
[1]U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, USA
[2]Clemson University, Baruch Institute of Coastal Ecology and Forest Science, Georgetown, SC, USA

Tidal freshwater forests, which exist along the upper edge of the tidal spectrum, are vulnerable to hydrological alterations resulting from the interaction of anthropogenic activities and climate change. Decreased freshwater discharge, coupled with sea-level rise, extends the reach of saline influence and can cause forest degradation and eventual conversion to oligohaline marsh. Saltwater intrusion not only affects plant production and community composition, but also has the potential to impact organic matter accumulation by causing shifts in microbial mineralization pathways. To understand how saltwater intrusion affects organic matter dynamics, we measured rates of root and rhizome belowground decomposition along a gradient of salinity and degradation on two replicate rivers. The gradient treatments included a healthy tidal freshwater forest (salinity < 0.5 ppt), a moderately degraded forest (salinity 0.5-2.0 ppt), a highly degraded forest (> 2.0 ppt) and a fully converted oligohaline marsh (3.7-4.5 ppt). We found a significant ($p < 0.001$) increase in root and rhizome decomposition in the moderately degraded (0.00053 % mass lost day^{-1}) and highly degraded (0.00051 % mass lost day^{-1}) forests compared to the healthy forest (0.00039 % mass lost day^{-1}). We also observed a decrease in decomposition rate as salinities increased in the oligohaline marsh (0.00023% mass lost day^{-1}). Our data support recent studies that suggest the introduction of sulfate into previously fresh soils stimulates sulfate reduction resulting in higher mineralization rates. The slower rates of decomposition observed in the oligohaline marsh indicate that the initial response of freshwater soils to saltwater introduction is moderated over the long-term, as the oligohaline marsh soil develops under the new salinity regime. This trend parallels our finding that surface elevation decreases in areas of initial saltwater intrusion, but increases in the oligohaline marsh, indicating that belowground decomposition plays an important role in regulating tidal freshwater elevation dynamics and sustainability during sea-level rise.

<u>Contact Information</u>: Camille L. Stagg, U.S. Geological Survey, National Wetlands Research Center, 700 Cajundome Boulevard, Lafayette, LA 70508 USA, Phone: 337-266-8537, Fax: 337-266-8586; Email: staggc@usgs.gov

VEGETATION DIVERSITY AND NUTRIENT ALLOCATION ALONG A SALINITY GRADIENT

Lori A. Sutter[1], *James E. Perry, III*[1] and *Randolph M. Chambers*[2]
[1]Virginia Institute of Marine Science, Gloucester Point, VA, USA
[2]The College of William & Mary, Williamsburg, VA, USA

Estimates suggest that relative sea level in the lower Chesapeake Bay tributaries is rising at 4-6.8mm/yr. Consequently, intertidal habitats of the Bay's tributaries are susceptible to the increased influx of saline water. This study investigates nutrient dynamics and vegetation diversity at four sites within three marshes along a salinity gradient on the Pamunkey and York Rivers (Virginia, USA): 1) tidal freshwater (Cumberland), 2) transitional oligohaline (two sites within Sweet Hall Marsh (SHM)) and 3) mesohaline (Taskinas Creek). A navigation channel constructed a century ago divides SHM and creates hydrodynamics that drives the salinity north of the cut to be 1-2 ppt higher than the marsh area in the south. *Spartina alterniflora* has appeared and is expanding its range into the part of SHM north of the thoroughfare that is currently dominated by *Peltandra virginica* and *Zizania aquatica*. Since *S. alterniflora* is considered a poor interspecies competitor, we explored the mechanisms behind this unexpected appearance of *S. alterniflora* through measures of plant diversity as well as soil and vegetative nutrient content in each of these marshes. Percent cover was estimated in June and September 2011 to capture seasonal vegetation changes. Soil and plants tissues were collected monthly June through October 2011 and analyzed for carbon (C), nitrogen (N) and phosphorus (P) content.

The results of a Bray-Curtis ordination using percent vegetative cover show the composition of Taskinas Creek clearly differs from the three other marshes. The second axis showed that the vegetation of north SHM is separating from the cohesive cluster representing south SHM and Cumberland Marsh. Four of the most common species were analyzed for nutrient content and preliminary data accounting for repeated measurements displayed no difference in C or N content or their ratios, with the exception of *Pontederia cordata*, which had significantly lower ($p<0.05$) tissue C and N content in the freshwater Cumberland Marsh when compared to south SHM. Carbon and N content in the soils was greatest at Cumberland and significantly different ($p<0.05$) than the other marshes. Phosphorus data are forthcoming. Soil stoichiometry of SHM is more similar to Taskinas Creek, yet the vegetation similarities are greatest between Cumberland and the two SHM sites. This might suggest that soils are responding to changes in salinity driven by sea level rise, with a lag time in vegetative response.

Contact Information: Lori Sutter, Virginia Institute of Marine Science, The College of William & Mary, PO Box 1346, Gloucester Point, VA 23062 USA, Phone: 804.684.7477, Email: lsutter@vims.edu

PEATLAND RESTORATION IN A CHANGING CLIMATE: RISKS AND CHANCES OF SALINIZATION IN COASTAL PEATLANDS

Gijs van Dijk[1], *Alfons J.P. Smolders*[1], *Roos Loeb*[1], *Jan G.M.* Roelofs[2] and Leon *P.M. Lamers*[2]
[1]B-Ware Research Center, Nijmegen, the Netherlands
[2] Radboud University Nijmegen, the Netherlands

Large-scale problems such as eutrophication and land subsidence have a strong negative impact on peatland biodiversity and on the prospects for its restoration. In European lowlands, the chance of salinization in coastal peatlands is increased by the combined effects of of sea level rise, land subsidence and decreased summer precipitation. This may impose risks on current freshwater peatlands, but it may also provide new opportunities to restore formerly brackish peatlands.

To test the effects of salinization on the biogeochemistry of peatland waters, we conducted controlled experiments in aquaria in the lab and in enclosures in the field. In the lab experiment the effects of constant versus fluctuating salinity levels were tested on the biogeochemistry of formerly brackish peat sediments, with and without enrichment with micro-organisms from a brackish environment. In the field the effects of increasing salinity with and without the addition of nutrients were tested. Increased salinization significantly decreased phosphate concentrations in the sediment porewater and surface water. Ammonium concentrations could both increase or decrease depending on the chemical conditions of the sediment. There was no effect of the introduction of micro-organisms from brackish locations. Salinization did not seem to influence carbon dioxide emission from underwater sediments, but strongly decreased the emission of methane. It was shown that fluctuating and constant salinity levels can have similar biogeochemical effects, which has important implications for management and restoration.

The results show that the salinization of lowland peatlands may not only be a risk for freshwater peatlands, but may also be a good restoration measure for eutrophied, formerly brackish peatlands by decreasing mineralization and nutrient availability. The restoration of the natural freshwater - brackish water gradient is expected to create conditions that will increase biodiversity.

Contact Information: Gijs van Dijk, B-Ware Research Center, Toernooiveld 1, 6525ED, Nijmegen, the Netherlands, Phone: 0031243652812, Email: g.vandijk@b-ware.eu

GEOGRAPHICALLY WEIGHTED MODELING OF SURFACE SALINITY IN THE FLORIDA BAY USING LANDSAT TM DATA

Zhixiao Xie, *Caiyun Zhang* and *Leonard Berry*
Department of Geosciences, Florida Atlantic University, Boca Raton, FL, USA

An effective remote sensing approach is needed for surface salinity monitoring in the Florida Bay to help measure the progress of the Comprehensive Everglades Restoration Plan (CERP) especially in the context of sea level rising. In this study, we utilized a geographically weighted regression (GWR) approach to model the surface salinity in the Florida Bay based upon spatially and temporally matched field surveyed salinity data and Landsat Thematic Mapper (TM) images. As a local spatial modeling approach, the GWR is specifically designed to handle non-stationary spatial data, which is ideal for modeling surface salinity in the bay due to the high spatial and temporal heterogeneity of the bay. The testing results demonstrated that the developed GWR models generated high regression R^2 values and reported low prediction root mean square errors (RMSE) in validation. It suggests the GWR approach is more effective in modeling the spatial variation pattern of surface salinity in ECE than the commonly used regression models. In addition, this study indicates that the GWR modeling with Landsat TM and other remotely sensed data may potentially serve as a cost-effective alternative or a supplement to field survey currently undertaken for salinity monitoring in the coastal areas of the Greater Everglades.

<u>Contact Information</u>: Zhixiao Xie, Department of Geosciences, Florida Atlantic University, 777 Glades Rd., Boca Raton, FL 33431, USA, Phone: 561.297.2852, Fax: 561.297.2745, Email: xie@fau.edu

SEA LEVEL RISE - VEGETATION SHIFTS AND DIVERSITY

PREDICTING AND DETECTING CONSEQUENCES OF SLR AND STORM SURGES ON COASTAL VEGETATION REGIME SHIFTS

Jiang Jiang[1], *D. L. DeAngelis*[2], *T. J. Smith, III*[3], *S.-Y. Teh*[4] and *H.- L. Koh*[4]

[1]University of Miami, Coral Gables, FL, USA
[2]U. S. Geological Survey, Coral Gables, FL, USA
[3]U.S. Geological Survey, St. Petersburg, FL, USA
[4]Universiti Sains Malaysia, Penang, Malaysia

The landward coastal zones of the Everglades are characterized by sharp ecotones between salinity-tolerant (halophytic) vegetation types, such as mangroves, and salinity-intolerant (glycophytic) vegetation types, such as freshwater marsh and hardwood hammocks. Empirical studies show a gradual landward migration of these ecotones in some areas, due to sea level rise (SLR), and evidence in some areas of rapid change from glycophytic to halophytic vegetation, possibly as regime shifts resulting from salinity overwash from storm surges. The plausibility of storm surge related regime shifts of glycophytic vegetation was illustrated by a spatially explicit model of the mangrove/hardwood hammock ecotone (Teh et al. 2008).

In view of potential effects of SLR on Everglades's ecosystems, particularly the consequences these pose for the Comprehensive Everglades Restoration Plan, both empirical and modeling studies on coastal vegetation are underway. The Spatially Explicit Hammock/Mangrove (SEHM) model of the ecotone between those vegetation types was used to show the influence of both abiotic (elevation gradient, groundwater salinity, tidal amplitude, precipitation, freshwater flow) and biotic factors (plant physiology, competitive abilities, dispersal, positive feedbacks between plants and soil salinity) on the resilience of this ecotone to SLR and storm surges. The model simulation results indicate that an environmental gradient of salinity, caused by tidal flux, is the key factor separating vegetation communities, while positive feedback involving the interactions of vegetation types with the vadose zone salinity increases the sharpness of boundaries, and maintains the ecological resilience of mangrove/ hammock ecotones against minor disturbances. The model also shows that the dry season, with its low precipitation, has a strong effect on the position of the mangrove/hammock ecotone. Importantly, modeling indicates that, in order to cause a regime shift, an overwash event must raise soil and groundwater salinity for a sufficiently long period. Storm surge simulations with the hydrology model BISECT demonstrate that effects of sufficient duration are possible.

The SEHM model has been modified to simulate the mangrove-freshwater marsh ecotone. This model is based on intensive field studies across a mangrove-marsh ecotone on the Harney River in Everglades NP. Analysis of historical aerial photographs indicates that mangroves have invaded approximately 140m into the sawgrass marsh. Sampling of sediment porewater shows that salinities routinely exceed 10psu in the sawgrass, especially during the dry season. Storm surges (e.g., Hurricane Wilma) can also transport saline waters through the 250m wide mangrove forest and into the marsh.

This work is part of an integrated project that also involves hindcasting and forecasting SLR and storm surges. The significance of this research extends to coastal areas worldwide.

<u>Contact Information</u>: Jiang Jiang, University of Miami, Department of Biology, Coral Gables, FL, United States, 33124, Email: jjiang@bio.miami.edu

RESULTS FROM A GROUND PENETRATING RADAR SURVEY AT THE MOUTH OF THE SOUTH HARNEY RIVER, SOUTHWEST COASTAL REGION, EVERGLADES NATIONAL PARK, FLORIDA

James B. Murray and *Herbert Pierce*
U.S.Geological Survey, Reston, VA, USA

A 25 MHz ground penetrating radar (GPR) survey was completed along two transects near the mouth of the South Harney River. Due to the concerns about the ability of GPR instruments in highly conductive enviroments we were not sure about what the data represented. These data were collected in an attempt to locate historic oyster reefs and to test the GPR in a marine environment. Due to high conduction losses expierienced by the GPR electomagnetic waves, observed anomolies in the data set needed to be comfirmed by careful testing. The GPR data were collected parallel (1) to the river mouth into the Gulf of Mexico and perpendicular (2) to the river mouth. Transect (1) moving out of the river into the Gulf is approximately one kilometer in length. Transect (2) collected north to south across the river outlets is approximately two kilometers in length. The data were processed using GPRSoft and RadExplorer software applying standard GPR data analyses procedures. Analyses of the transects indicate several anomalous highs and lows at various shallow depths (3-6m) approximately 100-200m west of the shore and normal to the mouth of the South Harney River. The anomalies were tagged as waypoints for later verification of location, extent, water depth, and sediment depth.

In September 2011, we reoccupied the north-south transect. We probed six anomalies identified by the GPR and verified each location and depth. The highs are limestone bedrock and the lows appear to be outlet channels cut by the river into the limestone bedrock. It is possible that the sediment layers observed above the tagged "high" anomalies identified by the GPR represent former oyster bars. Plans are in place to run several more transects at this location to enhance the data set and to do further testing of this method in a marine environment.

Contact Information: James B. Murray, EGPSC, USGS, 12201 Sunrise Valley Dr., Reston, VA, 20192, USA, Phone: 703-648-6918, Fax 703-648-6953, Email: jbmurray@usgs.gov

THE INFLUENCE OF SALINITY ON COASTAL HAMMOCKS IN EVERGLADES NATIONAL PARK

Sonali Saha[1] and *Jimi Sadle*[2]
[1]The Institute for Regional Conservation, FL, USA
[2]Everglades National Park, FL, USA

We collected field and experimental data to understand how potential changes in groundwater salinity resulting from predicted sea-level rise may influence coastal forests of Everglades National Park. We conducted field studies in coastal buttonwood and hardwood forests to monitor seasonal patterns of groundwater salinity from February – December 2011. We determined water uptake depth of five common coastal hammock species by comparing isotopic signatures of oxygen and hydrogen in plant stem tissues with ground, soil and rain water collected in the field. In a shade house experiment, we examined responses of the same study species to salinity levels ranging from 0 to 30 parts per thousand (‰).

Groundwater salinity ranged from 6-44‰ with the lowest salinity in communities most elevated and furthest from Florida Bay. Species differed in their water sources and uptake patterns in dry winter months with patterns converging during the wet summer. Hardwood hammock species accessed water from deeper soil layer (> 15 cm) and were rare in buttonwood hammocks. Species of buttonwood hammock used water from within top 15 cm of soil. Mortality in two hardwood hammock species resulted from salinities greater than 15‰ and all but one species showed declines in productivity associated with elevated soil water salinity. The results of this study imply that increasing groundwater salinity will result in a predictable pattern of the loss of hardwood hammock species. These experimental results are consistent with hypotheses related to the observed structural collapse of some hardwood communities observed as long ago as 1980.

Contact Information: Sonali Saha, The Institute of Regional Conservation, 22601 SW 152nd Ave. Miami FL 33170. Phone: 305-247-6547, Fax: 305-245-9797, Email: sahairc@gmail.com

MONITORING MANGROVE ECOTONAL MOVEMENT INTO EVERGLADES MARSHES

Kevin R. T. Whelan[1], *Timothy A. Fotinos*[2] and *Robert B. Shamblin*[1]
[1]National Park Service, Palmetto Bay, FL, USA
[2]Florida International University, Miami, FL, USA

The movement of mangrove-marsh ecotones can be the result of many physical forcing functions such as: long-term sea level rise, the effects of fire, manipulation (augmentation or reduction) of fresh water flows, hurricanes, and frost. Monitoring movement of mangrove-marsh ecotones is of great importance, particularly in a flat, low-lying region such as south Florida where these factors can affect a large area. The National Park Service - South Florida / Caribbean Inventory and Monitoring Network (SFCN) has developed a vegetation monitoring protocol that includes tracking the movement of mangrove communities at the local and landscape scale. Landscape monitoring occurs using aerial imagery which is then rigorously ground truthed. These ground truth locations also serve as witness post locations for resampling events that will occur approximately every ten years. In this way we are able to have a field monitoring location that can corroborate remotely sensed estimates of ecotonal movement.

Preliminary analysis of historical imagery shows that closed canopy mangrove forest encroached into marsh communities from 0-18 meters over the 14 year period from 1995 to 2009. Imagery, however, tells only part of the complex story. We have found that many areas are experiencing upslope establishment of dwarf red mangroves (*Rhizophora mangle*) and reduced graminoid cover that is not obvious from aerial imagery, thus requiring us to reanalyze the imagery and relocate witness posts. This illustrates the importance of field monitoring in addition to remote data.

SFCN has established several monitoring areas that span the extent of coastline in Everglades National Park in south Florida. These areas represent the range of variability in mangrove-marsh ecotonal structure from hard treeline to slowly transitioning admixture of dwarf mangroves and graminoids. They also include areas affected by varied freshwater and tidal influence ranging from semi-urban areas highly augmented by canals in the southeast to natural sheetflow regions in Shark Slough to stream dominated areas on the west coast.

A subset of the witness posts includes a transect that runs from mangrove forest to open marsh. At these intensive sampling sites, plant community structure will be monitored in order to understand changes occurring at the local level that facilitate mangrove encroachment.

Contact Information: Kevin R. T. Whelan, National Park Service, 18001 Old Cutler Road Suite 419, Palmetto Bay, FL 33157 USA, Phone: 305-252-0347, Fax: 305-253-0463, Email: Kevin_R_Whelan@nps.gov

SWS – SMP

THE EFFECT OF SALINITY ON RESPIRATION, GROWTH AND SURVIVAL OF BLUE TILAPIA, *OREOCROMIS AUREUS*

Lindsey Callier and *Ajoy Chakrobarti*
South Carolina State University, Orangeburg, SC, USA

Tilapias are internationally consumed delicate fish. Tilapia, specifically blue tilapia (*Oreocromis aureus)*, are native to Cameroon, Chad, Egypt, Israel, Jordan, Mali, Niger, Nigeria, Saudi Arabia, and Senegal in tropical and subtropical African and the Middle East *Oreochromis aureus* can adapt to many types of habitats, which is an indicator of its high tolerance and survival rates in saline waters. The blue tilapia has been studied by many researchers; however, effects of salinity on its growth, survival and respiration at different stages are not clear. The present study determined the optimum range of salinity in which blue tilapia can survive, grow and respire, and the differences between juveniles and young.

Tilapia's wide range of tolerance of environmental changes, including salinity, makes them excellent candidates for aquaculture. Two experiments were implemented in this research - one on respiration and survival of blue tilapia and another on growth and survival. The post larvae, juveniles and young were accommodated in a400 ml aquarium chamber, solitary or in a group of 10 fish, and immediately subjected to experimental waters. The effect of salinity on optimum growth and survival was observed in pre juvenile blue tilapia. Respiration and survival of blue tilapia was observed solely in tilapia young. Practical indices of salinity tolerance assessed the exposure of blue tilapia to various degrees of salinity, which ranged from 0 to 35 ‰. Results demonstrated that pre juvenile (< 25 days) are able to survive in salinities 0-10 ‰ for a 20 day period. Growth was observed to be most effective at 8 ‰. Young respiration was observed in 0- 35 ‰ with a high respiration rate in 0 ‰ and low in 25 ‰. A study of respiration, growth and survival had been initiated in hopes of discovering new methods of breeding in aquaculture.

Blue tilapia showed acute abilities to acclimate to specific experimental salinities greater than 20 ‰. The tolerance of blue tilapia to a persistent change in salinity was evaluated by exposing individual specimens to a progressively increasing saline environment (5 ppt) until each treatment reached its target salinity. Because blue tilapia is a fresh water fish, they died at 35 ‰ within 40 minutes (determined in a pilot study). All three specimens survived and were returned to freshwater environments.

Contact Information: Lindsey Callier, South Carolina State University, 300 College St. NE, Orangeburg, SC 29117 USA, Email: lindseycallier@gmail.com

A BEHAVIORAL STUDY OF SHARKS IN CAPTIVITY

***Mario C Flunory*[1], *Mary T Ortiz*[1] and *Anjelique M Restrepo*[2]**
[1]Kingsborough Community College, CUNY, Brooklyn, NY, USA
[2]Hunter College, CUNY, New York, NY, USA

Sharks have long been thought of as aggressive and even murderous creatures. They have been on display in aquaria for decades. They were originally put on display for entertainment purposes, but this quickly transitioned into a learning experience. While fear of is still present, people have begun to learn about these animals. Originally, humans didn't take the time to learn how captive environments affected sharks. Precautionary measures weren't taken until recently to ensure shark safety and health in these habitats.

In this project four behaviors (biting, fast swimming, rest, curiosity) before, during and after feeding, of Nurse (*Ginglymostoma cirratum*), Sandbar (*Carcharhinus plumbeus*) and Sand Tiger (*Charcharias taurus*) sharks were observed in 4 man-made aquaria (National Aquarium in Baltimore, New York Aquarium, Adventure and Jenkinson's Aquaria in New Jersey) and compared to published studies of these species in the wild. Multiple observations were made at each location. In addition, data were gathered on habitat size (gallons of water), shape (round vs. perpendicular), and other tank features (objects and organisms present). The hypothesis was that sharks in captivity will be less aggressive than those in the wild. For each of the three species studied, the number of behaviors observed, per shark, per visit were calculated. No aggressive biting was observed before, during or after feeding for any shark. The primary shark behavior observed was curiosity in all four aquaria. The sharks displayed minimal fast swimming. This may be attributed to the limitations of tank size. The sharks tended to be more motionless or at rest after feeding, perhaps because they were satiated. More activity was observed in Nurse sharks in Jenkinson's (58000 gal) and New York Aquaria (90000 gal) as compared to Baltimore (225000 gal) and Adventure (550000 gal) aquaria. Tank size may be a factor. The Sand Tigers were more active than Nurse sharks before feeding with respect to curiosity. The average numbers of observed curious behaviors were 12.17+/-11.83 per shark per visit versus 1.56+/-1.94 per shark per visit, respectively. The hypothesis was accepted. The sharks observed in captivity in this study were less aggressive than their counterparts in the wild. There may be a number of reasons for this, such as less competition for food and lack of stimulation. Future studies will include additional aquaria over longer time periods. This work was supported by Grant 2R25GM06003-05 of the Bridges to the Baccalaureate Program of NIGMS and Grant 0537101091 of the CSTEP Program of the NYS Department of Education. Jenkinson's Aquarium in New Jersey is acknowledged for their generous help with this project.

Contact Information: Mario C. Flunory, Department of Biological Sciences, Kingsborough Community College, CUNY, 2001 Oriental Boulevard, Brooklyn, NY 11235 USA, Phone: 718-368-5000 fax: 718-368-4873, Email: MarioCFlunory@aol.com

WHY DO SMALL PONDS REALLY MATTER? A CASE OF EAGLE CREEK PARK, INDIANAPOLIS, IN

Jahuan C. Jarrett and *Mamta Singh*
Martin University, Indianapolis, IN, USA

Eagle Creek Park is the largest park in Indianapolis, IN and one of the largest municipal parks in the United States. Several activities take place in Marinas, which is a major lake inside Eagle Creek Park.

The purpose of this study was to analyze the water quality of the Marinas wetland to determine if there were any factors of pollution that can be prevented or treated to make the community sustainable. My primary research objective was to assess selected water quality parameters of Marinas. I measured select lentic ecosystem parameters of the lake three times a month in spring 2010 to compare and contrast the results with an adjacent lentic ecosystem, Lilly Reflecting pond.

Selected water quality factors included both physical and chemical parameters. The parameters measured were: conductivity (µS/cm), air temperature, water temperature, pH, and total depth by using the Secchi disk. The necessary observations conducted were: flow severity, algae cover, water color, water clarity, water surface, water condition, water odor, and weather.

As predicted, algae cover, Secchi disk transparency, specific conductivity, and pH of Lilly reflecting pond was noticeably higher compared to Marinas. Furthermore, I will be accessing aquatic micro-invertebrates abundance and administering surveys to assess public perception and awareness of Marina's water quality. Further long term empirical research with an assessment of biological parameters is recommended for a detailed assessment of this lentic ecosystem.

Contact Information**:** Jahuan C. Jarrett, Biology and Environmental Science Department, Martin University, 2171 Avondale Place Indianapolis, IN 46218 USA, Home Phone: 317-546-7892, Cell Phone: 317-509-4865, Email: jjahuan@yahoo.com

SCALING OF RESPIRATION WITH BODY SIZE IN A SUSPENSION-FEEDING GASTROPOD

Edwige P. Lauture, *Andrew Bellinger* and *Dianna K. Padilla*
Stony Brook University, Stony Brook, NY, USA

Suspension feeding is unusual in gastropods, and it is assumed to be energetically expensive, especially for small animals. However, we have little data on the scaling of respiration with body size for invertebrates whose size ranges from less than 1 mm to 6 cm. A recent study on the scaling of respiration with size for a number of gastropods found a scaling constant of ~0.6 (Marsden, Shumway and Padilla in press). This study suggested that the scaling constant for *Crepidula fornicata* is greater than most gastropods, near 0.8. *Crepidula fornicata* can suspension feed and feed with its radula across all sizes. We examined the respiration rates of *C. fornicata* from newly metamorphosed individuals (< 1 mm) to adults when not feeding, when suspension feeding, and when grazing with their radula to understand the costs of scaling of different feeding mechanisms.

Contact Information: Edwige Lauture, Stony Brook 100 Circle Road, Mendelsohn Quad, Gray College, A322 Stony Brook, NY, 11790, USA, Phone: 347-285-8801, Email: edwigelauture@aol.com

ASSESSING THE EFFECT OF HUMAN DISTURBANCE ON LILLY LAKE WATER PARAMETERS

Philip A. Peterson and *Mamta Singh*
Martin University, Indianapolis, IN, USA

Despite the importance of Eagle Creek as both a recreation park and as a source of water for the city of Indianapolis IN, limited research has been conducted concerning its past and present water quality. Lilly Lake in particular serves as a popular site for park visitors to relax and enjoy themselves. In addition, other areas of the lake serve as a home for large amounts of vegetation and animal life, and as a source of drinking water.

The purpose of this study was to assess a relationship between human disturbance and water quality within Lilly Lake. The hypotheses were that there are variations in water quality parameters in locations less disturbed by human visitors, and if research suggested a disparity, it would have presented a strong case for conserving those nature reserves and more strictly limiting human disturbances.

Water quality testing kits thermometers, and a Secchi disk were used at three sites around Lilly Lake over a period of three months to assess the physical and chemical properties of the water. Differences such as additional submerged aquatic vegetation and a higher quantity of fish and insects in different sites were noted as testing was done. The results suggested that there were some key differences in the water in the immediate vicinity of the sites, possibly due to the plants and animals that were more abundant in the less trafficked areas. However, the parameter differences were not as obvious as expected and sometimes negligible. Further testing is recommended to assess the impacts of human disturbances on the Lilly Lake water quality with more certainty.

Contact Information: Philip Peterson via Mamta Singh, Biology and Environmental Science Department, Martin University, 2171 Avondale Place, Indianapolis, IN, 46218, USA, Phone: 317-917-3367, Email: philip.peterson@students.martin.edu

THE CONTRIBUTION OF EVAPOTRANSPIRATION TO THE WATER BUDGET OF AN ARIDLAND URBAN TREATMENT WETLAND

Christopher Sanchez[1], *Daniel L. Childers*[2], *Laura Turnbull*[2] and *Nicholas Weller*[2]
[1]Department of Ecosystem Science and Policy, University of Miami, Miami FL, USA
[2]School of Sustainability, Arizona State University, Tempe, AZ, USA

Background/Questions/Methods: One of the most important aspects of any wetland is the water budget. Quantifying how evaporation and evapotranspiration contribute to water residence time is crucial to understanding the cycling of biogeochemically active and non-active solutes through the water column, plants and soils—particularly in arid climates. We measured evapotranspiration and evaporation rates in a constructed treatment wetland in Phoenix during summer 2011, when both rates were at annual maxima and wastewater inflows were at an annual minimum. Our primary objectives were: 1) to measure the rates of wetland evaporation and evapotranspiration bi-weekly using a handheld infrared gas analyzer, and; 2) calculate a whole-system summer water budget using these rates plus inflow and outflow data. We hypothesized that; 1) the summer water balance will lead to seasonal evapoconcentration of bioactive solutes and salts, and; 2) this will put substantial stress on the ability of wetland plants and soil microbes to perform the desired ecosystem services of nutrient uptake and transformation. These water flux data and summer water budget will contribute to our overall goal of quantifying the hydrology budget for the Tres Rios treatment wetland, and will improve our general knowledge of wetland water treatment capacity in dryland areas.

Results/Conclusions: The primary drivers of variation in evapotranspiration were photosynthetically active radiation, air temperature, and relative humidity. We used these data from a nearby meteorological station, and plant biomass data, to scale our leaf-specific rates to the entire system. Daily evapotranspirative losses ranged from 3.7 to 6.5 cm day^{-1}; values that are 5 – 10 times higher than published results from mesic wetlands. This loss represented roughly 6 – 8% of the total effluent inflow to the system. On the average, *Typha latifolia* and *domingensis* contributed 2.7 cm day^{-1}, *Schoenoplectus acutus* contributed 2.2 cm day^{-1}, and S. *americanus* and S. *tabernaemontani* contributed less than 0.5 cm day^{-1} each. These interspecies differences were driven by differences in both plant-specific biomass and relative proportion of each species to whole-system biomass. Bi-weekly measurements of conductivity showed increases of up to 25% along transects within the wetlands from open water to the shoreline, suggesting that evapoconcentration of nutrients and solutes is occurring. We are continuing this sampling on a bimonthly schedule and will calculate a more rigorous annual water budget in summer 2012, once a year of data has been collected. This poster and research project is part of a broader effort to understand the ability of wetlands in arid climates to deliver ecosystem services related to water treatment.

Contact Information: Christopher A. Sanchez, Department of Ecosystem Science and Policy, University of Miami, Miami FL, 33146, USA, Phone: 305.898.1266, Email: c.sanchez16@umiami.edu

EFFECTS OF INCREASED TEMPERATURE ON A *TRICHOPTERA: HYDROPSYCHIDAE* SPECIES FOUND IN COSTA RICA

Katharine Stewart[1] and *David Rogowski*[2]
[1]Northeastern State University, Tahlequah, OK, USA
[2]Texas Tech University, Lubbock, TX, USA

Global warming and deforestation are worldwide concerns that have far reaching effects. Increased temperatures affect all types of habitats. This study looked at an aquatic insect, a Trichopteran species, found in premontane forest streams. In areas such as Costa Rica, there has been a lack of research in the area of aquatic habitats as well as aquatic insects, although much is known regarding this order in temperate climates. Also this area has lost nearly fifty percent of its forest due to deforestation. It is known that temperatures can increase up to seven degrees when riparian areas are cleared. This study looked at how increased stream temperature affects aquatic insects, specifically a *Trichoptera: Hydropsychidae* species found in Coto Brus, San Vito, Costa Rica.

Laboratory experiments were conducted to test the effects of temperature on mortality and behavior (case building) of a Trichopteran species from Costa Rica. The temperatures of three types of streams, primary forest, secondary forest, and urban, were monitored over the length of the experiment. Results of the lab experiment showed this species of *Trichoptera* had a higher rate of survival at lower temperatures, under 21˚C. *Trichoptera* had a higher rate of case building at these lower temperatures as well. Higher mortality rates and lower incidences of case building were observed at temperatures only a degree higher at 22.3˚C, with nearly complete mortality and no case building when temperatures exceeded 25˚C. Stream temperature analysis suggests a more stable temperature in both the primary and secondary forest, whereas the temperatures in the urban stream seem to fluctuate with the air temperatures.

Contact Information: K. Stewart, Northeastern State University, 600 N. Grand Ave, Tahlequah, OK, 74464 USA, Phone: 918-946-1505, Fax: 918-482-5102, Email: stewar04@nsuok.edu

RECOLONIZATION OF BLUE SPRING RUN BY RARE SNAIL SPECIES AFTER TROPICAL STORM FAY

***Sierra Taliaferro**, Rashan Moss, Michael Reiter* and *Alexis Brooks-Walter*
Bethune-Cookman University, Daytona Beach, FL, USA

Blue Spring State Park, Orange City FL, is an outdoor recreational attraction allowing visitors to swim, snorkel, kayak, and observe wildlife. Blue Spring run, a first-order spring, is an overwintering site for the West Indian manatee (*Trichechus manatus*) and several species of rare and endemic snails including the threatened Blue Spring pygmy silt snail *(Floridoba parva)* and the Blue Spring hydrobe *(Aphaostracon asthenes)*. Spotty population distributions of the rare snails, combined with the recent appearance of the invasive vermiculated sailfin catfish (*Pterygoplichthys disjunctivus*), have raised concerns about the ability of the snail populations to recolonize cleared or disturbed areas in the spring run.

In August 2008, tropical storm Faye passed over Blue Spring, contributing approximately 51 cm of rainfall, which flooded the spring run and created a major scouring event that cleared the run of the manatees and catfish, impacted snail habitat, and forced closure of the park. The absence of manatees and catfish provided an opportunity to observe the recolonization capacity of the snail populations into unoccupied areas due to downstream drift and the dispersal of nearby populations. Sampling areas were selected near a known existing snail population along the edge of the run by a newly-flooded swimming dock. Sampling began 36 days after park closure along a transect from the run edge into the middle of the spring run (previously heavily disturbed by catfish), on a nearby stairway extending upstream from the population (previously heavily disturbed by human activity), and the flooded dock itself. The run transect was used to determine the ability of the known population to move out into the run without catfish disturbance the ability of the snails to move up the stairway without human disturbance, and the ability of the snails to colonize new areas via drift from upstream.

Without inhibiting factors present, algal filaments began to recolonize surfaces and snails were found at densities of approximately 30 individuals per 200 cm^2 as far away as 2 m from the known population. Decreasing densities of snails were detected on the submerged stairs as one moved farther away from the existing localized population. However, a cold snap occurring 57 days after closure resulted in the appearance of manatees and sailfin catfish, and samples after that point found no algae or snails in the previously newly colonized locations. No snails were found on the submerged dock surface during the sampling period, which would have been more likely to be colonized by drift from upstream. This study suggest that there is potential for dispersive recolonization from existing localized snail populations if the habitat is allowed to reform, but no evidence of meaningful drift colonization from upstream was detected.

Contact Information: Sierra Taliafero, Department of Integrated Environmental Science, Bethune-Cookman University, 640 Dr. Mary McLeod Bethune Blvd., Daytona Beach, FL 32114-3099 USA, Phone: 414-719-2511, Fax: 386-481-2659, Email: sierra.taliaferro@cookman.edu

EAST WINSTON NORTH CAROLINA MASTER PLAN: OPEN SPACE NETWORK

James Totton[1] and *Anna Reaves*[2]
[1] North Carolina A&T State University, Greensboro, NC, USA
[2] Goler CDC, Winston-Salem, NC, USA

Created in the senior advanced landscape design class within the Landscape Architecture program at North Carolina A&T State University, this open space design of east Winston, located in Winston-Salem, North Carolina, illustrates the open space design proposed for this area.

In the master plan, the vegetation is well organized with rows of trees parallel to the streets bordering the sidewalks. This design exemplifies the potential that East Winston has in transforming the community into a sustainable one. There are open spaces for possible urban or passive parks, woodland, or community gardens, and a stormwater pond. The existing site contains open spaces that are privately owned. On the southwestern part of the area, invasive kudzu has taken over much of the area. The remaining vegetation is poorly maintained. Interstate 40 and North Carolina 52 form much of the boundary of the site. Different types of parks will be created on the site of East Winston, including pocket parks, wildlife/stormwater parks, linear parks, and urban plazas. They will serve to improve the overall health of the community and provide outlets for growth and economic development in East Winston. The urban wildlife in the wildlife/stormwater park will consist of migratory native birds, squirrels, and rabbits. Native vegetation such as dogwoods and willow oaks will be incorporated into the design. Brooklyn Bridge Park and Wellesley College are precedents because they exemplify what an urban forest/wildlife park should be.

Contact Information: James Totton, Landscape Architecture Program, North Carolina A&T State University, #231 Carver Hall, Greensboro, NC 27411, USA, Phone: 336-334-7520, Email: jrtotton@ncat.edu

URBAN WETLANDS

AN INVESTIGATION OF THE INFLUENCE OF URBANIZATION ON AMPHIBIANS IN HEADWATER SLOPE WETLANDS

Diane Alix and *Christopher Anderson*
School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL, USA

Wetlands are valuable ecosystems worldwide and alterations to their function can have drastic effects, particularly on wildlife. Land use change (urbanization specificly) can impact wetland habitat by altering hydrology, isolating populations, reducing adjacent habitat, and increasing pollutant exposure. Amphibian populations may be particularly susceptible to these land use changes and habitat alterations. Amphibians are often considered environmental indicators of wetland condition because of their ties to water and their sensitivity to environmental change. In 2011, we initiated a study to examine the role of surrounding land use change on headwater slope wetlands in south Alabama. A total of 15 headwater wetlands were selected along an urban-rural gradient representative of the region. For each wetland, urban land use was measured in its drainage catchment by using GIS to determine percent forest cover, road density, and percent impervious surface. Potential hydrologic changes related to land use were evaluated using water level recorders. Amphibians were sampled in each wetland at different seasons using a combination of constrained area searches (to target frogs and salamanders) and automated recording devices (to detect calling anurans). Species and taxa occurrence (including those considered sensitive such as salamanders from the family Plethodontidae) were examined across the urban-rural gradient. For each species detected, incidence of presence/absence was examined along the urban-reference gradient (using both impervious surface/road density and forest cover). Water level data from each wetland were used to help interpret the role of hydrologic alterations caused by land use. Through preliminary data, we identified trends related to amphibian occurrence and measures of land use change.

Contact Information: Diane Alix, School of Forestry and Wildlife Sciences, Auburn University, 602 Duncan Drive, Auburn, AL 36849, USA, Phone: 860-324-4855 Email: dma0012@auburn.edu

LAND-USE EFFECTS ON CARBON CYCLING AND HYDROLOGIC FUNCTION IN ALABAMA HEADWATER WETLANDS

W. Flynt Barksdale and *Christopher J. Anderson*
Auburn University, School of Forestry and Wildlife Sciences, Auburn, AL, USA

Headwater wetlands provide crucial societal values due to their natural ability to provide water quality, flood control, carbon sequestration, and important habitat. These systems have not been extensively studied in relation to land use change and their values are often unrecognized by local landowners and planners. Observations in southern Alabama indicate that wetlands surrounded by urban land use may experience an altered hydrology and associated functions. A study was initiated in 2010 to examine how surrounding urban land use may change the capacity of headwater wetlands to cycle carbon and store water. A total of 15 wetlands in Baldwin County, Alabama were selected across an urban gradient using measures of percent forest cover (16-100%), and percent impervious surface (0-24%) within each catchment. Carbon cycling was monitored in each wetland for over one year using measures of leaf litter production, soil carbon storage, and hydrologic export. Water levels, surface water runoff, and overall hydroperiod were monitored at each wetland using water level recorders. Early indications suggest that increasing urban land use is correlated with declines in wetland function. Urban wetlands show evidence of increasing surface water runoff and reduced water storage. Hydrologic response to discrete precipitation events has shown that wetlands tend to be flashier based on calculated Richard-Baker index and other indices. Early results also suggest that hydrologic export may be important output of carbon in more urbanized wetlands. The study will provide crucial Information to aid planners to better protect these important systems and minimize the negative effects of urbanization.

Contact Information: W. Flynt Barksdale, School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL 36849, USA, Phone: 334-844-8071, Email: barkswf@tigermail.auburn.edu

URBAN WETLANDS: PROPAGULE BANKS IN AQUATIC WETLAND ECOSYSTEMS: DISTURBANCES AS A KEY PROCESS

Gudrun BORNETTE[1], *Wei LI*[2] and *Florent ARTHAUD*[1]

[1]Université de Lyon, UMR5023 Ecologie des hydrosystèmes naturels et Anthropisés, Université Lyon, Lyon, France

[2]Laboratory of Aquatic Plant Biology; Wuhan Botanical Garden; The Chinese Academy of Sciences, Wuhan, Hubei, P. R. China

Disturbances are events that destroy at least partly plant communities, and are considered to favour a ruderal strategy. In aquatic habitats, ruderal plants may be short lived and produce abundant seeds. However, aquatic plants are atypical among herbaceous plants in the way they also propagate very efficiently through fragmentation and dispersion of dormant buds or apices. First, the talk investigates, on the basis of our own results and other studies, what kind of dispersal structure is favoured depending on the nature of the disturbing event, and its potential effect on spatial dispersal and regeneration niches. Second, it presents the consequences of such characteristics for propagule abundance in the bank, and the involvement of propagule banks in community resilience after disturbances. In a second step, we aim to propose the first elements of a model that combine the majors kinds of disturbances that occur in aquatic wetlands to propagule bank content and abundance, and the relationships between the propagule bank and the established vegetation.

Contact Information: Gudrun BORNETTE, Université de Lyon, UMR5023 Ecologie des hydrosystèmes naturels et Anthropisés, Université Lyon 1, ENTPE, CNRS, ISARA, 6, rue Raphael Dubois, 69622 Lyon, France, Phone: 33472431294, Email: gbornett@univ-lyon1.fr

ECOSYSTEM SERVICES AND EDUCATIONAL OPPORTUNITIES PROVIDED BY AN ARIDLAND URBAN TREATMENT WETLAND IN PHOENIX AZ

Daniel L. Childers and *Laura Turnbull*
School of Sustainability and Global Institute of Sustainability, Arizona State University, Tempe AZ, USA

Wetlands being used to treat wastewater effluent are expected to provide the ecosystem service of nutrient and contaminant uptake. Treatment wetlands in hot, arid climates also loose considerable water via transpiration and evaporation, particularly during the hot, dry growing season. This water loss may evapoconcentrate the nutrients and solutes that the wetland ecosystem is expected to process and sequester, perhaps making it more difficult for the system to provide desired ecosystem services. To address this potential challenge, we have been measuring a number of ecosystem-level parameters—including plant production, transpiration, evaporation, nutrient retention, and evapoconcentration—in a constructed treatment wetland at the City of Phoenix' Tres Rios Wastewater Treatment Plant since June 2010.

Summer plant biomass typically exceeded a total of 3 kg dry weight m^{-2} for the six dominant species (2 species of *Typha* and 4 species of *Schoenoplectus*); *Typha* biomass made up more than 90% of this total. Transpiration rates were highest during the hot summer months (typified by daytime high temperatures over 45°C and humidity as low as 2%), when the plants were responsible for a water loss rate equivalent to 4 – 6 cm water depth day^{-1} across the entire 100 ha wetland system. Water samples collected along 10 sampling transects in the wetland showed average declines in inorganic nitrogen concentrations, from the water's edge to the interior of the vegetation, of 73% and 80% for ammonium and nitrate+nitrite, respectively, while changes in soluble reactive phosphorus concentrations were not significant. Chloride content increased an average of 15% along these same transects, suggesting that evapoconcentration of solutes is occurring within the vegetated portions of the treatment wetland. In spite of this, the wetland vegetation and soils appear to be sequestering—and presumably transforming—large amounts of nitrogen but little phosphorus. Our next steps will include quantifying water and nutrient budgets, once we have a full year of data and mechanistic quantification of key biogeochemical processes in the soils, such as dentrification.

Our project at the Tres Rios treatment wetland is an example of another valuable opportunity that urban wetlands afford us: Education. Because urban wetlands are located in cities, they are also typically close to schools and universities, which make access easy. This allows us to use urban wetlands as field educational laboratories. Our Wetland Ecosystems Ecology Lab group at Arizona State University is doing exactly this, through our close interactions with the Central Arizona-Phoenix LTER Program. The research we present here has been carried out, even led, by undergraduate and graduate students under the guidance of a postdoctoral researcher (Turnbull) and faculty member (Childers). In Summer 2012, we will expand this team to include high school student researchers. The Tres Rios urban wetland is thus an excellent field collaboratory where students at multiple educational levels are learning how to conduct field research, how to work collaboratively, and how to mentor each other. We argue that urban wetlands, in general, should more frequently be asked to perform this valuable educational service.

Contact Information: Daniel Childers, Arizona State University, 800 South Cady Mall, Tempe, AZ 85287, United States, Phone: 480-965-2320, Email: dan.childers@asu.edu

ENHANCING URBAN WETLAND BIODIVERSITY BY REDUCING TRADE-OFFS BETWEEN MULTIPLE ECOSYSTEM SERVICES

Jenny Davis

Australian Centre for Biodiversity and School of Biological Sciences, Monash University, Clayton, Victoria, Australia 3800

Relationships between the multiple ecosystem services provided by natural and constructed urban wetlands in southeastern Australia were investigated to improve the ability to manage trade-offs and synergies related to biodiversity support. Many naturally occurring wetlands within the region have been lost or altered through draining and infilling for urban development. However, novel ecosystems have arisen through the construction of artificial wetlands on urban streams. These artificial systems are primarily designed to intercept nutrients in urban runoff for the protection of downstream estuarine and marine ecosystems. All wetlands (both natural and constructed) also provided biodiversity support and aesthetic amenity. During a recent decadal length drought only the constructed wetlands contained permanent water throughout the drier summer months. These systems acted as biotic refuges for waterbirds, turtles, fishes and aquatic invertebrates. Constructed wetlands also displayed higher nutrient concentrations, elevated levels of heavy metals and greater numbers of invasive fishes. Accordingly, the trade-offs between the ecosystem services provided by urban wetlands appeared to be greater for constructed than naturally occurring wetlands. However, the potential to enhance biodiversity support by maximizing the synergies between multiple ecosystem services was also greater in constructed urban wetlands.

Contact Information: Jenny Davis, School of Biological Sciences, Wellington Road, Monash University, Clayton, Victoria, Australia 3800, Phone: +61 3 9905 1063, Email: Jenny.Davis@monash.edu

CARBON STORAGE AND SEQUESTRATION BY URBAN WETLAND FORESTS IN ORLANDO, FLORIDA, USA

Edem K. Ekpe[1], *C. Ross Hinkle*[1], *K. Elizabeth Becker*[1] and *Francisco Escobedo*[2]
[1]Department of Biology, University of Central Florida, Orlando, FL, USA
[2]School of Forest Resources and Conservation, University of Florida, Gainesville, FL, USA

Urban wetlands provide ecosystem services such as flood control, groundwater replenishment, water purification, biodiversity reservoirs, and climate change mitigation and adaptation. Climate change mitigation and adaptation services are largely provided through carbon storage and sequestration. We assessed the structure and composition of the urban forests in Orlando, Florida, USA during the summer of 2010. Based on that assessment, we estimated the carbon storage and sequestration by the wetland forests in Orlando using the Urban Forest Effects (UFORE) model of the United States Department of Agriculture. We estimated the values of these ecosystem services using a central value of the social costs of carbon ($77.07/ton of carbon) used by the Interagency Working Group on Social Cost of Carbon of the United States Federal Government. For the purposes of this study, we defined wetlands as areas that are always or often inundated by water, and have persistent tree and/or shrubs vegetation characteristic of hydric soils.

An estimated 11% of the city's land cover was classified as wetlands while 73.5% of the wetlands were forested. Approximately 3.7 million trees (49% of trees) were in wetland forests. Tree density in wetland forests was about 1,291 trees per hectare. The most abundant species was pond cypress (*Taxodium ascedens*). Urban wetland forests were estimated to store 99 tons of carbon per hectare. Total carbon storage in wetland forests was about 284,900 tons or about 40.4% of carbon stored by all forest types combined. We estimated net carbon sequestration in wetland forests to be approximately 5.72 tons per hectare per year. Annual total of carbon sequestered by wetland forests was 16,279 tons per year. This was 46% of carbon sequestered by all urban forests combined. The carbon stored by the wetland forests in Orlando, FL provided services worth about $22 million dollars. Carbon sequestered by wetland forests provided services worth about $1.25 million dollars per year.

This study indicated that urban wetland forests in Orlando, FL stored and sequestered a higher proportion of carbon compared to other land cover types. The value of these ecosystem services provided by urban wetland forests is important to the city as a climate change adaptation strategy to offset carbon release. These results provide justification for the conservation of wetlands as an integral part of the city's strategic planning for future development.

<u>Contact Information</u>: Edem K. Ekpe, Department of Biology, University of Central Florida, 4000 Central Florida Blvd, Orlando, FL, USA, Phone: 407-823-2954, Fax: 407-823-5769, Email: edemekpe@knights.ucf.edu

CONCEPTUAL MODEL OF HABITAT RESTORATION FOR GOBIES IN TOKYO BAY, JAPAN

***Keita Furukawa**, Tomonari Okada, Satomi Kamimura* and *Jun Yoshida*
National Institute for Land and Infrastructure Management, Yokosuka, Kanagawa, Japan

Tokyo Bay is an enclosed, mostly populated, and intensively used bay in Japan (Furukawa and Okada, 2006). The inner bay catchment area has a total population of some 25 million. The concentration of population and industries in the catchment area of Tokyo Bay has brought remarkable changes to its coastline. Surrounded tidal-flats have been reclaimed by land fill, and only few natural tidal flat are remaining (98% of coastal line are covered by constructed structures). Furthermore, water quality of the bay is degraded (frequent red-tides, several times anoxic water upwelling and occasional fish kill are occurred by eutrophication).

Goby (*Acanthogobius flavimanus*) has nest in soft saline bed in 6-8m deep water in winter, and hatched larvae swim up to upstream limit of estuarine environment and settle on sandy shallow bed in spring. It becomes 6-8cm in early summer and growing up to 15-20cm in autumn. These seasons are ideal for easy fishing for public. Most of senior residents not only Tokyo bay, but also almost all around Japan, had experience of goby fishing in childhood. So, it can be said as one of vanishing culture for coastal residents in Japan.

Preliminary census for Gobies shows possibility of limitation, degradation and discretization of coastal habitats for Gobies. Some river mouth is serving marginal habitat of Gobies. Nevertheless, bay side of the habitat is affected by hypoxic water intrusion from bottom layer. Furthermore, in the canal network that is remaining water bodies of tidal-flats that reclaimed, life cycle of Gobies seems to be adopted by discretized environment. Some of them are not having marginal habitat, but they stay in the same place for long period.

Under these circumstances, conceptual model for the habitat restoration work is proposed. One part of the model is a construction of a small scale habitat in canal network. That is one of typical hardware type countermeasures. The effects of the construction have been tested by monitoring at constructed tidal-flats. It seems tidal-flats are acting as considerable habitat for Gobies. Nevertheless, amount of served Gobies are not enough to keep their population in high number since big pressure of fishing. It derives other part of the model, i.e. population management with minimum body size limit to the fishing. Using a normalized body size fraction in the targeted area, relative number of group can be conserved by setting appropriate threshold.

Contact Information: Keita Furukawa, Research Coordinator for Coastal and Marine Affaires, National Institute for Land and Infrastructure Management, Nagase 3-1-1, Yokosuka, Kanagawa, Japan, Phone: 81-46-844-5026, Fax: 81-46-844-1145, Email: furukawa-k92y2@ysk.nilim.go.jp

THE DYNAMICS OF SPECIES-RICH MEADOWS ON UK FLOODPLAINS

David Gowing

Open University, Milton Keynes, U.K.

The hydrology of European floodplains is increasingly regulated to provide ecosystem services, such as flood defence, water-supply, agricultural production and navigation. The water-regime of the alluvial soil on the floodplain is the dominant factor determining the species richness, diversity and composition of many habitats such as meadows. It is therefore necessary to consider the requirements of natural habitats when designing and managing water levels in these environments.

This paper describes an analysis of long term data sets from UK floodplains, which describe the response of vegetation to changing hydrology and the need for variability in the regime to allow some species to regenerate. There is a risk that over-regulating water levels will exclude the “extreme” events that are necessary for the maintenance of dynamism and diversity in floodplain habitats, which are a highly valued component of the British landscape. Our research has identified the need to monitor vegetation at fixed points in the floodplain, rather than through random sampling, because the variation due to spatial factors is so high. We survey vegetation at over one thousand fixed locations each year to identify the forces driving plant-community dynamics. One important output has been a measure of the lag-time between the driving event and the vegetation response, which has implications for how vegetation-monitoring data should be interpreted.

The interface between water levels and community composition is the soil itself. The porosity of soil is highly dependent on its structure and therefore conserving soil structure is an important aspect of managing floodplains for biodiversity. When structural pores are lost, it often becomes impossible to manage water levels in a way that suits target vegetation types. Conservation managers therefore need to understand not only the water-regime requirements of their target vegetation, but also the hydraulic properties of their soil if they are going to conserve or create habitats effectively.

Contact Information: David Gowing, Department of Environment, Earth and Ecosystems, Open University, Walton Hall, Milton Keynes MK7 6AA, U.K. Tel: +44 1908 659468, E-mail: d.j.gowing@open.ac.uk

CONTRASTING URBAN AND NATURAL WETLANDS IN SOUTH-CENTRAL NEW YORK

Rebecca L. Heintzman*, Megan A. Larson, John E. Titus* and *Weixing Zhu*
SUNY Binghamton, Binghamton, NY, USA

Urban ecosystems are becoming more common as urbanization increases globally. Urban wetlands are expected to exhibit vegetation and biogeochemical differences in comparison to wetlands in natural settings. This study examines selected differences between urban and natural wetland ecosystems in south-central New York, with particular focus on species richness and invasive species.

Twenty-six wetlands were surveyed over the summers of 2010 and 2011. Eighteen natural wetlands comprised three categories (Emergent, Scrub/Shrub, and Forested) and the remaining eight wetlands were urban. Vegetation, soil chemistry, and water chemistry data were collected.

Urban wetlands had significantly lower species richness than the three natural wetland categories (range of richness: 21-76; $p=0.001$, ANOVA with Tukey multiple comparison). They also had significantly higher soil electrical conductivity (range: 23-242 $\mu S\ cm^{-1}$, $p<0.001$) and soil pH (range: 4.42-7.52, $p<0.001$), and lower net N-mineralization rates (range: -0.73-1.82 $mg\ kg^{-1} day^{-1}$, $p=0.003$). Urban wetlands displayed greater cover of OBL species (range: 23-52%, $p=0.002$) and reduced cover of FACU species (range: 0-30%, $p=0.023$) as compared to forested natural wetlands. This suggests that urban wetlands experience more prolonged hydroperiods characteristic of emergent, and some scrub/shrub, wetlands.

Species richness was negatively correlated with % cover of invasive species (range: 0-69%, $r= -.47$, $p=0.015$), soil pH ($r= -.48$, $p=0.014$), soil electrical conductivity ($r= -.49$, $p=0.014$), and 'concentration of dominance' ($r= -.51$, $p=0.008$), but positively correlated with net N-mineralization rate ($r= .49$, $p=0.011$). Concentration of dominance was calculated as the sum of relative % cover for the top three ranked species in each site, and ranged from 32% to 90%.

Reduced species richness in urban wetlands appears to be a function of concentration of dominance, particularly in invasive species. We hypothesize higher invasive and dominance levels are due to biogeochemical factors, such as increased soil electrical conductivity in urban wetlands.

Contact Information: Rebecca L. Heintzman, Department of Biological Sciences, SUNY Binghamton, Binghamton, NY, 13902, USA; Phone: 607-777-2445; Fax: 607-777-6521; Email: rebecca.heintzman@gmail.com

COLONIZATION AND SUCCESSION IN RESTORED WET GRASSLANDS: LESSONS FROM LONG-TERM EXPERIMENTS

Norbert Hölzel

University of Münster, Germany

When first restoration projects in wet grassland started in Western and Central Europe during the 1970s and 1980s, abiotic site conditions such as hydrology and nutrient status as well as adequate management were considered to be major constraints to reestablish former biodiversity. However the experience of the last 30 years has shown that even after successful rewetting, lowering of productivity and the implementation of a proper management desired target communities and species did reestablish. Based on these experiences the lack of viable propagules in the seed bank and dispersal limitation of target species were identified as further crucial obstacles to the restoration of former biodiversity. To overcome these limitations, starting in the 1990s, the introduction of target species or even entire communities via seed addition or hay transfer was increasingly used as a supplementary. Such measures often proved to particularly successful especially when they were combined with other methods such as topsoil removal to reduce nutrient availability and competition by established vegetation. In my talk I will present data from wet grassland restoration projects monitoring the effects of various restoration measures for relatively long periods of 15 to 20 years. The results show that strong and divergent dynamics may be triggered by different restoration techniques and changes in management such as the cessation of fertilizer application, reduction of mowing frequency or the introduction of species with hay. In many cases, even after 20 years, restoration measures and alteration of management did not result in stable stages and there was still a directed ongoing change in vegetation composition. It is concluded that only long-term studies offer the opportunity to gain sound and profound insights in the factors and processes that determine successional pathways in ecological restoration. Restoration projects can and should be increasingly utilized as a test of ecological theory.

Contact Information: Norbert Hölzel, Working Group Ecosystem Research, Institute of Landscape Ecology, University of Münster, Robert-Koch-Str. 28, D-48149 Münster, Tel: ++49/(0)251/8333994, Fax: ++49/(0)251/8338338, Email: nhoelzel@uni-muenster.de

MITIGATION OF PESTICIDES AND COPPER IN A STORMWATER WETLAND RECEIVING RUNOFF FROM A VINEYARD CATCHMENT

Gwenaël Imfeld and *Elodie Maillard*
Laboratory of Hydrology and Geochemistry of Strasbourg (LHyGeS), University of Strasbourg/ENGEES, Strasbourg Cedex, France

Wetlands can collect contaminated runoff from agricultural catchments and have intrinsic physical, chemical and biological processes useful for mitigating pesticides. However, knowledge about the ability of wetlands to mitigate pesticide mixtures in runoff is currently very limited. In addition, little Information exists on benthic macroinvertebrates communities in wetlands that receive pesticide-contaminated runoff. Our results show that stormwater wetlands that primarily serve for flood protection can also be effective tools for reducing concentrations and loads of runoff-related pesticides. Concentrations and loads of 20 pesticides and degradation products, as well as copper were continuously recorded during the period of pesticide application (April to September 2009, 2010 and 2011) at the inlet, the outlet and in sediments of a stormwater wetland that collects runoff from a vineyard catchment. In parallel, we assessed in the stormwater wetland the temporal changes in the macroinvertebrates.

Removal rates of dissolved loads ranged from 39% (simazine) to 100% (cymoxanil, gluphosinate, kresoxim methyl and terbuthylazine). Dimethomorph, diuron, glyphosate and metalaxyl were more efficiently removed in spring than in summer. More than 77% of the input mass of suspended solids was retained, underscoring the capability of the wetland to trap pesticide-laden particles. Only flufenoxuron was frequently detected in the wetland sediments. An inter-annual comparison showed that changes in the removal of aminomethylphosphonic acid (AMPA, a degradation product of glyphosate), isoxaben or simazine can be attributed mainly to the larger vegetation cover in 2010 compared to 2009. More than 80% of the copper load entering the wetland was retained in the sediments and the plants. Our results demonstrate that stormwater wetlands can efficiently remove pesticide mixtures and copper in agricultural runoff during critical periods of pesticide application. Nevertheless, fluctuations in the runoff regime, as well as the vegetation and hydrochemical characteristics affect the removal rate of individual pesticides and copper.

Concentrations of the insecticide flufenoxuron ranged from 1.5 to 18.5 µg/kg in runoff suspended solids, reached 6 µg/kg in the wetland sediments, whereas concentrations remained under the detection limit in the aqueous phase. Tough 40 different macroinvertebrate taxa were found in the wetland, the density, diversity and abundance of macroinvertebrates largely varied over time. Multivariate statistical analysis revealed that concentrations of flufenoxuron and metalaxyl, vegetation cover as well as flow conditions were factors that determine significantly the macroinvertebrate community structures. This study notably highlights the potential impact of flufenoxuron-contaminated runoff and wetland characteristics on macroinvertebrate communities in stormwater wetlands that collect contaminated runoff.

Contact Information: Gwenael Imfeld, Laboratory of Hydrology and Geochemistry (LHyGeS), University of Strasbourg/ENGEES, CNRS, 1 rue Blessig, 67084 Strasbourg Cedex, France, Phone: + 333-6885-0407, Email: imfeld@unistra.fr

INORGANIC NITROGEN DYNAMICS IN AN URBAN CONSTRUCTED WETLAND UNDER BASE FLOW AND STORM FLOW CONDITIONS

Miranda Kearney[1], *Weixing Zhu*[1] and *Joseph Graney*[2]

[1]Department of Biological Sciences, State University of New York at Binghamton, Binghamton, NY, USA

[2]Department of Geological Sciences, State University of New York at Binghamton, Binghamton, NY, USA

In urban landscapes constructed wetlands are often used to treat wastewater. These systems have been shown to decrease nitrogen (N) pollution and improve water quality. However, many studies focus just on N reduction under baseflow conditions. In light of the continued impact of climate change on the frequency and intensity of storms, it is becoming increasingly critical to understand how these systems function during storm events as well as under baseflow conditions.

Our research focused on N dynamics in an urban constructed wetland located on the State University of New York, Binghamton campus. From 2007-2011, during baseflow conditions, we collected weekly to monthly grab samples along the flow path from the inlet to the outlet of the wetland, except some winter months. Discharge was calculated for baseflow using several methods: automated stage height measurements using data loggers; manually measuring the height of the water over weirs at the inlet and outlet; and constructing area weighted cross-sections using a hand-held flow meter. From July 2010 through March 2011, we used two ISCO automated samplers to collect water samples and stage measurements near the weirs during storm events. In the lab, all water samples were analyzed for inorganic nitrogen (IN: NO_3-N and NH_4-N). A mass balance input and output budget was calculated by multiplying concentration and discharge values for each sampling event and averaging them to calculate mean monthly fluxes.

Under baseflow conditions, the wetland significantly reduced IN concentrations between the inlet and the outlet in all sampling years (2007-2008; 2008-2009; 2009-2010; 2010-2011) and for the spring, summer, and autumn seasons, but not during the winter. With increasing distance from the inlet, during 2007-2008, 2008-2009, and 2009-2010, IN concentrations were reduced linearly (R^2 = 0.88, 0.96 and 0.95, respectively). In terms of IN flux, 2007-2008 was the only sampling year where the wetland functioned as a net N source (5.29 kg N entered and 11.19 kg N exported). However, over the entire four-year sampling period, 41% of the N entering the wetlands was removed. In contrast, the wetland removed N in only three of the nine storm events sampled and overall, N export was 13% greater than the input.

Our results show that during baseflow, the constructed wetland was capable of reducing N load from urban sources. However, it had a limited ability to reduce N during storm events. Thus, future climate change scenarios could alter the N reduction capacity of urban constructed wetlands.

Contact Information: Miranda A. Kearney, 1Department of Biological Sciences, State University of New York at Binghamton, Binghamton, NY, 13902 USA, Email: MKearne1@binghamton.edu

REPRODUCTION, DISPERSAL, EMERGENCE, AND ESTABLISHMENT OF *PHRAGMITES AUSTRALIS* IN DISTURBANCES IN CHESAPEAKE BAY TIDAL WETLANDS

Karen M. Kettenring [1,4], *E.L.G. Hazelton*[1,4], *S.K. Gallagher*[2,4], *H.M. Baron*[3,4], *M.K. McCormick*[4], *M. Sievers*[4,5] and *D.F. Whigham*[4]

[1]Utah State University, Logan, UT, USA
[2]University of Wisconsin and Wisconsin Department of Natural Resources, Madison, WI, USA
[3] Oregon State University, Corvallis, OR, USA
[4]Smithsonian Environmental Research Center, Edgewater, MD, USA
[5]Case Western Reserve University, Cleveland, OH, USA

Phragmites australis is one of the most invasive plants in North American wetlands and is widespread in brackish tidal wetlands of the Chesapeake Bay. Here we synthesize results from multiple studies of *Phragmites* reproduction, dispersal, emergence, and establishment in the Chesapeake, particularly as they relate to natural and human-derived disturbances. Genetic studies demonstrate that the expansion of *Phragmites* has mostly been due to the production and dispersal of viable seeds, rather than rhizomes. Most seeds are dispersed locally but long distance dispersal also occurs. The initial establishment of *Phragmites* from seed likely occurs in disturbed sites within or immediately adjacent to wetlands. Disturbances that occur due to anthropogenic activity are typically the result of marsh vegetation removal for the construction of shoreline features or the burial of marsh vegetation by sediment that originated in upland habitats. Natural disturbances also occur within wetlands and are typically smaller. A survey of within-wetland disturbances in four vegetation types revealed that most were linear, likely resulting from deer or human trails. Muskrat feeding activities and nesting sites were also important sources of disturbances. In a field experiment with experimentally created disturbances, seed germination and seedling emergence was substantially higher in disturbances, likely due to higher light and/or temperature, but rhizome sprouting was not affected by disturbances. However, when established seedlings were transplanted into disturbed and undisturbed areas, there was no effect of disturbance on survival. We conclude that disturbances are critical for seed germination and the very earliest stages of establishment but are less important for the long-term survival of seedlings. The emergence of presumably genetically distinct seedlings from disturbances also has consequences for the ability of stands to perpetuate themselves. *Phragmites* requires multiple genotypes for successful cross pollination and viable seed production, although genetic diversity within stands appears to decline with age and may affect seed reproduction. This feedback between seedling emergence, increased genetic diversity, and higher viable seed production also has implications for restoration. We are currently testing the hypothesis that the removal of *Phragmites* may facilitate its spread. Removal of *Phragmites*, a form of habitat disturbance, may create optimal conditions for *Phragmites* seedling emergence from the seed bank, which would increase local levels of genetic diversity and stand-level viable seed production. While the suite of studies that we have conducted demonstrate the importance of disturbances to *Phragmites* invasion, the large number of patches that occur in areas where no obvious disturbance has occurred suggests that other processes also play a key role in *Phragmites* establishment. Our ongoing research continues to focus on the mechanisms responsible for *Phragmites* invasion in disturbed and undisturbed areas.

Contact Information: Dr. Karin M. Kettenring, Department of Watershed Sciences and Ecology Center, Utah State University, 5210 Old Main Hill, Logan, UT, 84322, USA; Phone: 435.797.2546; Email: karin.kettenring@usu.edu

SIMILARITY BETWEEN THE STANDING VEGETATION AND SEED BANK VARIES AT TWO SPATIAL SCALES IN AN URBAN RETENTION WETLAND

Megan A. Larson and *John E. Titus*
SUNY Binghamton, Binghamton, NY, USA

Few studies compare the characteristics of seed banks and standing vegetation of urban wetlands, yet this Information may have important implications for management practices. To compare the seed bank and standing vegetation in a constructed retention wetland located on the Binghamton University campus (Vestal, NY, USA; 0.15 ha), we collected sediment cores in May 2011 from five quadrats on each of three equally spaced transects perpendicular to the main axis of the wetland. Seedling emergence from this sediment was monitored in the greenhouse for 6 months with both drawdown and flooded conditions. In June 2011, percent cover of plant species in the standing vegetation was recorded to the nearest 5% in the same 1 m^2 quadrats.

.

Thirty seven species emerged from the seed bank, while 24 were observed in the standing vegetation. Based on relative density, the three most dominant species arising from the sediment were *Leersia oryzoides* (34.8%), *Alisma triviale* (18.8%), and *Lemna minor* (13.3%). The three most dominant species in the vegetation survey, based on relative percent cover, were *Myosotis scorpioides* (18.0%), *Typha* spp. (17.7%), and *Leersia oryzoides* (13.6%).

Sørenson's similarity index comparing the flora of the seed bank and the standing vegetation for all 15 quadrats collectively was 0.459 – a relatively modest figure, but well within the range reported from comparable studies. However, the similarity index at the plot level (n=15) decreased as the number of species in the seed bank increased ($r = -0.608$, $p<0.05$). Further analysis suggests that this correlation results from (a) dominance patterns of *Typha* spp. in the standing vegetation, and (b) a significant decrease in the species richness of the seed bank as distance from the inlet increased (t-test, $p<0.05$). The settling of seeds entering the wetland via the inlet could account for this latter trend.

Evaluating characteristics of seed banks and standing vegetation at different spatial scales has provided insight into important processes in urban wetlands.

Contact Information: Megan A. Larson, Department of Biological Sciences, SUNY Binghamton, P.O. Box 6000, Binghamton, NY 13902, USA; Phone: 607-777-2445; Fax: 607-777-6521; Email: mlarson2@binghamton.edu

DISPERSAL POTENTIAL OF A TIDAL RIVER: COLONIZATION OF A CREATED TIDAL FRESHWATER MARSH ON THE DELAWARE RIVER, USA

Mary Allessio Leck
Rider University, Lawrenceville, NJ, USA

The 32.3 ha created mitigation wetland, adjacent to the Delaware River, was completed late in 1994. Stockpiled soils were not used and only 14 macrophyte species were planted. Three marsh sites, with differing completion dates, and three locations, relative to tidal channels, were sampled. Between 1995 and 1999 seed bank and vegetation surveys permitted a view of initial species dynamics involving both seed density or cover and species richness. Vegetation surveys were continued through 2011, and in 2011 a seed bank survey was also undertaken.

During the first five years, 177 species emerged from seed bank samples, with a maximum of 32.3 ±1.8 /sample; six species were added by 2011 samples. Early samples contained 65 (1995) to 116 (1998) total species. In 2011, there were 61 with a maximum of 12.0 ±1.1 species /sample. Comparing species richness across three sites for mid locations, 1999 total species and species /sample were higher (27-60%, 33-57% respectively) than 2011 values. In vegetation plots during the first five years, 72 cover species were present. In 2011, there were 49; of these 14 were new and the majority (13) were woody and occurred in upland edge plots under a woody canopy. In 2011 only *Mikania scandens* and *Phragmites australis* had increased in importance, as they had in vegetation plots. Overall, despite continuing importance of some species (e.g., *Lindernia dubia, Ludwigia palustris, Lythrum salicaria*), the trend was toward lower seed bank densities and richness so that by 2011, e.g., at mid point locations, densities and species /sample were lower than 1999 values (69-92%, 37-66%, respectively).

Species varied in persistence in the seed bank and vegetation, and among sites and with location. *Juncus effusus*, e.g., was an important vegetation component in only one site and only in mid and upland edge locations. It declined rapidly from 26-32% in 1995 to 2-2.8% in 1997. It continued to be an important seed bank species and in 2011 was 24-34% of location totals. Initial colonization was influenced by timing of site completion. Vegetation patterns were influenced by inundation, *in situ* seed production, growth form, and vegetation influence on water and seed movement.

Dispersal was primarily via tidal water; even wind-dispersed species were observed moving in or on water. Cyperaceae, with 33 species of five genera, were especially numerous. Eight rare species (NJ State threatened and endangered) occurred either in seed bank or vegetation samples. The single most important change was increase in *Phragmites australis* in the vegetation; by 2010 it was estimated to cover >80% of the entire created wetland. While *Lythrum salicaria*, although common, did not appear to reduce species richness, *Phragmites* has had substantial impact.

Contact Information: Mary Allessio Leck, Department of Biology, Rider University, 2083 Lawrenceville Road, Lawrenceville, NJ 08648, USA, Phone: 732-821-8310, Fax: 609-895-5782, Email: leck@rider.edu

RETENTION OF HEAVY METALS AND POLY-AROMATIC HYDROCARBONS FROM ROAD WATER IN A CONSTRUCTED WETLAND AND THE EFFECT OF DE-ICING

Karin Tromp[1,2], ***Ana T. Lima***[3], *Arjan Barendregt*[4] and *Jos T.A. Verhoeven*[1]

[1]Institute of Environmental Biology, Utrecht University, The Netherlands
[2]Hoogheemraadschap van Delfland, Delft, The Netherlands
[3] Department of Earth and Environmental Sciences, University of Waterloo, Waterloo, Canada
[4]Interfacultary Institute for Risk Assessment Science, Toxicology Division, Utrecht University, Utrecht, The Netherlands

A full-scale remediation facility including a detention basin and a wetland was tested for retention of heavy metals and Poly-Aromatic Hydrocarbons (PAHs) from water drained from a motorway in The Netherlands. The facility consisted of a detention basin, a vertical-flow reed bed and a final groundwater infiltration bed. Water samples were taken of road water, detention basin influent and wetland effluent. By using automated sampling, we were able to obtain reliable concentration averages per 4-week period during 18 months. The system retained the PAHs very well, with retention efficiencies of 90-95%. While environmental standards for these substances were surpassed in the road water, this was never the case after passage through the system. For the metals the situation was more complicated. All metals studied (Cu, Zn, Pb, Cd and Ni) had concentrations frequently surpassing environmental standards in the road water. After passage through the system, most metal concentrations were lower than the standards, except for Cu and Zn. There was a dramatic effect of de-icing salts on the concentrations of Cu, Zn, Cd and Ni, in the effluent leaving the system. For Cu, the concentrations even became higher than they had ever been in the road water. It is advised to let the road water bypass the facility during de-icing periods. At the end of the design liftetime of 25 years, the sediment and filling medium of the facility will have to be sanitized.

Contact Information: Ana T. Lima, University of Waterloo, 200 University Avenue West, Waterloo N2L 3G1, Canada 519-888-4567, Email: atlima@uwaterloo.ca

MITIGATION OF TWO INSECTICIDES BY WETLAND PLANTS: FEASIBILITY STUDY FOR THE TREATMENT OF AGRICULTURAL RUNOFF IN SURINAME

Shirley S. Mahabali, *Walter Steurbaut* and *Pieter Spanoghe*
Ghent University, Department Crop Protection, Ghent, Belgium

In Suriname (South America) a three months study was performed to assess the removal/assimilation of two insecticides e.g. lambda-cyhalothrin and imidacloprid by two plant species common in the research area. The primary goal of this study is to investigate the removal of these pesticides in the water phase of wetland mesocosms under different treatments (addition of high and low target concentrations). The latter related to different application rates applied in the field. Another goal is to assess the uptake of these pesticides by two plants e.g. *Nymphaea ampla* and *Eleocharis interstincta.* The results are also needed decide on which type of plants to use in a field scale wetland (future activity). The study was performed from June to August 2011 at the Anton de Kom University of Suriname.

For this study a total of ten tubs (60cm(L)x30cm(W)x18cm(H)) were used. The tubs were filled (9 cm) with a sand-pot soil mixture (ratio 2:1). Four mesocosm were planted with *Nymphaea ampla* and four with *Eleocharis interstincta,* while two tubs functioned as controls (no addition of pesticides). For each pesticide treatment a total of four tubs were used; two tubs consisting of the same plant. Water was added gradually up till 7 cm above soil. For lambda-cyhalothrin two (2) batches were performed of four weeks each, with a target concentration of respectively10 µg/l and 50 µg/l, added after a two weeks interval. For imidacloprid a total of three (3) batches were performed with a target concentration of respectively 60, 180 and 1000 µg/l. General water quality measurements (pH, Temperature, TDS) were performed and evapotranspiration determined.

For lambda-cyhalothrin comparable results (100 % removal after 72 h) were obtained for both low and high target concentrations for mesocosms planted with *Nymphaea ampla,* while for the *Eleocharis interstincta* mesocosms, a 100 % removal was observed after 48 hours (low target concentration). For mesocosms planted with *Eleocharis interstincta* a 100 % removal was obtained after 216 hours for the low target concentration and 86 % or *Nymphaea ampla* mesocosms. For the highest concentration of imidacloprid the removal was on average 72 % for both plant species. After the experimental period, a mass balance was applied to calculate the uptake by different media (plants, roots and soil).

Contact Information: S. Shirley Mahabali, Department of Crop Protection, Ghent University, B-9000, Ghent, Belgium, Phone: 0032-9-264-6009, Email: s.mahabali@uvs.edu

LINKING UN-HABITAT, THE RAMSAR CONVENTION, URBAN WETLANDS AND ECOSYSTEM SERVICES

R. J. McInnes
RM Wetlands & Environment Ltd, Oxfordshire, UK

The United Nations Human Settlements Programme (UN-HABITAT) is mandated by the UN General Assembly to promote socially and environmentally sustainable towns and cities with the goal of providing shelter for all. The Convention on Wetlands (Ramsar, Iran, 1971), called the “Ramsar Convention”, is an intergovernmental treaty that embodies the commitments of its member countries to maintain the ecological character of their Wetlands of International Importance and to plan for the “wise use”, or sustainable use, of all of the wetlands in their territories. The two organizations have collaborated on developing principles for urban planning and wetlands, resulting in a draft resolution being presented before the Ramsar Conference of Parties in Bucharest in July 2012.

UN-HABITAT has developed this initiative further through an investigation of Urban Biodiversity, Ecosystem Services and Wetlands-Based Adaptation in Cities. Adopting a pressure-state-response (PSR) model as the conceptual and analytical construct an analysis of over 50 urban case studies from across the world has been conducted. Each case study has been characterized using metrics on economic development, governance, regional distribution and freshwater biodiversity. A series of response options have been identified which address a range of pressures, including inter alia habitat fragmentation, deforestation, unplanned settlements and poor spatial planning. Planned and serendipitous ecosystem services have been identified for the response options. In order to understand how the effects of response strategies and the ecosystem services they deliver vary among different social, political and economic contexts the analysis evaluated the difficulty in capturing market and non-market values and incorporating them into decision-making and how this influenced the choice of response option.

This paper will demonstrate how collaborative working between international organizations, underpinned by scientific studies, can develop strategies and guidance for implementation in cities where human demand is greatest and wetlands continue to be degraded and lost.

Contact Information: R. J. McInnes, RM Wetlands & Environment Ltd, Ladman Villas, Littleworth, Oxfordshire, SN7 8EQ, UK, Phone: +44 (0)1367 248081, Email: rob@rmwe.co.uk

MICROBIAL PROCESSES IN CONSTRUCTED TIDAL WETLANDS FOR REMOVAL OF NITROGEN FROM URBAN WASTEWATERS

Aaron L. Mills[1], *Eric Lohan*[1,2], *Joseph Battistelli*[1] and *Kristina Reid-Black*[1,2]
[1]University of Virginia, Charlottesville, VA, USA
[2]Living Machine Systems, L3C, Charlottesville, VA, USA

The use of constructed tidal wetlands in urban and suburban locations has led to the internal recycling of wastewater generated by building inhabitants to provide reuse water for sanitary and cooling purposes for the facility (500+ inhabitants) resulting in a 75% reduction in water use. The tidal system results in enhanced nitrogen removal such that influent total nitrogen (TKN) concentrations of 160 mg/L are reduced to 2.2 mg/L effluent concentrations. Microbial nitrogen removal processes, particularly nitrification and denitrification are enhanced in tidal systems because of the alternating aerobic-anaerobic conditions contained in a single vessel. Laboratory examinations of pilot scale reactors demonstrated a maximum accumulation of both nitrifying organisms (both ammonia and nitrite oxidizing bacteria) and total bacteria (within which the nitrifiers and denitrifiers are contained) just above the vertical midpoint of each reactor, regardless of the amount of nitrogen loaded. Similar maxima were not seen in reactors operated as intermittent trickling filters. When the rate of water cycling was changed (i.e., filling and draining), longer cycle times resulted in increased nitrogen removal. Bacteria capable of anammox (anaerobic ammonium oxidation to dinitrogen) were observed at low levels in all reactors, but the numbers were insufficient to indicate any substantive contribution to the observed nitrogen removal.

The results suggest that tidal-flow reactors represent an improvement in the efficiency of nitrogen removal as compared with conventional single-cell wetlands, and certainly over wetlands operated similarly to trickling filters. Examination of the microbial dynamics within the wetlands provides a base of Information for further improvement in the efficiency of the constructed wetlands.

Contact Information: Aaron Mills, Laboratory of Microbial Ecology, University of Virginia. P.O. Box 400123, Charlottesville, VA 22904-4123, USA, Phone 434.924.0564, Email: amills@virginia.edu

CARBON EXPORT AND BUDGET OF CREATED WETLANDS: IMPORTANCE OF HYDROLOGY

Evan J. Waletzko and ***William J. Mitsch***
The Ohio State University, Columbus, OH, USA

Detailed carbon budgets were created for two 1-ha flow-through riverine created wetlands at the Olentangy River Wetland Research Park at The Ohio State University, Columbus. For two years, measurements were taken of dissolved non-purgeable organic carbon (NPOC), dissolved inorganic carbon (DIC), fine particulate organic matter (FPOM), and coarse particulate organic matter (CPOM). Methane emissions, soil sequestration, aquatic primary productivity, and macrophyte above ground net primary productivity were estimated as well. The carbon budget successfully balanced carbon inputs (1838 ± 41 g C m^{-2} yr^{-1}) and exports (1804 ± 59 g C m^{-2} yr^{-1}) with only 1.8 % of the estimated inputs unaccounted for. FPOM and CPOM concentrations and exports positively correlated with hydrologic flow under most circumstances; NPOC and DIC concentrations are either negatively or poorly correlated with hydrologic flow under most circumstances, probably due to dilution. In all seasons except winter the combined carbon concentration export of NPOC, DIC, FPOM, and CPOM increases with increased hydrologic flow. Although carbon concentrations increase from inflow to outflow the total surface water export of carbon is less than the inflow due to groundwater recharge from the wetlands.

Contact Information: William J. Mitsch, The Olentangy River Wetland Research Park, The Ohio State University, 352 West Dodridge Rd., Columbus, OH 43202 USA, Phone: 614-292-9774, Email: mitsch.1@osu.edu

NUTRIENT AND SEDIMENT CYCLING AND RETENTION IN URBAN FLOODPLAIN WETLANDS

***Gregory B. Noe**, Cliff Hupp, Nancy Rybicki, Ed Schenk* and *Jackie Batson*
National Research Program, U.S. Geological Survey, Reston, VA, USA

Floodplain wetlands are critical locations in landscapes for retaining river nutrient and sediment loads. However, little is known about the water quality functions of urban floodplains. Here we report on the role of floodplains in the retention and cycling of phosphorus (P), nitrogen (N), and sediment in Difficult Run, an urban Piedmont watershed (151 km^2) in Virginia, USA. We used a budgeting approach to quantify fluxes of material between the stream and floodplain (floodplain sedimentation and bank erosion) and internal floodplain cycling (sedimentation, soil mineralization, plant uptake). Our hypotheses were that material fluxes would vary as a function of floodplain hydrologic connectivity (laterally and longitudinally), flood subsidy of material would stimulate internal floodplain biogeochemical cycles, and that floodplains would be a net sink of nutrients and sediment. Flux rates (g m^{-2} yr^{-1}) were measured over a three year period in three lateral geomorphic zones at each of six sites arranged longitudinally from the headwaters to the mouth of the watershed (34 plots total), representing gradients in potential hydrologic connectivity.

Greater inputs of N and P from sedimentation stimulated total vegetative N and P uptake fluxes, in particular by herbaceous plants (α=0.05). Locations with greater inputs of P from sedimentation also had greater soil N mineralization turnover rates converting organic N into inorganic N. However, this was likely due to the stimulation of herbaceous plant fluxes, which had a stronger positive correlation with soil N turnover rate and soil N mineralization flux than did sedimentation fluxes. Annual vegetation N flux was positively correlated with soil N mineralization flux. In summary, hydrologic connectivity increased inputs of nutrients from sedimentation that stimulated soil nutrient mineralization and plant nutrient cycling.

Average rates of floodplain sedimentation were comparable (2778, 7.7, and 1.37 g m^{-2} $yr^{-1}$of sediment, N, and P, respectively) to other floodplain ecosystems with high river sediment and nutrient loads. Average rates of bank erosion (1092, 2.7, and 0.54 g m^{-2} $yr^{-1}$of sediment, N, and P, respectively) were less than floodplain sedimentation. However, bank erosion exceeded floodplain sedimentation at two headwater sites. Average rates of N and P mineralization in floodplain soils (4.5 g-N m^{-2} yr^{-1}, 0.11 g-P m^{-2} yr^{-1}) were less than inputs from sedimentation. Average vegetative N and P cycling rates (7.1 g-N m^{-2} yr^{-1}, 0.64 g-P m^{-2} yr^{-1}), including both litterfall and herbaceous production, were similar to mineralization rates. Together these flux rates indicate that the floodplain of Difficult Run is on average a net sink for sediment, N, and P, with nutrients tightly cycled internally and likely low rates of nutrient export back to the river. In conclusion, urban floodplains can provide valued ecosystem services by retaining large quantities of sediment, N, and P to improve downstream water quality.

Contact Information: Greg Noe, U.S. Geological Survey, 430 National Center, Reston, VA 20192, USA, Phone: 703-648-5826, Fax: 703-648-5484, Email: gnoe@usgs.gov

SALTMARSH ECOSYSTEM RESTORATION ON INTERTIDAL/SUBMERGED CAP IN AN URBAN SYSTEM

Joseph Shisler[1]*, Matthew Adkins*[2]*, Jeff Beckner*[3] and *Tim Iannuzzi*[4]

[1]ARCADIS, Cranbury, NJ, USA
[2]CSX Transportation, Inc. Lithia Springs, GA, USA
[3]ARCADIS, Augusta, GA, USA
[4]ARCADIS, Annapolis, MD, USA

The restoration of impacted estuarine systems in the urban environment includes a number of factors especially associated with the capping of pollutants. The existing conditions consisted primarily of debris associated with more than a hundred years of historical site use as a wood treating facility in Gautier MS. These impacts were addressed with beneficial modifications to the transition area, intertidal and submerged habitats. In addition, containment was accomplished by the construction of a two foot impervious cap consisting of several layers for protection that extended from the upland into the estuary. The tidal marsh restoration was driven by utilizing the Hydrogeomorphic Approach (HGM) which facilitated an evaluation of site conditions pre and post condition. The existing tidal fringing wetlands were evaluated using HGM for before construction for post evaluation to determine success.

Final beneficial modifications include the expansion of a fringing wetland system, development of a transition area with two turtle nesting areas for a state threatened species, and creation of oyster reef habitat. The fringing tidal wetland was created on the rip-rap armament by covering with sand to create a substrate for intertidal planting while the transition area rip-rap was covered with topsoil. Over 100,000 plants of five species (*Juncus roemerianus*, *Schoenoplectus robustus, Spartina alterniflora,* Spartina *cynosuroides*, and *Spartina patens*) were removed, maintained, and incorporated into the fringed tidal wetland restoration as required by state and federal permits. The areas were supplemented with additional seeding and planting with indigenous species to increase diversity and stability of restored plant communities. The plantings and development of the wetland creates a soil bioengineered system to increase protection of the cap from storm events. A compliance monitoring and adaptive management plan has been developed for the project to insure the objectives are met for a functioning transition area, intertidal wetland, and oyster reef.

Contact Information: Joseph Shisler, ARCADIS, 8 South River Road, Cranbury, New Jersey, 08512, USA, Phone: 609-860-0590 x245, Fax: 609-860-0491, Email: joseph.shisler@arcadis-us.com

URBAN WATERSHED BASED RESTORATION: HABITAT CONVERSION IN THE GREEN-DUWAMISH ECOSYSTEM

James R. Thomas
U.S Army Corps of Engineers, Seattle, WA, USA

Many of the floodplain valleys in the Puget Sound area have been extensively developed, resulting in loss of floodplain, riparian, stream, and wetland acreage and functions. In some areas, nearly all or the remaining undeveloped land are wetlands or other protected resources. The shortage of undeveloped land in urban areas can be a limiting factor for ecological restoration efforts. One solution is to convert existing habitat areas to replace lost functions, but this is done at the expense of one resource to benefit another.

The Green-Duwamish watershed is located in Western Washington, south of Seattle in a floodplain river valley. Howard Hanson dam controls the flow of the Green River and the river valley has a series of levee structures to reduce flood frequency. The Green River valley originally converted over time from a riparian/wetland/floodplain complex to agricultural fields. In the last forty years, it has been further developed to heavy retail/commercial use. The only significant undeveloped acreage in the area is wetlands. The changes in local land use has resulted the loss of natural functions, including critical stream functions. The Green-Duwamish watershed is known habitat for several salmon species including Chinook (*Oncorhynchus tshawytscha*) and Coho (*O. kisutch*). A primary goal of the Green-Duwamish Ecosystem Restoration Plan is to improve and create salmonid habitat.

The Upper Springbrook Restoration Project, one of many projects proposed as part of the Green-Duwamish plan, included a new alignment of 900ft of Upper Springbrook Creek to benefit salmon. The pre-project alignment had been channelized into a straight roadside ditch, vegetated by aggressive invasive non-native plants. The new alignment design has multiple bends, pool and riffle combinations, and several pieces of large woody material secured in the stream bed, complimented by dense planting of native woody and herbaceous species. To accomplish this realignment, approximately 2 tenths of acre of forested wetland was converted to stream.

Construction on this project was completed in September, 2011. Within twenty-four hours of fish exclusion screen removal, Chinook salmon were observed spawning in the new stream alignment. This project is an example of how a habitat conversion that improves a suite of functions can be used to implement a watershed restoration plan.

Contact Information: James R. Thomas, Environmental and Cultural Resources Branch, Seattle District, US Army Corps of Engineers, Seattle, WA, 98124 USA, Phone 206-439-4531, Fax: 206-764-6676 , Email: james.r.thomas@usace.army.mil

THE EFFECTS OF ARTIFICIAL FLOATING WETLAND ISLAND (FWI) TYPE ON PLANT BIOMASS AND GROWTH DYNAMICS

Julie Vogel[1], *Alexandra Jangrell-Bratli*[2], *James Bays*[3], *Melanie Riedinger-Whitmore*[4] and *Deby Cassill*[4]

[1]St. Petersburg College, Seminole, FL, USA
[2]ALS Environmental, Jacksonville, FL, USA
[3]CH2MHILL, Tampa, FL, USA
[4]University of South Florida St. Petersburg, St. Petersburg, FL, USA

Artificial floating wetland islands (FWI) can be used to create wetland habitats by allowing plant growth in areas that otherwise may be too deep. Increasingly, FWIs are proposed to improve water quality especially in urban areas. The materials for the artificial floating wetland islands might be wide ranging, but should be durable, functional, environmentally sensitive, buoyant, and easily anchored.
With funds received from a 2010 Society of Wetland Scientists student grant, two FWI types were constructed to determine if FWIs made from natural materials such as bamboo would perform similarly to those islands made of plastic derived materials (PVC) with regard to vegetation dynamics, biomass, plant percent cover, carbon, nitrogen, and phosphorus content, material durability, and buoyancy. Fifteen FWIs were placed in Crescent Lake, a eutrophic urban lake in St. Petersburg, FL and planted initially with pickerelweed (*Pontederia cordata*), bulrush (*Schoenoplectus tabernaemontani*), golden canna (*Canna flaccida*), and duck potato (*Sagittaria lancifolia*). After the initial planting, three FWIs were enclosed in polyethylene plastic sheeting suspended from water surface to sediment. Data were collected on percent cover, weight, and plant species composition through the 2010 growing season. At the study conclusion, biomass was harvested and oven dried. Nitrogen, carbon, and phosphorus contents were analyzed for each species.

All FWIs remained buoyant throughout the study, however the substrate on the bamboo islands disintegrated within one month in the aquatic environment. This time span was not sufficient for most bamboo island vegetation to establish and create a self-sustaining buoyant root mat.
Vegetation dynamics depended on FWI type. Emergent macrophytic vegetation decreased 13% on average across all islands. Conversely, floating aquatic vegetation (FAV) increased on average 39%. Ludwigia (*Ludwigia grandiflora*) colonized the FWIs naturally, averaging 40% on all harvested islands by the end of the study, which was greater than any other emergent macrophyte. Percent nitrogen, phosphorus and carbon were dependent on species rather than FWI type. Ludwigia and water lettuce (*Pistia stratiotes*) had the greatest percent of nitrogen (3.7% and 3.9%) and phosphorus (0.2% and 0.4%), respectively.

Location and enclosure led to differences in percent cover within the FWIs. A lakeward or landward location within the study area accounted for 44% of variation in the total mean percent cover ($p<0.001$). A north or south location within the study area accounted for 32% of variation ($p=0.002$). The presence of an enclosure accounted for 24% of variation ($p=0.014$).

From this study, it was determined that FWI type, vegetation composition, and site location have an impact on FWI vegetation dynamics, nutrient uptake, and durability. These parameters should be taken into account when designing and implementing FWIs in urban areas to meet specific project objectives.

<u>Contact Information</u>: Julie Vogel, St. Petersburg College Seminole Campus, 9200 113th Street North Seminole, FL 33772, USA, Phone: 727-678-1470, Email: vogel.julie@spcollege.edu

APPLICATION OF WETLANDS FOR NUTRIENT POLISHING IN URBAN ENVIRONMENTS

Jan Vymazal
Czech University of Life Sciences Prague, Prague, Czech Republic

In the past, urban stormwater management was only concerned with collecting and distributing stormwater to minimize flooding. However, during the last several decades more attention has been paid to stormwater treatment. Nutrient concentrations in stormwater runoff are time dependent, as are the flows. The concentrations and loads are episodic due to periods of dry deposition followed by first flush of runoff after rain, followed by exponential decrease in runoff constituent concentrations. Typical inflow concentrations of total nitrogen and total phosphorus in urban stormwater vary between 1.0 and 4 mg/l and 0.1 and 0.5 mg/l, respectively. For stormwater runoff, several treatment measures are used, including dry and wet ponds, vegetated open channels, sand filters and wetlands. Treatment wetlands are recognized for their ability to remove phosphorus and nitrogen from urban stormwaters while providing other important services such as reduction of peak flows. Most typically, treatment wetlands for stromwater runoff are designed as free water surface wetlands with deeper zones for sedimentation at the inflow.

Various wetland components play a role in the retention of phosphorus in stormwater wetlands. While uptake by plants, periphyton and bacteria can give a rise to an initial rapid removal of P, the soil compartment represents a major phosphorus sink in stormwater wetlands in the long run. The recent results from stormwater wetlands in Southeast Asia have demonstrated that phosphorus removal could be substantially enhanced by proper soil selection. For nitrogen, the major removal routes are denitrification and plant uptake provided the biomass is regularly harvested. However, denitrification may be hampered by low carbon content in some stormwater runoff waters. The literature survey revealed that average TP and TN removal in urban stormwater wetlands is 45% and 43%, respectively.

It has been demonstrated that common stormwater constituents including nutrients, can be predicted on the basis of the ratio of wetland surface area to contributing watershed area. However, the literature survey has revealed that this ratio for both natural and constructed vary considerably between 0.6% and 23%. It has been found that every 1% increase in urban area required that roughly 0.1% of the watershed area be used as wetland for treating stormwater runoff. Recently, it has been reported that long-term nutrient removal in urban stormwater wetlands can be adequately described in terms of mean hydraulic loading rate.

Contact Information: Jan Vymazal, Czech University of Life Sciences Prague, Faculty of Environmental Sciences, Department of Applied Ecology, Kamýcká 129, 165 21 Praha 6, Czech Republic, Phone: +420 22438 3825, Email: vymazal@yahoo.com

URBAN LAND-USE EFFECTS ON SALT MARSH RESIDENT CYPRINODONTIFORMES IN THE GULF OF MEXICO

Chris J. Anderson[1] and ***Madeline E. Wedge***[2]
[1]Auburn University, Auburn, AL, USA
[2] Auburn University, Auburn, AL, USA

Salt marshes provide important habitat for fish and decapod crustaceans. Urban land-use has been shown to have a variety of impacts on salt marshes and their dependent species, especially fish. Urban land-use has been linked to altered fish community structure, decreased abundance, increased pollutant exposure, as well as altered benthic invertebrate communities, which are prey for many fish species. Since fish from the Gulf of Mexico make up a significant part of the total fish landings both commercially and recreationally in the United States, it is important to know how urban land-use may affect this critical habitat. Research in this area is particularly lacking for salt marshes dominated by *Juncus roemerianus*, which are common along the Gulf of Mexico. In 2011, a study was initiated to examine the effect of shoreline development on salt marsh resident Cyprinodontiformes. The study focused on *Juncus*-dominated marshes in small tidal creeks draining to Wolf Bay, Perdido Bay, and Pensacola Bay in Alabama and west-Florida. We examined marshes in three urban (≥30% surrounding urban land use) and three reference (no surrounding urban land use) creeks for Cyprinodontiformes occurrence. Two salt marsh residents, *Fundulus grandis* and *Poecilia latipinna*, were evaluated further for differences in size, abundance, and condition between fish captured from urban and reference marshes. Preliminary data suggests that complex interactions are determining the condition of these fish. This Information will be useful in assessing urban impacts on other salt marshes as well as further understanding of how altering habitat and prey sources of commercial fish due to increasing human populations in coastal areas will affect local fisheries.

Contact Information: Madeline E. Wedge, School of Forestry and Wildlife Sciences, Auburn University, 603 Duncan Drive, Auburn, AL 36949 USA, Phone: 334-844-9063, Email: mew0027@auburn.edu

WATER QUALITY/CONTAMINANTS - EMERGING CONTAMINANTS

REMOVAL OF PHARMACEUTICAL COMPOUNDS BY CONSTRUCTED WETLANDS UNDER DIFFERENT REDOX CONDITIONS

***A. F. Hamadeh**[1], Piet Lens[2]* and *G. Amy[1]*
[1] WDRC/ King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia
[2] UNESCO-IHE Institute for Water Education, Delft, The Netherlands

Pharmaceutically active compounds (PhACs) as well as other organic micropollutants (OMPs) are detected in the aquatic environment. PhACs released from wastewater are eventually found in surface, ground, and coastal waters. Most of these compounds are not totally removed by conventional wastewater treatment techniques, and the residuals of PhACs should be removed in a sustainable way from drinking water and other surface waters. It is known that PhACs, which have human health and some toxicity effects, are not totally removed by conventional wastewater treatment methods and become a new aquatic environmental problem due to the widespread use of drugs in recent decades.

Constructed wetlands (CWs), as one of the natural wastewater treatment techniques, are used throughout the world for wastewater treatment, they can potentially enhance reclaimed water quality to be recharged to the groundwater. They are effective in removing bulk organics (COD, BOD), suspended solids and OMPs. The removal efficiency of PhACs from urban wastewater depends on the nature of the compound, temperature, type of plant present and redox potential (aerobic and/ or anoxic conditions).

The goal of this research is to study the effect of oxygen and plant availability on the removal of some PhACs like Acetaminophen, Atrazine, Primidone, Sulfamethoxazole, Trimethoprim, Iopromide, Dilantin, Fluoxetine, Carbamazepine and DEET through CWs. In order to achieve this goal, an indoor CWs setup was built; this setup includes four series. Series 1 and 2 consist of three PVC boxes in a row, the dimensions for each box are (L x W x H: 70x30x30 cm). Only one of these series has continuous air injection from the bottom, all of these boxes have been planted with *phragmites australis* plant, and were exposed to light to simulate the outdoor environmental conditions. Series 3 and 4 consist of one box each; one aerated and other non-aerated, both boxes were left without plants. Each box was divided into two halves under the same conditions to duplicate the observations.

Synthetic secondary wastewater effluent was fed to all of these boxes; the quality of the feed water (influent) as well as the effluent of each box was analyzed for DOC and different nutrients. In ongoing experiments the selected PhACs are being spiked to the feed water with the concentrations and the percentage removal of these compounds monitored at the effluent.

The relationship between the removal efficiencies and the working environments (aerated planted, non-aerated planted, aerated non-planted, non-aerated non-planted) will be defined, and the optimum removal conditions will be specified for each compound from the selected group.

Contact Information**:** A. F. Hamadeh, Water Desalination and Reuse Center (WDRC)/ King Abdullah University of Science and Technology (KAUST), Thuwal 23955-6900, Saudi Arabia, Phone: +966-545-962-740, Email: ahmed.alhamadat@kaust.edu.sa

PHARMACEUTICAL REMOVAL IN TROPICAL SUBSURFACE FLOW CONSTRUCTED WETLANDS

Dong Qing Zhang[1], *Soon Keat Tan*[2], *Richard M. Gersberg*[3], *Tao Hua*[1], *Junfei Zhu*[1] and *Nguyen Anh Tuan*[1]

[1]DHI-NTU Centre, Nanyang Environment & Water Research Institute, Nanyang Technological University (NTU), Singapore
[2]School of Civil and Environmental Engineering, NTU, Singapore
[3]Graduate School of Public Health, San Diego State University, USA

Many pharmaceutical compounds are the emerging contaminants in the modern society. Since these pharmaceuticals are typically present at trace levels (in the ng L^{-1} range), and wastewater treatment plants (WWPTs) are not designed for their removal, many pharmaceuticals escape treatment and are released into the environment. Compared to conventional technical solutions for water treatment, constructed wetland (CWs) provide a low-cost alternative which make them suitable for wastewater treatment where land availability is not a limiting factor. Determining the fate of emerging organic contaminants in an aquatic ecosystem is crucial for developing CWs treatment technology.

In addition to traditional parameters (i.e., COD, ammonium-N and phosphorus), we carried out experiments in subsurface flow constructed wetlands (SSF CWs) in Singapore to evaluate the fate and transport of 8 pharmaceutical compounds. The CW system included three parallel horizontal subsurface flow constructed wetlands (HSSF CWs) and three parallel unplanted beds fed with synthetic wastewater in continuous mode at different hydraulic retention times (HRTs). Pharmaceutical analysis will feature Solid Phase Extraction (SPE) followed by chromatographic analysis which was performed on a Shimadzu Ultra Fast Liquid Chromatograph (Shimadzu, Japan).

The findings of the tests at 2-6 day HRTs showed that the pharmaceuticals could be categorized as i) very efficiently removed compounds with removal higher than 85% (ketoprofen and salicylic acid); ii) moderately removed compounds with removal efficiencies between 50 and 85% (naproxen, ibuprofen and caffeine); and iii) poorly removed compounds with elimination rate lower than 50% (carbamazepine, diclofenac, and clofibric acid). Except for carbamazepine and salicylic acid, removal efficiencies of the selected pharmaceuticals showed significant ($p < 0.05$) enhancement in planted beds as compared to the unplanted beds. Removal of caffeine, ketoprofen and clofibric acid were found to follow first order decay kinetics with decay constants higher in the planted beds than the unplanted beds. Correlations between pharmaceutical removal efficiencies and log K_{ow} were not significant ($p > 0.05$), implying that their removal is not well related to the compound's hydrophobicity. The findings of the study suggested that CWs in tropical locations may have the advantage of higher temperatures for the removal of pharmaceuticals at relatively low HRTs.

<u>Contact Information</u>: Dong Qing Zhang, DHI-NTU Centre, Nanyang Environment & Water Research Institute, Nanyang Technological University, N1.2-B1-02, 50 Nanyang Avenue, Singapore 639798, Phone: +65 6790 6619, Fax: +65 6790 6620, Email: dqzhang@ntu.edu.sg

DEVELOPMENT OF OPTIMIZATION METHOD OF WETLAND NETWORKS TO REDUCE THE ENRICHMENT OF POLLUTANTS IN FOOD WEBS IN AN ESTUARY

***Honggang Zhang**, Baoshan Cui, Zhiming Zhang* and *Xiaoyun Fan*
State Key Joint Laboratory of Environmental Simulation and Pollution Control, School of Environment, Beijing Normal University, Beijing, China

Estuarine wetlands are suffering from rapid development of the urbanization. Large areas of estuarine wetlands have been invaded and occupied and the remaining wetlands have become patchiness and fragmentation. Additionally, large amounts of pollutants discharged by anthropogenic activities are gradually accumulated in the estuarine wetlands and flow into the circulation of materials in the wetland food webs through direct penetration and transfer along the food chain, which are direct threat to the wetland organisms to survive and thrive. Based on the above two reasons, estuarine wetlands have become the research focus of many environmental and ecological scientists. There are many studies on the patterns of the estuarine wetlands and the food web structures in these wetlands; however, there are lacks of case studies which can integrate these two aspects.

The area and distance between each wetland patch closely relate to the species composition, which directly determines the structure of the wetland food web, and thus can affect the enrichment of pollutants in the food webs. In this study, the correlations between the trophic structure of food webs and the area and distance between each wetland patch were studied. The biological connectivity of the wetland networks was calculated based on the movement distance of animals with different trophic levels. Finally, we developed a method to optimize the patterns of the wetland networks based on the food web structure in the estuary to reduce the risk of the enrichment of pollutants in the wetland food webs. The application of the theory and methods in the Pearl River Estuary demonstrated that the theory and methods for regulating the wetland networks proposed by this study are effective and practical tools. The enrichment of pollutants in the food web can be reduced after the optimization of the wetland networks in the Pearl River Estuary.

Contact Information: Honggang Zhang, Beijing Normal University, No.19 Xinjiekouwai Street, Beijing 100875, China, Phone: 8.61059E+11, Email: baggio818@126.com

THE INFLUENCE OF THE CONNECTION MECHANISM FOR WETLAND NETWORK TO THE SALTWATER INTRUSION IN THE PEARL RIVER DELTA

Zhiming Zhang and *Baoshan Cui*

School of Environment, Beijing Normal University, State Key Joint Laboratory of Environmental Simulation and Pollution Control, Beijing, China

The connectivity for wetland network is inner and external hydrological and biological connectivity between different wetlands. There are more or less interactions among wetland patches by corridors with structural and functional connectivity in the wetland network. The connectivity for wetland network can strengthen material cycle, energy flow, and Information transmission, and will improve the service function of wetland ecosystems. In this paper, the graph theory and hydrology are employed to analyze the structural and functional connectivity of wetland network in Pearl River Delta (PRE), China. The indexes in different scales are used to reflect the spatiotemporal variability of the connectivity for wetland network. Using hydraulic resistance as the weighted attribute of river segments, the least-cost path algorithm in graph theory is used to detect the preferential flow paths of saltwater intrusion. The results showed that a negative exponential relationship between the freshwater discharge from upstream and the extent of saltwater intrusion at both high water slack and low water slack in PRE was identified. The flow paths of saltwater intrusion match the main river channels. The indexes in different scales can be used to enrich and develop of the building methods for wetland network. The spatial and temporal variability of structures and ecological functions of wetland network are simulated and optimized to establish multi-goal regulation patterns of wetland network. This paper provides new insight for management of saltwater intrusion in deltas.

Contact Information: Zhiming Zhang, Beijing Normal University, No. 19 Xinjiekouwai Street, Beijing, 100875, China, Phone: 8.61059E+11, Email: zzm0312@163.com

WATER QUALITY/CONTAMINANTS - METALS MERCURY

ACCUMULATION OF METALS IN THE WATER, SEDIMENT AND FISH SPECIES OF TWO IMPOUNDMENTS OF THE OLIFANTS RIVER, SOUTH AFRICA

***A. Addo-Bediako**, A. Jooste* and *W. Luus-Powell*
Department of Biodiversity, University of Limpopo, Sovenga, 0727, South Africa

A survey of the water and sediment quality and bioaccumulation of metals in two fish species was carried out in two impoundments, Flag Boshielo Dam and Phalaborwa Barrage in the middle and lower Olifants River respectively. Concentrations of Ca, K, Mg, Na and trace metals (Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Sn, Sr and Zn) in the water and sediment, as well as the physical and chemical characteristics of the water were determined over a two-year period (April 2009 – September 2011). Water and sediment samples were collected from three sites representing the inflow, middle and dam wall of each impoundment. The middle part generally had higher metal concentrations than the lower part which may be attributed to the impact of pollution sources in this area coming from mining, industrial and agricultural activities in the upper and middle catchments of the river. Thus, the concentrations of most variables did decrease from the middle to the lower part of the river and may be due to dilution of the water by tributaries of the Olifants River, although there were few metals which had higher concentrations at the lower part than the middle part of the river and this could be due to pollution from the mining activities in the Phalaborwa area. Similar to the concentrations of metals in the water and sediment, the concentrations of metals in the muscle tissues of the two fish species, *Clarias gariepinus* and *Shibe intermidus* collected at Flag Boshielo Dam were higher than those from Phalaborwa Barrage, and the concentrations of some of the metals were higher in the fish muscle tissues than those of the sediment. There were significant correlations between some metals in the sediment and those of the fish muscle tissues. The bioaccumulation factor values showed that accumulation of most metals was higher in *C. gariepinus* than *Shibe intermidus.* The difference in the metal concentration of the fish species could be due to their method of feeding.

Contact Information: A. Addo-Bediako, Department of Biodiversity, University of Limpopo, Sovenga, RSA, Email: abe.addo-bediako@ul.ac.za or aabediako@hotmail.com

UNDERSTANDING THE DISSOLVED ORGANIC MATTER-MERCURY CONNECTION IN WETLANDS: LESSONS FROM THE FLORIDA EVERGLADES

George Aiken[1], *Brian Bergamaschi*[2], *Cynthia Gilmour*[3], *David Krabbenhoft*[4] and *William Orem*[5]

[1]U.S. Geological Survey, Boulder, CO, USA
[2]U.S. Geological Survey, Sacramento, CA, USA
[3]Smithsonian Environmental Research Center, Edgewater, MD, USA
[4]U.S. Geological Survey, Middleton, WI, USA
[5]U.S. Geological Survey, Reston, VA, USA

Dissolved organic matter (DOM) in wetlands controls a number of environmental processes important for ecosystem function including the absorption of light, mineral dissolution/precipitation, transport of hydrophobic compounds (such as pesticides), and the transport and reactivity of metals. Of particular concern are those biogeochemical processes that influence the fate, bioavailability and transport of mercury (Hg), especially those processes related to microbial Hg methylation by sulfate-reducing bacteria. In our studies of DOM and Hg in the Florida Everglades, we have used both field observations and laboratory experiments to elucidate the nature of these interactions and, ultimately, to provide Information necessary to adequately model the behavior of Hg in wetland systems. Our results have shown that DOM influences Hg transport and chemistry through strong binding interactions and, in the presence of sulfide, through the interactions of DOM with metacinnabar (β-HgS). The interactions of DOM with β-HgS are particularly important because they control HgS geochemical behavior through the stabilization of nanocolloidal β-HgS. As a result of these interactions, the β-HgS species remain relatively small and disordered, highly reactive, and available for uptake and subsequent methylation by sulfate-reducing bacteria. These DOM-Hg interactions, therefore, are critical for providing a better understanding of the methylation process. In field and laboratory experiments, we have been able to demonstrate that both the concentration and chemistry of DOM strongly influence Hg methylation. While sulfate is a master variable controlling both sulfate reduction and the methylation of Hg, DOM-HgS interactions modulate the methylation process, thereby influencing the formation of methylmercury (MeHg). Future efforts to model and anticipate the effects of sulfate on the formation of MeHg in both natural and managed wetland systems will need to address the potential influences of DOM. To assist with this need, we are presently working to demonstrate that inherent optical properties of DOM, such as UV absorbance, which provide insights into the physical and chemical makeup of the DOM, are useful proxies for both DOM and Hg concentrations within the Everglades system. Organic matter optical measurements are relatively inexpensive to obtain, can be designed into *in situ* monitoring devices, and may facilitate our understanding of mercury dynamics in complex wetland environments.

Contact Information: George Aiken, USGS, 3215 Marine Street, Boulder, CO 80303, USA; Phone: 303-541-3036, Fax: 303-541-3084, Email: graiken@usgs.gov

TIDAL FLUX OF DISSOLVED ORGANIC CARBON, TOTAL MERCURY, AND METHYLMERCURY FROM SHARK RIVER ESTUARY

Brian A Bergamaschi[1]*, David P Krabbenhoft*[2]*, George R Aiken*[3]*, Eduardo Patino*[4]*, Darren G. Rumbold*[5] and *William H Orem*[6]

[1] United States Geological Survey California Water Science Center, Sacramento CA
[2] United States Geological Survey Wisconsin Water Science Center, Madison WI
[3] United States Geological Survey National Research Program, Boulder CO
[4] United States Geological Survey Florida Water Science Center, St. Petersburg, FL
[5] Florida Gulf Coast University, Ft. Myers, FL
[6] United States Geological Survey, Reston VA

Dissolved organic carbon (DOC) export from mangrove swamps accounts for 10% of the global terrestrial flux of DOC to coastal oceans. Given recent reports of high concentrations of mercury (Hg) in mangrove tissues and mangrove marsh waters, and the known high affinity of Hg species for DOC in surface waters, there is concern that a large Hg flux may accompany the DOC flux from mangroves. Methyl mercury (MeHg), the form of Hg that bioaccumulates, has several potential sources in coastal waters. It may be produced in low-oxygen environments in terrestrial systems, then exported to coastal waters; it may be produced within estuarine and coastal sediments; or it may be produced in coastal wetlands such as mangroves, then tidally pumped into surrounding waters. One issue for addressing the high Hg concentrations in coastal fish species in South Florida is that little is known about the magnitudes of Hg and MeHg export from mangrove swamps into coastal and estuarine waters.

Estimating mass fluxes of carbon and mercury species in estuarine environments is challenging because of bidirectional flows, rapidly changing concentrations, and the multiple factors that affect tidal interactions with wetlands. We used continuous acoustic measurements of discharge combined with continuous measurements of fluorescent dissolved organic material (FDOM) as a proxy for DOC, Hg, and MeHg. We established the relationship of FDOM to DOC, total Hg and MeHg concentrations by measuring FDOM in situ while collecting discrete water samples throughout the estuary over a range of salinities.

We found that continuous measurements of FDOM and turbidity in conjunction with acoustic measurements of discharge was a valuable tool for investigating DOC, THg, and MeHg mass fluxes in tidal systems. Fluxes of DOC found were similar to those previously reported. Fluxes of Hg and MeHg were 5 or more times those previously reported for wetlands. Most Shark River DOC, FTHg, and FMeHg export was driven by tidal pumping as opposed to flow from fresh water regions. For the periods measured, discharge due to net freshwater flow accounted for less than 5% of the estimated constituent flux. The magnitude of the DOC, Hg, and MeHg fluxes were strongly affected by water height and precipitation – even though fluxes were tidally driven. Our results show that tidal mangrove systems may be a significant source of THg and MeHg to coastal waters.

Contact Information: Brian Bergamaschi, U.S. Geological Survey, California Water Science Center, 6000 J St., Sacramento, CA 95819-6129 USA, Phone: 916-278-3000, Fax: 916-278-3071, Email: bbergama@usgs.gov

HYDROLOGIC CONTROLS ON METHYLMERCURY TRANSPORT FROM WETLANDS TO STREAM IN COASTAL PLAIN BASINS

Paul M. Bradley[1], *Celeste A. Journey*[1], *Paul A. Conrads*[1], *Mark E. Brigham*[2], *Douglas A. Burns*[3] and *Karen Riva-Murray*[3]

[1]U.S. Geological Survey, Columbia, SC, USA
[2]U.S. Geological Survey, Mounds View, MN, USA
[3]U.S. Geological Survey, Troy, NY, USA

Methylmercury (MeHg) in streams is often attributed to methylation in up-gradient wetland areas, with episodic flood events maximizing wetland-stream hydrologic connectivity and dominating MeHg supply to the stream habitat. A number of studies have demonstrated that Coastal Plain streams in the southeastern United States are particularly vulnerable to high MeHg bioaccumulation and have attributed this vulnerability to wetland abundance and strong hydrologic connectivity between wetland areas and adjacent stream aquatic habitat. Because characteristically coarse-grained Coastal Plain sediments favor vertical infiltration with little surface runoff, flood events attributable to Coastal Plain precipitation are driven by rising groundwater, promoting efficient transport of MeHg from wetland/floodplain source areas to the stream habitat and increasing in-stream availability.

Several observations at McTier Creek, South Carolina, however, suggest that good hydrologic connectivity and efficient MeHg transport in Coastal Plain systems are not limited to flood conditions. Close correspondence between stream water levels and shallow-groundwater levels at McTier Creek indicate good hydrologic connectivity exists prior to flood conditions. Dissolved MeHg concentrations do not increase under flood conditions. Thus, we assessed the flux of water and dissolved mercury (Hg) species (FMeHg and total Hg (FTHg)) from surface water and groundwater sources in a short reach at McTier Creek during separate events in April and July 2009, to determine the importance of shallow groundwater Hg transport from floodplain areas to the stream under non-flood conditions. Mass balance assessments indicated that, under non-flood conditions, the primary supply of water, FMeHg, and FTHg within the reach (excluding upstream surface-water influx) was groundwater discharge, rather than tributary transport from wetlands, in-stream MeHg production, or atmospheric deposition. The results indicate efficient transport of MeHg from out-of-channel (wetland and riparian floodplain) areas to the stream aquatic habitat in Coastal Plain streams of the southeastern United States, even under non-flood conditions.

<u>Contact Information</u>: Paul M. Bradley, South Carolina Water Science Center, U.S. Geological Survey, 720 Gracern Rd, Suite 129, Columbia, SC 29210 USA, Phone: 803-750-6125, Fax: 803-750-6181, Email: pbradley@usgs.gov

LANDSCAPE CONTROLS ON TOTAL AND METHYL HG IN THE UPPER HUDSON RIVER BASIN, NEW YORK, USA

D. A. Burns [1], *K. Riva-Murray*[1], ***P. M. Bradley***[2], *G. R. Aiken*[3] and *M. E. Brigham*[4]

[1]U.S. Geological Survey, 425 Jordan Rd., Troy, NY
[2]U.S. Geological Survey, 720 Gracern Rd., Columbia, SC
[3]U.S. Geological Survey, 3215 Marine St., Suite E-127, Boulder, CO
[4]U.S. Geological Survey, 2280 Woodale Dr., Mounds View, MN

Surface water mercury concentrations, especially those of the environmental neurotoxin methylmercury (MeHg), can vary widely across regional landscapes. Approaches are needed to better predict spatial variation in Hg species concentrations across heterogeneous basin landscapes that include mountainous areas, wetlands, and open waters. Here, we used multivariate regression to develop models that predict the spatial variation of total Hg (THg) and MeHg concentrations across the 493 km^2 Upper Hudson River basin in the Adirondack Mountains of New York, an identified "hot spot" for freshwater Hg contamination. High spatial variation of about 6-fold for THg concentrations and 40-fold for MeHg concentrations were present across this basin for samples collected synoptically during spring and summer of 2006 and 2008 at 27 sub-basins within the Upper Hudson. THg, MeHg, dissolved organic carbon (DOC), and iron (Fe) concentrations were significantly greater in summer than spring reflecting the increased influence of riparian areas dominated by wetlands during summer. Hg species concentrations were significantly related to percent wetland area and to DOC concentrations, but these relations were weaker in summer when only about one-third of spatial variation was accounted for by bivariate regression relations. In contrast, multivariate regression relations that included metrics of: (1) hydrogeomorphology such as slope and overland flow distance, (2) riparian/wetland area, and (3) open water, explained 66% to more than 90% of spatial variation in these data for each Hg species in each of the seasons. These metrics reflect the combined influence of basin morphometry and riparian soils on Hg source and transport, and the role of open water as a Hg sink in this riverine ecosystem. Multivariate models based solely on these landscape metrics predicted Hg species concentrations as well as or, in some cases, better than models based on more expensive and time-intensive chemical and physical metrics, such as DOC concentrations and specific ultra-violet absorbance. Metrics derived from a digital elevation model, land cover, and hydrography show great promise for identifying areas of expected high Hg concentrations in waters and biota in the Adirondack region, and are likely applicable in similar glaciated riverine landscapes dominated by mountains, riparian wetlands, and lakes/ponds.

Contact Information: Paul Bradley, U.S. Geological Survey, 720 Gracern Rd, Suite 129, Columbia, SC 29210, United States, Phone: 803-750-6125, Email: pbradley@usgs.gov

EVALUATION OF MERCURY LOADS FROM CLIMATE CHANGE PROJECTIONS FOR MCTIER CREEK, SOUTH CAROLINA

Paul A. Conrads[1], *Paul M. Bradley[1]*, *Stephen T. Benedict[2]* and *Toby D. Feaster[2]*
[1]Hydrologist, U.S. Geological Survey, 720 Gracern Road, Columbia, SC, USA
[2]Hydrologist, U.S. Geological Survey, 405 College Avenue, Clemson, SC, USA

McTier Creek is a small coastal plain watershed located in Aiken County, South Carolina. McTier Creek forms part of the headwaters for the Edisto River basin, which is noted for having some of the highest recorded fish-tissue mercury concentrations in the United States. A simple water-quality load model, TOPLOAD, which was developed for McTier Creek, utilizes a mass balance equation in conjunction with hydrologic simulations from the topography-based hydrological model - TOPMODEL. TOPLOAD is an effective tool for analyzing the relative flux contribution of the simulated surface and groundwater flow paths in TOPMODEL.

Climate models for the Southeastern United States project increased temperatures across the region but also project differing precipitation results with some models indicating an increase in precipitation and some, a decrease. Climate models for the Southeast generally agree that the frequency and durations of droughts are likely to increase due to the higher temperature and resulting increases in evapotranspiration. To evaluate effect of projected climate change on flow paths for McTier Creek due to changes in hydrology, downscaled data from two global circulation models (GCM) for one emission scenario were used as inputs to TOPLOAD. One GCM, the Community Climate System Model (CCSM), projects an increase in total precipitation whereas the other GCM, ECHO (a hybrid of the European Center atmospheric GCM [ECHAM] and the Hamburg Primitive equation ocean GCM [HOPE]), projects no significant change in total precipitation. Both models project changes in precipitation intensity and duration. The relative changes in the total mercury flux contributions for the flow paths in TOPLOAD for each GCM and the management implications will be given in this presentation.

Contact Information: Paul A. Conrads, USGS South Carolina Water Science Center, Stephenson Center – Suite 129, 720 Gracern Road, Columbia SC, 29210 USA, Phone: 803.750.6140, Fax: 803.750.6181, Email: pconrads@usgs.gov

TRACE METALS IN SEDIMENTS FROM THREE PROTECTED AREAS IN SOUTH FLORIDA: ASSESSMENT OF BACKGROUND CONCENTRATIONS AND EVALUATION OF RISK FOR MANAGEMENT PURPOSES

Joffre E. Castro[1], *Adolfo M. Fernandez*[2], *Valentina Gonzalez-Caccia*[2] and ***Piero R. Gardinali***[2,3]
[1]Everglades National Park, South Florida Ecosystem Office, Homestead, Florida, USA
[2]Southeast Environmental Research Center, Florida International University, Miami, Florida, USA
[3]Department of Chemistry & Biochemistry, Florida International University, Miami, Florida, USA

A comprehensive environmental assessment was completed on 20 elements: two reference metals (Fe, Al) and several minor trace metals (As, Ba, Co, Cr, Cu, Mn, Ni, Pb, V, and Zn), for surface soils and sediments collected from 50 sites in Everglades National Park (ENP), the coastal fringes of Biscayne National Park (BNP), and Big Cypress National Preserve (BICY). Samples were analyzed by a combination of traditional acid digestions (EPA3050) and followed by ICP/MS detection (EPA6020). Although there was no widespread contamination across the parks, there were some specific areas of concern. A screening-level evaluation based on an effect index grouped trace metals as having negligible, possible, and probable effects on the biota. For example, Cu in BNP and Cr and Pb in ENP were considered of concern because their adverse effect likelihood to biota was assessed as probable; consequently, they were selected for further risk characterization. Also, stations were ranked based on an overall contamination index. The three most contaminated sites were BB10 in BNP and E3 and E5 in ENP. The first site was located in a marina in BNP and the other two sites were along the eastern boundary of ENP adjacent to current or former agricultural lands. A regional assessment tool was developed for evaluating future impacts from restoration projects and to assist with resource management. The tool consists of enrichment plots and statistically derived background concentrations. Finally, an equally accurate but much simplified approach is presented for developing enrichment plots for other environmental settings.

Contact Information: Piero Gardinali, Florida International University, 3000 NE 151 Street, Biscayne Bay Campus, MSB356, North Miami, FL 33181, United States, Phone: 305-348-6354, Email: gardinal@fiu.edu

MERCURY DYNAMICS IN A COASTAL PLAIN WATERSHED: A MULTIPLE MODEL APPROACH

***Heather E. Golden*[1]**, *Christopher D. Knightes*[2], *Paul A Conrads*[3], *Gary M. Davis*[2], *Toby D. Feaster* [4], *Celeste A Journey*[3], *Stephen T. Benedict*[4], *Mark E. Brigham*[5] and *Paul M. Bradley*[3]

[1] US Environmental Protection Agency, Office of Research and Development, Ecological Exposure Research Division, Cincinnati, OH, USA
[2] US Environmental Protection Agency, Office of Research and Development, Ecosystems Research Division, Athens, GA, USA
[3] US Geological Survey, South Carolina Water Science Center, Columbia, SC, USA
[4] US Geological Survey, South Carolina Water Science Center, Clemson, SC, USA
[5] US Geological Survey, Mounds View, MN, USA

Mercury-related fish-consumption advisories are widespread in the coastal plain of the southeastern U.S., where atmospherically deposited mercury interacts with an abundance of wetlands and high-dissolved organic carbon (DOC) and acidic waters. Recent trends in decision-making processes require knowledge of mercury cycling at a variety of spatial scales (e.g., mesoscale watersheds, regions) and within diverse land cover types to better understand and manage the effects of this challenging water quality issue. Watershed models are primary tools for advancing questions related to such ecological exposure research. Spatially-explicit process-based watershed models can (1) improve spatial and temporal linkages between controls on environmental processes and subsequent water quality when observational studies are limited and (2) predict future changes in surface waters by using mathematical formulations. However, the science of spatially-explicit watershed scale mercury modeling is just beginning to emerge and most approaches have not been applied in mixed land cover, coastal plain watersheds that contain an array of wetland complexes. In response to this gap in current knowledge, we quantify total mercury (HgT) concentrations and fluxes from McTier Creek Watershed, South Carolina, USA, using three novel independently developed watershed mercury models (a grid based watershed mercury model (GBMM), the VELMA-Hg model, and the TOPMODEL-Hg model) and measured in-stream HgT concentrations and fluxes. The study watershed is located in an upper coastal plain landscape, an area with more diverse land cover, a larger drainage area, and a different geophysical setting than many previous sites of mercury research in North America, i.e. small forested headwater boreal or northern forested catchments. Therefore, we aim to improve the characterization of mercury cycling in coastal plain watersheds, identify important watershed processes influencing total mercury loadings to surface waters on daily and seasonal time scales, and advance the developing science of watershed-scale mercury modeling. Based upon our understanding of the diverse mercury dynamics represented within each model, simulated HgT fluxes at the watershed outlet using these models, and observed HgT data, this study moves toward our goals.

Contact Information: Heather Golden, Office of Research and Development, National Exposure Research Laboratory, Ecological Exposure Research Division, 26 W. Martin Luther King Drive, MS-579, Cincinnati, OH 45268, USA, Phone: 513-569-7773; Email: golden.heather@epa.gov

COPPER ISOTOPE FRACTIONATION: A PROXY FOR BIOGEOCHEMICAL PROCESSES IN WETLANDS RECEIVING COPPER-CONTAMINATED RUNOFF?

Gwenaël Imfeld, *I. Babcsanyi, M. Granet* and *F. Chabaux*
Laboratory of Hydrology and Geochemistry of Strasbourg (LHyGeS), University of Strasbourg/ENGEES, CNRS, Strasbourg Cedex, France

Copper is an essential micronutrient for many organisms but may also be a contaminant in terrestrial and aquatic ecosystems. Little is known about the transfer of copper in soil and aquatic ecosystems receiving copper pollution. Though stormwater wetlands are engineered worldwide to temporarily retain urban and agricultural runoff, knowledge on the transfer of runoff-related copper in wetland systems is scarce. The understanding of processes that control during storm events the mobilization and the transfer of copper in biogeochemically dynamic ecosystems, such as wetlands, require novel approaches. Here we evaluated, using copper isotope fractionation, the fate and transfer of copper in a stormwater wetland that regularly receive contaminated runoff from a 42 ha vineyard catchment (Rouffach, Alsace, France).

Runoff water, suspended solid, sediment, plant and vineyard soil samples were collected monthly through the period of copper application on the vineyard (March to July 2011) for copper quantification and isotopic analysis using MC-ICP-MS. The results show that 80 % of the runoff-related copper was retained within the wetland. The isotopic shift of aqueous copper between the inlet and the outlet of the wetland ranged from 0.08 to 0.53 ± 0.1 ‰. Inflowing copper in runoff was depleted in 65Cu when passing through the wetland, suggesting that copper was retained by both sorption to Al, Fe oxy(hydr)oxides and complexation with insoluble organic matter. Further studies will focus on copper isotope fractionation during elementary processes, such as sorption and precipitation, in order to interpret and decipher the isotope fractionation observed in complex wetland systems.

Contact Information: Gwenael Imfeld, Laboratory of Hydrology and Geochemistry (LHyGeS), University of Strasbourg/ENGEES, CNRS, 1 rue Blessig, 67084 Strasbourg Cedex, France, Phone: + 333-6885-0407, Email: imfeld@unistra.fr

MERGANSER – AN EMPIRICAL MODEL TO PREDICT FISH AND LOON MERCURY IN NEW ENGLAND LAKES

***John M. Johnston**, James B. Shanley[1], Richard Moore[2], Richard A. Smith[3], Eric K. Miller[4], Alison Simcox[5], Neil Kamman[6], Diane Nacci[7], Keith Robinson[2], Melissa M. Hughes[7], Craig Johnston[2], David Evers[8], Kate Williams[8], John Graham[9], Susy King[10]*

[1]US Geological Survey, P.O. Box 628, Montpelier, VT, USA
[2]US Geological Survey, 331 Commerce Way, Pembroke, NH, USA
[3] US Geological Survey, MS 413, Reston, VA, USA
[4]Ecosystems Research Group, Ltd., 16 Beaver Meadow Road, Norwich, VT, USA
[5]US EPA Region I, Boston, MA, USA
[6]Vermont Department of Environmental Conservation, Waterbury, VT, USA
[7]US EPA National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division, Narragansett, RI, USA
[8]BioDiversity Research Institute, 19 Flaggy Meadow Road, Gorham, ME, USA
[9]Northeast States for Coordinated Air Use Management, Boston, MA, USA
[10]New England Interstate Water Pollution Control Commission, Lowell, MA, USA

MERGANSER (MERcury Geo-spatial AssessmeNtS for the New England Region) is an empirical least squares multiple regression model using mercury (Hg) deposition and readily obtainable lake and watershed features to predict fish (fillet) and common loon (blood) Hg in New England lakes. We modeled lakes larger than 8 ha and with drainage area completely within the USA (4404 lakes), using 3470 fish (12 species) and 254 loon Hg concentrations from 420 lakes. MERGANSER predictor variables included Hg deposition, watershed alkalinity, percent wetlands, percent forest canopy, percent agriculture, drainage area, population density, mean annual air temperature and watershed slope. The model returns fish or loon Hg for user-entered species and fish length. MERGANSER explained 63% of the variance in fish and loon Hg concentrations. MERGANSER predicted that 32-cm smallmouth bass had a median Hg concentration of 0.53 μg g^{-1} (root mean square error 0.27 μg g^{-1}) and exceeded EPA's recommended fish Hg criterion of 0.3 μg g^{-1} in 90% of New England lakes. Common loon had a median Hg concentration of 1.07 μg g^{-1} and was in the moderate or higher risk category of >1 μg g^{-1} Hg in 58% of New England lakes. MERGANSER can be applied to target fish advisories to specific unmonitored lakes and for scenario evaluation, such as the effect of changes in Hg deposition, land use, or warmer climate on fish and loon mercury.

Contact Information: John Johnston, U.S. EPA, 960 College Station Rd., Athens, GA 30605, United States, Phone:706-355-8300, Email: johnston.johnm@epa.gov

BIOGEOCHEMICAL AND COMMUNITY STRUCTURAL CONTROLS ON MERCURY IN EVERGLADES FOOD WEBS

Peter Kalla[1], *Joel Trexler*[2], *Curtis Pollman*[3], *Jeannie Daniel*[4], *Evelyn Gaiser*[2] and *Daniel Scheidt*[1]
[1]U.S. Environmental Protection Agency, Region 4, Athens, GA, USA
[2]Florida International University, Miami, FL, USA
[3]Aqua Lux Lucis, Inc., Gainesville, FL, USA
[4]University of Georgia, Athens, GA, USA

Iterative, synoptic data from Everglades R-EMAP spatial surveys show that methylation and bioaccumulation of mercury is strongly influenced by sulfur and phosphorus. Sulfur at sub-toxic levels drives methylation, while phosphorus controls the bioavailability of mercury (in part through its influence on organic carbon levels) and the complexity of trophic structure in the calcareous periphyton communities where efficient bio-accumulation can occur. These relationships are illustrated through a series of increasingly complex models of mercury in the omnivorous forage fish Gambusia affinis, beginning with simple correlations and culminating in path analysis. Structural equation models explain why mercury in mosquitofish varies so widely in space and time throughout the Everglades, despite the spatial and temporal uniformity of atmospheric deposition. These models could be linked to hydrological models, to predict future mosquitofish mercury concentrations and to suggest management actions that could ameliorate the effects of mercury deposition in the Everglades.

Contact Information: Peter Kalla, U.S. EPA Region 4 Laboratory, 980 College Station Road, Athens GA 30605 USA, Phone: 706-355-8778, FAX: 706-355-8726, Email: kalla.peter@epa.gov

LINKING ATMOSPHERIC MERCURY DEPOSITION TO HUMAN AND WILDLIFE EXPOSURE (SOURCE TO RECEPTOR) BY COUPLING VELMA AND WASP WITH BASS TO SIMULATE FISH TISSUE MERCURY CONCENTRATIONS

C. D. Knightes[1]*, H.E. Golden*[2]*, G. Davis*[1]*, M.C. Barber*[1]*, M.E. Brigham*[3]*, K.R. Murray*[4]*, B.C. Eikenberry*[5]*, C.A. Journey*[6]*, P.A. Conrads*[6] and *P.M. Bradley*[6]

1 US Environmental Protection Agency, Office of Research and Development, Ecosystems, Research Division, Athens, GA, USA
2 US Environmental Protection Agency, Office of Research and Development, Ecological Exposure Research Division, Cincinnati, OH, USA
3 US Geological Survey, Mounds View, MN, USA
4 US Geological Survey, Troy, NY, USA
5 US Geological Survey, Middleton, WI, USA
6 US Geological Survey, South Carolina Water Science Center, Columbia, SC, USA

Mercury (Hg) is the toxicant responsible for the majority of fish advisories across the United States, with 1.25 million miles of rivers under advisory due to the exposure risk from ingesting Hg-contaminated fish. The processes governing Hg exposures in lotic ecosystems are not well-understood, in large part because of the intricate linkages between lotic habitats and the surrounding watersheds and riparian wetlands. Atmospheric deposition of Hg is the primary source of Hg to many aquatic ecosystems. However, in systems where the watershed area greatly exceeds the surface water area, the indirect loading of Hg from the watershed is often the dominant pathway of Hg supply to the stream habitat. To understand the Hg exposure concentrations within streams and rivers, Hg fate and transport from source (atmospheric deposition) to receptor (ingestion of fish tissue) must be understood and quantitatively represented. Mechanistic models are often used to simulate the fate and transport of contaminants in environmental systems. Here we present a modular, multi-media, source-to-receptor approach, which uses atmospheric deposition and meteorology as forcing functions and employs three linked mechanistic models: 1) VELMA, Visualizing Ecosystems for Land Management Assessment, a spatially explicit, dynamic watershed hydrology and biogeochemical cycling model simulating flow and fluxes of divalent inorganic mercury (Hg(II)), methylmercury (MeHg), dissolved organic carbon (DOC), dissolved inorganic nitrogen (DIN) and dissolved organic nitrogen (DON); 2) WASP, Water quality Analysis Simulation Program, a spatially explicit, dynamic surface water fate and transport model that predicts instream surface water and sediment concentrations of elemental mercury (Hg(0)), Hg(II), and MeHg; and 3) BASS, Bioaccumulation and Aquatic System Simulator, a model that simulates population and bioaccumulation dynamics of age-structured fish communities and predicts MeHg concentrations in fish tissue based on fish species, age, length, and weight. By linking these models in series we can better understand the watershed processes and dynamics that govern fish tissue bioaccumulation, the primary driver of Hg exposure risk in wildlife and humans.

Contact Information: Christopher Knightes, USEPA, 960 College Station Rd., Athens, GA 30605, United States, Phone: 706-355-8326, Email: Knightes.Chris@epa.gov

MODELING MERCURY EXPOSURE AT DIFFERENT SCALES IN THE MCTIER CREEK WATERSHED AND EDISTO RIVER BASIN, SC, USA

C. D. Knightes[1], *H.E. Golden*[2], *P.M. Bradley*[3], *G. Davis*[1], *C.A. Journey* [3], *P.A. Conrads*[3] and *M.E. Brigham*[4]

[1] US Environmental Protection Agency, Office of Research and Development, Ecosystems Research Division, Athens, GA, USA
[2] US Environmental Protection Agency, Office of Research and Development, Ecological Exposure Research Division, Cincinnati, OH, USA
[3] US Geological Survey, South Carolina Water Science Center, Columbia, SC, USA
[4] US Geological Survey, Mounds View, MN, USA

Mercury (Hg) is the toxicant responsible for the largest number of fish advisories across the United States, with 1.25 million river miles under advisory. The processes governing fate, transport, and transformation of Hg in lotic ecosystems are not well-understood, in large part, because these systems are intimately linked with their surrounding watersheds. To understand the Hg exposure concentrations within streams and rivers, the Hg fate and transport within the watershed must be understood. Atmospheric deposition is the primary source of Hg to many aquatic ecosystems. However, in systems where the watershed area greatly exceeds the surface water area, the indirect loading of Hg coming from the watershed is often the dominant pathway of Hg supply to the stream habitat. Despite its importance, there is little understanding and associated modeling representation of how atmospherically deposited Hg transports and transforms within the watershed on its way to receiving streams.

In this study, we apply a linked watershed hydrology and biogeochemical cycling (N, C, and Hg) model (VELMA, Visualizing Ecosystems for Land Management Assessment) to predict daily flow and daily fluxes and concentrations of total mercury (THg), methylmercury (MeHg), dissolved organic carbon (DOC), dissolved inorganic nitrogen (DIN), and dissolved organic nitrogen (DON). VELMA is a 3-dimensional spatially (pixel-based) and temporally (daily time step) explicit watershed model consisting of four soil layers, which simulates Hg, N, and C transport and transformation within the watershed. The modeling effort was performed in concert with a rigorous Hg sampling effort as part of the USGS NAWQA program, including a focused study reach and upstream sampling stations. VELMA was applied at a series of different scales within a Coastal Plain watershed (McTier Creek, SC, USA): a focused reach (0.11 km^2), two sub-watersheds (28 km^2, 24 km^2) and the full watershed (79 km^2).

The focused reach data set was used to parameterize VELMA and to identify important Hg fate and transport processes, including transformation and loss mechanisms associated with the deposition of Hg, precipitation on the land surface, and the subsequent surface and subsurface transport to the receiving stream. This focused reach parameterization was then applied, with no further calibration, to the larger scale watersheds. Through this analysis, we assessed how well the current model structure represents the system and evaluated the potential for future improvements. During certain months, VELMA under-predicted MeHg concentrations, suggesting that riparian-zone processes governing MeHg loading to the main channel may be under-represented by the current model structure.

Contact Information: Christopher Knightes, USEPA, 960 College Station Rd., Athens, GA 30605, United States, Phone: 706-355-8326, Email: Knightes.Chris@epa.gov

MERCURY BIOACCUMULATION IN PYTHONS FROM THE FLORIDA EVERGLADES

***David Krabbenhoft*[1], *Michael Tate*[1], *Jacob Ogorek*[1], *John DeWild*[1], *Charlie Thompson*[1], *Kristen Hart*[2] and *Skip Snow*[4]**

[1] U. S. Geological Survey, Middleton, WI, USA
[2] U.S. Geological Survey, Davie, FL, USA
[3] National Park Service, Everglades National Park, Homestead, FL, USA

The U.S. Geological Survey and National Park Service are collaborating on an examination of mercury (Hg) bioaccumulation in invasive pythons captured in the Everglades National Park (ENP) region. Interest in understanding the levels of Hg in pythons from the Everglades is twofold: (1) an examination of the literature revealed no published papers regarding Hg body burdens in python tissues; and, (2) one possible population control strategy for the pythons in ENP is allowing for hunting, and concerns for possible unsafe Hg exposure to hunters who may consume python meat. The USGS Mercury Research Laboratory has analyzed 137 adult tail-tissue samples for their total Hg content, and a subset (24) of those for their methylmercury (MeHg) content. In addition, we have analyzed tail tissue samples from 25 hatchlings and their mother. The primary goals of this effort were to quantify the range of observed Hg and MeHg levels in adult and hatchling tissues from pythons captured in the Everglades region, and to determine if there are controls (e.g., age, weight, length, sex, capture location, diet) on Hg and MeHg concentrations that can help us to understand their exposure and to inform resource managers and the public on the possible health threat from consuming python meat.

The mean observed Hg levels were surprisingly high 4.3 ppm (micro grams per gram, dry weight), which is about 3-4 times greater than previously observed concentrations in tail tissues of American alligator, which is the long held apical predator in the Everglades. Equally surprising was the observed range in concentrations (0.003 – 36.9 ppm) among the adult specimens. By comparison, the mean hatchling Hg concentration was 0.001 ppm. The results for MeHg, which is the more toxic and bioaccumulative form of Hg, in both adult and hatchling specimens revealed that on average about 80% of the total Hg body burden was in the form of MeHg. We are unaware of any other species that show a similar MeHg:Hg ratio for adults and young. Although a distinct geospatial trend in the Hg results is not apparent, it is clear that the specimens from the Shark River Slough (SRS) are generally elevated compared to other areas. This observation is consistent with other recent research results from the ENP, which show that MeHg in Gambusia (Mosquito Fish) and surface water are greatest in the SRS. This suggests that pythons are exposed to MeHg through their diet, which in turn is modulated by local environmental controls of MeHg production. Currently, we are pursuing other lines of evidence to explain the extremely high and wide ranging Hg concentrations observed for Everglades pythons, including the use of carbon and nitrogen isotope analysis (a trophic position indicator) and gut content analysis. These results will be presented at this poster presentation.

Contact Information: David P. Krabbenhoft, U.S. Geological Survey, 8505 Research Way, Middleton, WI, 53562, USA, Phone: 608-821-3843, Fax: 608-821-3817, Email: dpkrabbe@usgs.gov

METHYLMERCURY PRODUCTION IN EVERGLADES NATIONAL PARK: BIOGEOCHEMICAL DRIVERS AND IMPLICATIONS FOR RESTORATION

David Krabbenhoft[1], *John DeWild*[1], *Charlie Thompson*[1], *Jacob Ogorek*[1], *George Aiken*[2], *William Orem*[3], *Jeffrey Kline*[4] and *Joffre Castro*[4]

[1]U. S. Geological Survey, Middleton, WI, USA
[2]U.S. Geological Survey, Boulder, CO, USA
[3]U. S. Geological Survey, Reston, VA, USA
[4]National Park Service, Everglades National Park, Homestead, FL, USA

Elevated levels of mercury (Hg) in the food web of the Florida Everglades have been well recognized for about two decades. Researchers have revealed the vexing complexity of ecosystem-scale factors that control Hg bioaccumulation across the Everglades, including: land use, elevated levels of atmospheric Hg deposition, water use and management, and disturbances (e.g., fire and droughts). Many of these factors directly interface with the Everglades Restoration Program. The key to understanding elevated Hg levels and toxicity to biota depends on unraveling the immense complexities of the Hg methylation process. Methylmercury (MeHg) is the most toxic and bioaccumulative form of Hg in the environment, and although it represents a minor fraction (generally less than 5 percent) of the Hg in air, water and sediment, it comprises almost all of the Hg in tissues of most top predators species. In the Everglades, as well as most other aquatic ecosystems, MeHg production generally is controlled by two groups of factors: those that affect metabolic activity of sulfate reducing bacteria (SRB); and, those that affect the bioavailability of inorganic Hg(II). SRB activity is principally controlled by three factors: the occurrence of organic-rich, anaerobic sediments; sulfate; and, organic carbon. The factors controlling the bioavailability Hg(II) are less well defined, but scientists largely agree on the following: overall Hg abundance (or loading), specific ligands that control dissolved Hg speciation (e.g., sulfide and dissolved organic carbon (DOC)), and water quality indicators (e.g., pH, redox, and particle concentration). Thus, to provide an understanding of what controls spatial and temporal distributions of MeHg across the Everglades, researchers must link macro-scale land use factors and micro-scale biogeochemical factors in order to inform decision makers on how various restoration strategies may affect future MeHg production and biological exposure.

In the past two years, the USGS and NPS have been undertaking annual survey of surface water and forage fish from 76 sites across Everglades National Park (ENP). The project is designed to assess the distribution and occurrence of MeHg across the ENP, and relate it to the major factors that affect Hg methylation discussed above. The results show several regions of elevated MeHg occurrence: the top of the head of Shark River Slough, the C111 Basin, and the mouths of the Shark River and Taylor Sloughs. Each of these locations is associated with moderate sulfate concentrations ($1<x<20$ mg/L). The top of the Shark River and the C111 regions are associated with canal water releases of sulfate, whereas sulfate at the two coastal zones appears to be of marine. Likewise, there are areas of very low MeHg abundance associated with the Rocky Glade region, and far northwestern ENP. Both of these areas are associated with very low sulfate and DOC concentrations, yet appreciable inorganic Hg. This observation verifies the necessity of the coexistence of sulfate, DOC and Hg in order to drive MeHg formation.

<u>Contact Information</u>: David P. Krabbenhoft, U.S. Geological Survey, 8505 Research Way, Middleton, WI, 53562 USA, Phone: 608-821-3843, Fax: 608-821-3817, Email: dpkrabbe@usgs.gov

MODELING THE EFFECTS OF SULFATE LOADING AND METHYLMERCURY PRODUCTION IN THE EVERGLADES

William Orem[1], *David Krabbenhoft*[2], *Cindy Gilmour*[3], *George Aiken*[4], *Mark Schafer*[5] and *G. Ronnie Best*[6]

[1]U.S. Geological Survey, Reston, VA, USA
[2]U.S. Geological Survey, Middleton, WI, USA
[3]Smithsonian Environmental Research Center, Edgewater, MD, USA
[4]U.S. Geological Survey, Boulder, CO, USA
[5]U.S. Army Corps of Engineers, Jacksonville, FL, USA
[6]U.S. Geological Survey, Ft. Lauderdale, FL, USA

Sulfate loading to freshwater wetlands from anthropogenic sources (e.g. acid rain, urban and agricultural pollution) is commonly observed worldwide, but has only recently been recognized as a significant contaminant issue for freshwater wetlands. Sulfate itself has little direct effect on ecosystem function, but has large indirect impacts through the stimulation of microbial sulfate reduction in anoxic wetland environments such as wetland soils. Microbial sulfate reduction produces toxic and highly reactive sulfide as an endproduct. At high sulfate loading, buildup of sulfide can be toxic to flora and fauna, alter metal speciation and the bioavailability of trace elements through the formation of insoluble metal sulfides, increase nutrient release from soils via internal eutrophication, and increase rates of organic soil (peat) biodegradation. At much lower levels of sulfate loading, increased rates of toxic methylmercury (MeHg) production (via microbial sulfate reduction) and bioaccumulation are often observed.

The Everglades, Florida is a wetland environment where sulfate contamination is extensive, and high levels of MeHg in biota are observed. Sulfate loading originates from canal water discharged into the ecosystem from agricultural sources in the Everglades Agricultural Area (EAA). Everglades restoration activities are resulting in changes in flow patterns and where sulfate-contaminated water is delivered. This has raised concerns about how the most sensitive parts of the ecosystem, such as Everglades National Park, will be impacted. Additional sulfate loading from aquifer storage and recovery (ASR) as part of the restoration effort further complicate the picture.

Land and water managers need to understand how Everglades restoration will impact: sulfate loading, sulfate distributions and MeHg production and bioaccumulation. Information is needed on: rates of sulfate removal and sequestration in soils, dilution of sulfate as canal water flows from high to low sulfate concentration zones, remobilization of sulfur from wetland soils, and the complex relationship between sulfur biogeochemistry and MeHg. Current sulfate loading to the Everglades from the EAA is in the range of 116,000 metric tons yr^{-1}. Dilution of sulfate is modeled using chloride as an unreactive proxy. Rates of sulfate removal are estimated by calculating the reduction in surface water sulfate across the marsh, and from sulfate addition experiments in mesocosms. The relationship between sulfate loading and MeHg production is complicated by sulfide inhibition of methylation, with a maximum in methylation at concentrations of about 10 mg/L for much of the ecosystem. Incorporation of this Information into the Everglades Landscape Model (ELM) and /or the Everglades Mercury Model will allow estimates of how restoration will impact the ecosystem.

Contact Information: William Orem, USGS, 12201 Sunrise Valley Drive, MS 956, Reston, VA 20192, USA; Phone: 703-648-6273, Fax: 703-648-6419, Email: borem@usgs.gov

MERCURY BIOACCUMULATION BY MACROINVERTEBRATES AND FISHES OF STREAMS IN CONTRASTING LANDSCAPES

Karen Riva-Murray[1], *Lia C. Chasar*[2], *Paul M. Bradley*[3], *Douglas A. Burns*[1] and *Martyn A. Smith*[1]
[1]U.S. Geological Survey, Troy, NY, USA
[2]U.S. Geological Survey, Tallahassee, FL, USA
[3]U.S. Geological Survey, Columbia, SC, USA

Ecological controls on mercury bioaccumulation in streams are complex and spatially variable. Because studies conducted in different environmental settings have produced seemingly conflicting results with respect to these controls, spatially and temporally intensive studies in diverse aquatic ecosystems are essential. We evaluated mercury bioaccumulation in two medium-sized (< 80 km^2) forested basins in regions that differ in climate and topography – the Adirondacks of New York and the Coastal Plain of South Carolina. Multiple stream locations were sampled seasonally during 2007-2009. Game fish were less piscivorous in NY than in SC, so although mean Hg concentrations in most macroinvertebrate feeding groups were not significantly different between the two regions, mean Hg concentrations in game fish were lower in NY (1300 ng/g, dry wt.) than SC (2400 ng/g, dry wt.). Topography, wetland amount, and water chemistry were more spatially-variable in NY, contributing to greater spatial variability in Hg in biota, positive correlations with dissolved methylmercury and organic carbon in streamwater, and negative correlations with overland flow distance (OFD, an indicator of hydrologic transport distance to the stream channel). OFD was strongly correlated with Hg in macroinvertebrates within the Fishing Brook basin, and was superior to wetland amount (quantified at both basin and riparian scales) as an indicator of Hg in biota. This study demonstrates the importance of local-scale environmental factors to mercury bioaccumulation in topographically-heterogeneous landscapes, and provides support for the use of macroinvertebrates as effective sentinels of mercury contamination in streams.

<u>Contact Information</u>: Karen Riva-Murray, U.S. Geological Survey, New York Water Sciences Center, 425 Jordan Road, Troy, NY 12180, USA, Phone: 518 285-5617, Fax 518 285-5601, Email: krmurray@usgs.gov

METAL/METALLOID ACCUMULATION/REMOBILIZATION DURING AQUATIC LITTER DECOMPOSITION IN FRESHWATER

Jörg Schaller

Institute of General Ecology and Environmental Protection, University of Technology Dresden, Tharandt, Germany

Organic sediments are known to be a significant sink of inorganic elements and metal pollutants in contaminated ecosystems. Metal / metalloid content of detritus has been shown to increase significantly during decomposition. However the role of the decomposer community in this fixation and the factors that make sediments a sink of metals and metalloids remains unclear. The effect of an invertebrate shredder, *Gammarus pulex L*. on metal fixation during litter decay was examined to investigate decomposers role in organic sediments acting as a sink. We tested the effect of these invertebrates in a laboratory and a field experiment. Leaf litter from *Alnus glutinosa* (L.) Gaertn. with 1152 mg kg-1 U of dry biomass (DM) and without uranium was used in a 14-day laboratory experiment. The uranium concentration in the particulate organic material (POM) at the end of experiment was 1427 mg kg-1 DM (1). After 14 days of decay, the residues of the leaves showed a uranium concentration of 644 mg kg-1 DM. Thus, *G. pulex* enhanced metal fixation into the organic partition of sediments by increasing the amount of smaller particles in the aquatic system (2). Results were verified with further experimentation in a wetland stream at a former uranium mining site, as a field experiment. Metal and metalloid content in leaf litter increased significantly during decomposition, while at the same time the carbon content decreased. During decomposition, *G. pulex* as an ecosystem engineer significantly facilitated the enrichment of magnesium (250%), manganese (560%), cobalt (310%), copper (200%), zinc (43%), arsenic (670%), cadmium (100%) and lead (1340%) into small particle sizes (3). The enrichments occurred under very high concentrations of dissolved organic carbon. Smaller particles have higher surface area that results in higher biofilm development. Further, the highest amounts of elements were observed in biofilms. Therefore, invertebrate shredders like *G. pulex* can enhance retention of large amounts of metal and arsenic in wetlands.

Furthermore, invertebrate shredder have a significant effect on formation of dissolved organic matter and remobilization of cobalt, molybdenum and cesium, but no significant effect on remobilization of all other measured elements.

<u>Contact Information</u>: Jörg Schaller Institute of General Ecology and Environmental Protection, University of Technology Dresden, PF 1117, 01737 Tharandt, Germany, Phone: 0049 351 463 31375, Fax: 0049 351 463 31399, Email: Schaller@forst.tu-dresden.de.

ZERO ORDER SULFATE DISAPPEARANCE RATE IN AN EVERGLADES WETLAND ESTIMATED USING MODEL CALIBRATION

Michael G. Waldon[1], *Chunfang Chen*[2], *Hongqing Wang*[3], *Hamid Bazgirkhoob*[2] and *Ehab A. Meselhe*[2]
[1]A.R.M. Loxahatchee NWR, Boynton Beach, FL, USA
[2]University of Louisiana-Lafayette, USA
[3]USGS National Wetlands Research Center, Lafayette, LA, USA

Although sulfate contamination is a serious environmental issue in the Everglades, it has received less attention compared to phosphorus enrichment. Sulfate impacts wetlands through several mechanisms. Sulfate reduction, which is assumed to be the major mechanism of sulfate disappearance, produces potentially toxic sulfide, and is linked to methylation of mercury. Sulfate enters the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge), a remnant of the historic Everglades, in pumped stormwater discharges with a mean sulfate concentration of approximately 50 mg L^{-1}. Within the marsh interior sulfate concentrations at times fall below a detection limit of 0.1 mg L^{-1}. Spatial and temporal patterns of sulfate concentration in the Refuge marsh provide insight into the dynamics of water flow and solute transport. We developed surface water sulfate models of the Refuge using four alternative hydrodynamic and constituent models with varying levels of spatial aggregation. These models were previously calibrated for stage, and chloride concentration which is modeled as conservative. Thus the sulfate results serve to further test modeled stage and transport.

We initially modeled sulfate disappearance rate as a first-order process in which the rate of disappearance of sulfate mass from the water column was proportional to sulfate concentration. This model only fit observed data well when the disappearance rate constant varied spatially by more than an order of magnitude. We observed that this calibrated constant varied inversely with mean sulfate concentration, and conjectured that a zero order model would match observations while obviating rate constant spatial variation. In zero order loss, sulfate mass disappears at a constant rate. However, zero order models are conceptually troubling because at some very low levels, sulfate concentration must limit disappearance. We finally selected a Monod rate formulation which approximates zero order disappearance at higher concentration, and first order disappearance at low sulfate concentration. A half-saturation constant in the formula specifies the transition concentration between zero and first order disappearance. Calibration using our most spatially aggregated model found the half-saturation sulfate concentration to be near or below 1 mg L^{-1}, and demonstrated relative insensitivity to this constant. The zero order disappearance rate was identified using our most spatially aggregated model to be roughly 15 g sulfate m^{-2} yr^{-1}.

Zero order implies that some factor other than sulfate concentration limits disappearance. Because disappearance rate is spatially constant, this limiting factor must be uniform in intensity or availability. Thus, surface water phosphorus or dissolved oxygen concentrations are ruled out as limiting factor because of substantial spatial variation. Future research should identify the factor(s) limiting disappearance, and examine the effect of model spatial aggregation on estimation.

Contact Information: Michael G. Waldon, A.R.M. Loxahatchee NWR, c/o USFWS, 646 Cajundome Blvd, Ste 400, Lafayette, LA, USA, Phone: 337-482-3668, Fax: 337-291-3139, Email: mike@mwaldon.com

DEMONSTRATION PROJECT FOR MERCURY ABATEMENT AND HABITAT ENHANCEMENT IN THE MICCOSUKEE TRIBE OF INDIANS OF FLORIDA

Gintautas S. Zavadzkas and *Rory M. Feeney*
Miccosukee Fish and Wildlife Department, Miccosukee Tribe of Indians of Florida, Miami, FL, USA

The Miccosukee Tribe of Indians of Florida live in the middle of the Everglades protecting 903 square miles of unique habitat. In this region, elevated Hg concentrations create mercury-laden fish and the high incidence of exotic fish influxes limit the use for subsistence and cultural purposes, posing serious health, cultural and environmental problems. The Tribe in partnership with the US Fish & Wildlife service rehabilitated a two mile canal in the federal reservation. We tested the existing conditions in the canal to determine the original mercury level of the system (soil, water and Fish), finding levels of mercury in soil and water below 0.5 ppm. The fish sampled by electro fishing where 0.5 to 1.5 ppm and in the FDA limited consumption range. The restoration removed as much biomass as possible from the canal by mechanical means (excavator dredge) and chemical (herbicide and picicide). Approximately 6 tons of fish were removed and a forced air composting experiment was conducted to deal with the utilization of fish carcasses. Mercury in the compost was < 0.14 ppm and MeHg was < 0.05 ppm showing lower concentration levels than fish in the canal. After the mechanical and chemical processes were completed the canal was restocked with several native fish species and vegetation controlled by means of triploid carp plus the herbicide Sonar at half the recommended dosage per acre. Hg bioaccumulation and current habitat status from recent sampling events conducted 3 years after restocking will be presented.

Contact Information: Gintautas Zavadzkas, Miccosukee Fish and Wildlife Department, Miccosukee Tribe of Indians of Florida, PO Box 440021, Miami, FL, USA, Phone: 305-223-8380, Fax 305-8942397, Email:gintasz@miccosukeetribe.com

WATER QUALITY/CONTAMINANTS
- NON-POINT SOURCE BEST MANAGEMENT PRACTICES

WETLANDS AS A KEY TO WATER QUALITY BEST MANAGEMENT PRACTICES ON FLORIDA RANCHLANDS

Patrick J. Bohlen
University of Central Florida, Orlando, FL, USA

The Northern Everglades region includes the Kissimmee River, Lake Okeechobee and adjacent coastal estuaries to the east and west. Beginning in the 1940s public agencies and private landowners began to transform this region with a vast drainage system to facilitate agricultural production and human settlement. Today, the hydrologic regime of the 1.4 million ha upstream watershed is governed by hundreds of publicly managed flow-control structures and thousands of miles of canals and ditches.

The hydrological and land use changes in the Lake Okeechobee watershed have fragmented wildlife habitat and accelerated the movement of water and nutrients into regional water bodies, increasing nutrient loads into the lake and causing more extreme water level fluctuations. Total P concentration in Lake Okeechobee has more than doubled since the 1970's, causing increased algal blooms and eutrophication mainly due to nutrient runoff from agricultural land. When lake levels are high, nutrient-laden freshwater is pumped out of the lake through canals to the St. Lucie and Caloosahatchee estuaries which are being harmed by the combination of excess fresh water and high nutrient concentrations.

Cattle ranches in the Lake Okeechobee watershed provide valued wetland ecosystem services. Ranches north of the lake, which are mainly cow-calf operations, are the dominant land use in the watershed representing some 0.5 million ha of agronomically-improved pastures as well as native range on land parcels typically ranging from 500-5,000 ha, with a couple over 50,000 ha. Concentrated in the south-central region of the Florida peninsula (Fig. 3) these ranches contribute to Florida's ranking as 12th-13th nationally in the production of cattle (USDA-NASS 2008). These large ranches encompass extensive natural communities, provide critical wildlife movement corridors, support water recharge and storage, and harbor both common wildlife species as well as several federally threatened and endangered species (e.g. woodstorks, *Mycteria americana*, indigo snakes, *Drymarchon corais couperi*; crested caracara *Caracara cheriway*; Florida grasshopper sparrows *Ammodramus savannarum floridanus*); and Florida panther *Puma concolor coryi*).

Although nutrient loads from cattle pastures are low relative to other land uses on a per acre basis, the large acreage of ranches makes them a significant contributor to overall nutrient loads. In cooperation with the state agriculture and environmental agencies, the Florida Cattlemen's Association developed water quality BMP guidelines which include practices for water quality improvements, including modifications to fencing, drainage, feed/water location, and fertilization as well as changes in rotational grazing protocols that are expected to reduce phosphorus runoff if implemented. Increasing retention/detention of drainage waters within cattle pastures, and rehydrating previously drained wetlands, has been suggested as a potentially effective way to reduce nutrient loads.

In this talk I will provide a synthesis of various projects examining the potential of ranch wetland management for water quality issues, and wetland biodiversity and conservation issues in the region. The various approaches that have been used and assessed include water detention, wetland rehydration, impoundments, and other beyond-BMP approaches, such as conservation easements and Payment-for-Environmental-Services program, that also have the potential to harness wetland ecosystem services to address water quality issues in the region.

Contact Information: Patrick Bohlen, University of Central Florida, 4000 Central Florida Blvd, Bldg 20, Orlando, FL 32816, USA, PH: 407-823-1940, Email: patrick.bohlen@ucf.edu

POLYMER ENHANCED BEST MANAGEMENT PRACTICES (PEBMPS): WETLAND WATER QUALITY, CONSTRUCTION, AND MAINTENANCE

[1]***Kyla J. Iwinski,*** [2]*Steven R. Iwinski*

[1]Applied Polymer Systems, Inc., Woodstock, GA, USA
[2]Northern Michigan University, Marquette, MI, USA
[3]University of Denver, Denver, CO, USA

This presentation provides an introduction to Polymer Enhanced Best Management Practices (PEBMPs) used in wetland water quality, construction and maintenance. The most common PEBMPs that are currently in use in Florida and the Eastern US will be discussed and illustrated along with brief case histories throughout the Southeast Region. The general focus will be on dewatering systems, sediment containment and water clarification BMPs that use polymer enhancements for coastal and interior applications.

Sediment and excess nutrients enter water bodies through erosion, fertilizer, manure, crop runoff, and urban and industrial activities. This causes eutrophic conditions leading to algal blooms and water quality degradation. Fine particulates are a point of attachment for contaminants such as nutrients, phosphorous, bacteria, heavy metals, pesticides, and endocrine disruptors, all of which may have negative effects when discharged into water bodies.

Various studies have shown that turbidity levels as low as 10-100 NTU's will start to affect aquatic life and some fish will begin to show signs of stress. Turbidity levels have varying impacts on aquatic life causing decreased light, food, and oxygen, and mechanical effects and temperature increases. In addition to problems created by turbidity, excess nutrients can lead to harmful algal blooms. Algal blooms not only cause aesthetic, odor, and, taste problems, but many species of algae produce dangerous toxins. Blooms of toxic algae can cause sickness and even death in wildlife, domestic pets, livestock, and humans.

Polymer Enhanced Best Management Practices (PEBMP's) involves using anionic, water soluble polymer technologies to enhance current best management practices (BMPs) and greatly reduce sediment loss as well as the amount of sediment and nutrients entering a water body. Two possible solutions are: (1) capture or retain the sediment and nutrients before it can wash into a water body or (2) use polymer enhancement in conjunction with other BMPs to remove nutrients and turbidity. In various tests and case studies using PEBMPs, a 75-85% reduction in phosphorous has been found as well as a 95+ percent reduction in total suspended solids (TSS) and NTU's.

Contact Information: Kyla J. Iwinski, Applied Polymer Systems, Inc., Woodstock, GA 30189, USA, Phone: (o) 678-494-5998, (c) 404-353-3546, Fax: 678-494-5298, Email: kylaiwinski@aol.com cc: info@siltstop.com

BEST MANAGEMENT PRACTICES FOR WATER RESOURCE CONSERVATION: WHAT ARE WE LEARNING?

Robert Kröger[1]*, J. Dan Prevost*[2] and *Trey Cooke*[2]
[1]Department of Wildlife, Fisheries and Aquaculture, Mississippi State University, Mississippi State, MS, USA
[2]Delta F.A.R.M. / Delta Wildlife

Agricultural best management practices (BMPs) can help reduce nutrient and sediment concentrations and loads leaving farm fields, which in turn can reduce negative impacts on downstream aquatic systems. For nearly three decades, significant federal investment in technical and financial assistance has been provided to implement farm BMPs. But few conservation programs attempt to estimate the amount of nutrient and sediment reduction resulting from cost-shared practices, let alone potential positive effect on local or regional water quality. This talk will encompass numerous ongoing and published scientific evaluations of BMPs within the MS Delta and the Lower Mississippi Alluvial Valley (LMAV). A review of BMPs within the LMAV highlighted only 18 articles (9 BMPs) that provided BMP efficiencies that met specific criteria of (a) row-crop agriculture, (b) clay/silt loam soils, (c) slopes 0-5%, and (d) occurred within the LMAV. The majority of the nine key BMPs for the LMAV provided significant nutrient reductions ranging from 15 - 100%. Field studies of innovative management practices such as low-grade weirs and slotted pipes have provided the very first nutrient reduction efficiency data for these structures in an agricultural field setting. Experimentally, it has been shown that weirs significantly increase nutrient reductions over conventionally drained systems. Field scale data on weirs is showing between 35-60% reductions for nitrate-N between inflow and outflow. Furthermore, the system documented a significant lag-effect that needs to be considered when evaluating BMP efficiencies. Slotted pipes have been quantified for the amount of sediment accumulation behind the structure. Observing sediment accumulation trends, (curvi-linear ; $r^2 = 0.76$) and applying a Von Bertalanffy non-linear model for sediment accumulation through time for the evaluated sites, highlights that highest sediment accumulation occurs with 235 d following installation. These sediment accumulation rates can be translated to sediment volume and mass, and when multiplied by the total phosphorus concentration of the sediment provides a potential for evaluating performance for this specific BMP.

<u>Contact Information</u>: Robert Kröger, Assistant Professor, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University, Box 9690, Mississippi State, MS, 39762, USA, PH: 662-325-4731 Email: rkroger@cfr.msstate.edu

IMPROVING THE EFFECTIVENESS OF BMPS IN THE EVERGLADES AGRICULTURAL AREA

Timothy A. Lang, *Samira H. Daroub, Jehanghir Bhadha* and *Manohardeep Josan*
University of Florida/IFAS, Everglades Research and Education Center, Belle Glade, FL, USA

The Everglades in south Florida is the largest contiguous body of organic soils in the continental United States. A portion of the northern Everglades was drained at the beginning of the 20th century for agricultural and urban purposes, becoming what is known today as the Everglades Agricultural Area (EAA). The EAA comprises an area of approximately 283,300 ha and is planted predominantly to sugarcane (*Saccharum spp*.) with the remaining arable land planted to winter vegetables, sod, and rice (*Oryza sativa* L.). To farm successfully, growers in the EAA actively drain their fields via an extensive array of canals, ditches, and large volume pumps. Excess water is pumped off farms into South Florida Water Management District (SFWMD) conveyance canals, from which it is pumped to Stormwater Treatment Areas (STA). After treatment to reduce P concentration, water is sent southward to the WCAs and the Everglades National Park (ENP). Concerns about the quality of drainage water leaving the EAA basin and entering the ENP prompted the Florida legislature to adopt the Everglades Regulatory program, part of the Everglades Forever Act (EFA). The main objective of the program is to implement Best Management Practices (BMPs) to reduce P loads from the EAA basin by 25% or greater compared to a ten-year, pre-BMP baseline period.

Since its inception 15 years ago, the BMP program in the EAA has been very successful at reducing basin P loads. There are, however, spatial and temporal differences in BMP performance in the EAA sub basins. Some of the factors affecting the performance include water level management in farm canals (canal elevations –inside, outside, and head difference-, and pump to rainfall ratio), cropping practices (percent sugarcane, percent flooded and fallow fields), rainfall and irrigation (rainfall, irrigation demand, irrigation P concentration and irrigation P load) and farm-specific constants (farm size, soil series/soil depth, sub basin location).

Currently we are investigating the impact of floating aquatic vegetation on water quality and sediment accumulation rates and characteristics in farm canals. Our aim is to manage the floating aquatic vegetation in farm canals to change the water chemistry and encourage the production of inorganic sediments that are less labile, and less transportable during drainage pumping. The goal is to develop a new innovative BMP to further reduce P loads especially in sub-basins with higher loads. Providing economic incentives for further load reductions at the farm, sub-basin, or basin level may lead to increased effectiveness of BMPs.

<u>Contact Information</u>: Timothy Lang, University of Florida, Everglades Research and Education Center, Belle Glade, FL, 33430, USA, Phone: 561 261 2354, Fax: 561 993 1582, Email: talang@ufl.edu

USING DITCH VEGETATION TO REDUCE PESTICIDE LOADS IN RUNOFF: FIRST FLUSH AND BEYOND

Matthew T. Moore*, Heather L. Tyler* and *Martin A. Locke*
USDA Agricultural Research Service, Oxford, MS, USA

Agricultural pesticide use is necessary to help meet the increased demand for a safe and secure food supply for the United States, as well as the global community. Even with proper application and careful management, the possibility of pesticide leaching and detachment in runoff still exists following certain storm events. Several different management practices have been designed to reduce the impacts of pesticides on aquatic receiving systems. Many such practices focus on the use of vegetation to slow runoff and sorb various contaminants. Three common drainage ditch macrophytes, *Leersia oryzoides* (cutgrass), *Typha latifolia* (cattail), and *Sparganium americanum* (bur-reed) were assessed for their ability to reduce concentrations of atrazine, diazinon, and permethrin in simulated agricultural runoff water. Replicate mesocosms (1.25 m x 0.6 m x 0.8 m) were filled with a bottom layer of sand on top of which 20 cm of Lexington silt loam sediment was placed. Mesocosms were then planted with monocultures of the three representative aquatic macrophytes. Three mesocosms were left unvegetated to serve as controls. Systems were filled with pesticide-free water to a level to maintain a 6 h hydraulic retention and allowed to equilibrate for seven weeks prior to experimentation.

In June, each mesocosm was amended with a mixture of atrazine (10.4±0.28 µg/L), diazinon (3.54±0.20 µg/L), cis-permethrin (1.01±0.01 µg/L), and trans-permethrin (0.77±0.01 µg/L) over a 6 h period using FMI piston pumps . Forty-eight hours following the experiment's initiation, pesticide-free water was amended into the mesocosms to assess effects of flushing on the pesticide retention. *L. oryzoides* and *T. latifolia* significantly reduced overall atrazine loads ($p = 0.0073$ and $p = 0.0421$, respectively) when compared to unvegetated controls. No significant differences in overall diazinon load retention were noted between plant species. Each plant species significantly decreased the initial load (after 6 h) of trans-permethrin, while both *L. oryzoides* and *T. latifolia* significantly reduced the overall trans-permethrin loads ($p = 0.0022$ and $p = 0.0020$, respectively) when compared to unvegetated controls. These results demonstrate the ability of native ditch vegetation to mitigate pesticides associated with agricultural runoff. Likewise, they provide farmers and action agencies with supportive data for selection of vegetation in drainage ditches used as management practices. Future research will focus on effects of hydraulic retention time and mixtures of plant species in pesticide mitigation.

Contact Information: Matthew T. Moore, USDA Agricultural Research Service, Water Quality and Ecology Research Unit, PO Box 1157, Oxford, MS 38655 USA, Phone: 662-232-2955, Fax: 662-232-2988, Email: matt.moore@ars.usda.gov

SELECTION OF SOIL TEST PHOSPHORUS EXTRACTANT AND INDEX FOR CALCAREOUS SOILS

Kelly T. Morgan and *Kamal Mahmoud*
University of Florida, Immokalee, FL, USA

One best management practice (BMP) for optimizing phosphorus (P) fertilizer rates is the use of an indexed soil test. Soil testing with Mehlich-1as an index of P availability for Florida vegetable production has existed for more than 30 years. The index allows the grower to accurately predict soil P availability and adjust P fertilizer rates for production on sandy acidic soils. A soil test index of high or very high indicates that no response is likely to added fertilizer nutrient. A project was initiated in 2005 to assess the applicability of current soil text indices in a water shed with high surface water P concentrations. The C-139 Basin is a 170,000-acre agricultural basin in Hendry County, Florida that is tributary to the Everglades. The soils were found to have higher pH (>7.0) and very high Calcium (Ca) concentrations (>400 ppm) compared with similar soils in other locations in the state. These conditions result in precipitation of fertilizer P rendering it unavailable for crop uptake. Objectives of this project were: 1) demonstrate the current soil test index BMP for P fertilization practices for vegetables, 2) document accuracy of the current soil P test index under field conditions, and 3) determine the relative P availability measured by selected soil test extractants. Three to four fertilizer P rates were applied (including a 0 P rate) at each location for three to six years of the project. Soil test results indicated that the soil samples at the beginning and during each of the field studies were high or very high in extractable soil P. The soil P concentrations extracted by Mehlich-1 did not decrease appreciably over the period of this demonstration indicating the extraction of non-plant-available soil P. Growth and yield of green beans increased with increased P application when the P index indicated that no added P should have been required. This observation was not constantly true for tomato crops grown, with some crop plants tending to be larger, with higher leaf P concentration and larger yields of larger fruit when fertilizer P was applied at higher rates while other crops did not show the same results. Thus, P in soils with high soil test P, pH greater than 7 and elevated Ca concentrations was less available for plant uptake resulting in reduced growth and yield than the current Mehlich-1 based index would suggest. Sequential soil analysis was used to determine relative concentrations of various soil P constituents. The analysis indicated that water soluble and some bicarbonate extractable soil P are available to and utilized by the crop plants. This Information combined with multiple soil extractants indicated that Mehlich-1, Mehlich-3 and Bray extract water, bicarbonate and weak acid extractable forms of soil P. Olsen extracts water and some bicarbonate forms of soil P, and AB-DTPA extracts only water extractable forms. Thus a conclusion of this project would be that Olsen extractant should be used on the soils of the C-139 basin and correlates best with crop growth and yield.

Contact Information: Kelly Morgan, University of Florida, 2685 SR 29N, Immokalee, FL 34142, USA, PH: 239-658-3400, Email: conserv@ufl.edu

A COST ANALYSIS OF LOW IMPACT DEVELOPMENT STORMWATER TREATMENT METHODS IN FLORIDA

Daniel C Penniman[1], *Mark Hostetler*[2], *Tatiana Borisova*[3] and *Glenn Acomb*[4]

[1]School of Natural Resource and Environment, University of Florida, Gainesville, FL, USA
[2]Department of Wildlife Ecology and Conservation, University of Florida, Gainesville, FL, USA
[3]Department of Food and Resource Economics, University of Florida, Gainesville, FL, USA
[4]Department of Landscape Architecture, University of Florida, Gainesville, FL, USA

Low Impact Development (LID) is a fairly new practice used to treat stormwater, and it has been shown to effectively reduce pollutant loading, A USEPA study has indicated that LID projects may be cost effective, however, there has been a lack of research on the economic costs of implementing LID in Florida. The objectives of this study are (1) to compare LID costs to conventional stormwater treatment costs for construction in Florida; (2) to create a cost profile of different LID methods for stormwater treatment; and (3) to identify the primary barriers for firms attempting to implement LID in Florida.

Using a snowball sampling method, we identified 29 design firms throughout Florida that have used LID within the planning and/or other stages of residential development projects. A combination of online surveys, a specialized data collection tool and phone interviews with key employees of the firms is being used to obtain opinions and cost analysis data. Preliminary results will be presented from these surveys and interviews. The findings from this research will help better inform the Florida design/development industry on economic aspects of LID, help regulatory bodies craft policies to encourage LID implementation, and provide a source of Information/data for proper consideration of LID costs and benefits. The findings will be focused to help develop recommendations on key strategies that can be employed to increase the utilization of LID in urban development projects.

<u>Contact Information</u>: Daniel Penniman, School of Natural Resource and Environment, Gainesville, FL, USA, PH: 850-380-5200, Email: danielcpenniman@gmail.com

VEGETATION BUFFERS, WATER QUALITY AND ECOSYSTEM RESTORATION

Felicia Orah Rein[1], *Karen Holl*[2], *Mark Los Huertos*[3], *Daniel Mountjoy*[4], *Robert Curry*[3] and *Jean Langenheim*[2]

[1]Geosciences Department, Florida Atlantic University, Boca Raton, Florida, USA
[2]Environmental Studies, University of California, Santa Cruz, California, USA
[3]Watershed Institute, California State University, Monterey Bay, California, USA
[4]USDA, Natural Resources, Salinas, California, USA

In this study, we have focused on restoring native plant populations on former farm lands and investigating their ability to protect ecosystem resources such as soil, nutrients, and water. While focusing on grassland restoration, we also sought to evaluate whether the native grasses can serve to reduce pollution through vegetative buffer strips (VBS) as a BMP. Previous research suggests that VBS reduce agricultural nonpoint source pollution inputs into adjacent water bodies. The study wetland drains into Monterey Bay National Marine Sanctuary. This system suffers from highly accelerated erosion rates and severe sediment loss, as well as degraded water quality. We compared vegetation composition of different grass buffer strips in a fragmented coastal agricultural landscape to evaluate the potential for native grass restoration of sites that receive agricultural runoff. We investigated several ecosystem resources by monitoring nutrient cycling, soil quality and sediment loss and capture, water chemistry in groundwater, soil water and surface water, and plant biomass and nutrient content. Ultimately, these variables all affect water quality.

Vegetative buffers bordering Elkhorn Slough, draining into Monterey Bay, California, were seeded with grasses to test if they would establish, survive and become effective at protecting water quality by reducing sediment loss and preventing the associated sediment-bound pollutants from entering receiving water bodies. Species seeded included: 1) native perennial grasses (a mix of *Nassella pulchra, Bromus carinatus* and *Deschampsia cespitosa)*, 2) non-native annual barley grass (*Hordeum vulgare*), and 3) an unseeded treatment consisting of volunteer weedy vegetation.
Our results suggest that some species of native perennial grass can establish on former agricultural lands, but long-term survival may be difficult without extensive management. We evaluate our results and link them to environmental management recommendations to guide VBS composition and maximize its effectiveness. Morphology of the plant was important in sediment capture and rooting depth was important in nutrient uptake. Longevity of the species is an important consideration for long term restoration goals.

In the sediment transport study, gully erosion rates were significantly affected by VBS composition. Native perennial grasses were most effective in the second year at trapping sediments originating from the agricultural field, measured as deposition. Timing of vegetation establishment, rainfall intensity and slope steepness were important factors influencing sediment loss. We conclude by examining sediment deposition into receiving water bodies, such as ports and rivers and provide environmental management strategies for dredging those sediments and the potential beneficial uses of that dredged material.

Contact Information: Felicia Rein, 7890 Palacio Del Mar, Boca Raton, FL, 33433, USA, Phone: 954-778-0239, Email: rein@scientist.com

EFFECTS OF ROOT-ZONE GLYPHOSATE EXPOSURE IN TWO DITCH SPECIES

Lyndsay E. Saunders[1], *Melissa B. Koontz*[1], *Matthew T. Moore*[2] and *S. R. Pezeshki*[1]
[1]University of Memphis, Memphis, TN, USA
[2]National Sedimentation Laboratory, Oxford, MS, USA

Glyphosate is one of the most widely applied herbicides globally. While extensive research exists on the effects of glyphosate on non-target plant species exposed via drift and by-spray, little work has been done investigating the effects of root-zone glyphosate exposure that is associated with runoff from agricultural fields. The objective of this experiment was to determine the lethal and sublethal concentrations of glyphosate for two ruderal species commonly found in agricultural ditches, *Panicum hemitomon* and *Polygonum hydropiperoides*, when exposed to glyphosate in the root-zone. Glyphosate solution (100 mL) was introduced to the top of the potting substrate (sand) of individual plants in concentrations of 0, 10, 1000, 10000 mg L^{-1}. All plants of *P. hemitomon* and *P. hydropiperoides* displayed 100% mortality within 7 days of exposure to 10000 mg L^{-1}. All *P. hemitomon* plants survived (0% mortality) at lower concentration exposures, while *P. hydropiperoides* had higher rates of mortality for concentrations of 10 and 1000 mg L^{-1} (17% and 100%, respectively). Treatment differences were also observed in both species for leaf chlorophyll content. The results of this experiment allow for further experimentation utilizing sublethal root-zone glyphosate concentrations to further understand the physiological and morphological effects of such exposures on ditch species and their functioning.

<u>Contact Information</u>: Lyndsay E. Saunders, Department of Biological Sciences, University of Memphis, 3774 Walker Avenue, Memphis, TN 38152 USA, Phone: 901-338-3516, Email: lesaunde@memphis.edu

THE EFFECT OF HYDRAULIC RETENTION TIME AND FLOW PATH ON NITRATE AND ATRAZINE ATTENUATION IN A BIORETENTION SWALE

***Amy N. Smith*[1]**, *Lenore P. Tedesco*[2], *Pierre-Andre Jacinthe*[1] and *Meghna Babbar-Sebens*[1]

[1]Indiana University-Purdue University Indianapolis, Indianapolis, IN, USA

[2]The Wetlands Institute, Stone Harbor, NJ, USA

A bioretention swale was tested for its effectiveness as a best management practice for reducing nitrate (NO_3^-) and atrazine export from agricultural tile drains in the US Midwest. The system includes a combination of subsurface (anaerobic) and surface (aerobic) cells, and was designed with the expectation that these different flow paths would allow for effective transformations of the various contaminants that are normally present in drainage waters. More specifically, anaerobic conditions in the subsurface cell would support denitrification, whereas aerobic conditions in the surface cell should be favorable for atrazine degradation. The goal of this study is to identify the biogeochemical processes (sorption, microbial degradation, vegetative uptake) controlling NO_3^- and atrazine removal, and to experimentally create conditions conducive to the attenuation of these water pollutants by changing the hydraulic retention time (HRT). Starting in summer 2011, sampling of the bioswale inflow, outflow, and across the surface and subsurface cells has been conducted to assess contaminant attenuation during periods of long HRT (> 2 days) and short HRT (< 2 days). Preliminary results have demonstrated the effectiveness of the bioswale at reducing the discharge of nutrients into nearby streams. Evaluation of the bioswale is ongoing, and involves experimental variations of HRT to determine the optimal HRT for effective NO_3^- and atrazine removal during different seasons. These results will be discussed in relation to a suite of biophysical parameters (water level, temperature, conductivity and dissolved oxygen) to better characterize bioswale flow paths and underlying biogeochemical processes.

Contact Information: Amy N. Smith, Department of Earth Sciences, Indiana University-Purdue University Indianapolis, 723 West Michigan Street, SL118, Indianapolis, IN 46202, USA, Phone: 317-690-4507, Fax: 317-274-7966, Email: amynsmit@iupui.edu

WATER QUALITY/CONTAMINANTS - NUTRIENTS

BIOGEOCHEMICAL SEGMENTATION AND DERIVATION OF PROTECTIVE NUMERIC NUTRIENT CRITERIA FOR COASTAL EVERGLADES WATERS, SOUTH FLORIDA

Henry O. Briceño[1], *Joseph N. Boyer*[2] and *Joffre Castro*[3]
[1]Southeast Environmental Research Center, Florida International University, Miami, FL, USA
[2]SERC & Dept. Earth & Environment, Florida International University, Miami, FL, USA
[3]Everglades National Park, National Park Service, Homestead, FL, USA

Water quality in the Everglades National Park is the result of a long-term and poorly understood interplay of local, regional and global forcing, drivers, pressures and responses, including the impacts from anthropogenic interventions that have occurred in this region since the early 1900's. We selected a holistic approach to basin segmentation before Numeric Nutrient Criteria derivation, to account for variability not only dictated by a given nutrient level, but by the combination of imposed conditions (nutrients, geomorphology, circulation, management, etc). FIU's water quality monitoring data was used for basin segmentation with an objective classification of stations combining PC analysis and clustering methods in tandem. Nutrient (TN, TP) concentration thresholds for each segment were derived, by identifying concentrations that were associated with above average increases in CHL-a. For this purpose, CHLa z-scored cumulative sums were plotted along either TP or TN gradients, mimicking nutrient dose-experiments. These graphs illustrated the successive reactions of phytoplankton biomass to nutrient enrichment, highlighted the main threshold, and provided Information showed to assess the potential health status of phytoplankton communities in the water column. Although threshold calculations were segment-specific, their levels transcend segment boundaries, resulting in a regional stepwise pattern, perhaps dictated by the dominance of specific phytoplankton assemblages. Calculated thresholds would fix the upper limit for nutrient concentrations mean of the baseline distribution, above which a long-term NNC would not be considered protective of the actual segment conditions with respect to phytoplankton biomass.

<u>Contact Information</u>: Henry O. Briceño, Southeast Environmental Research Center, OE-148, Florida International University, Miami, FL, 33199, USA, Phone: 305-348-1269, Fax: 305-348-4096, Email: bricenoh@fiu.edu

FLOATING WETLAND FOR NUTRIENT REMOVAL IN A STORMWATER INFILTRATION BASIN

***Ni-Bin Chang**, Martin Wanielista* and *Zhemin Xuans*
Stormwater Management Academy, Orlando, FL, USA

Groundwater contamination due to nutrient inputs via the infiltration flows from stormwater retention and detection ponds is a vital concern in groundwater management. This study represents a pioneering test of a full-scale retention pond (wet pond) with the inclusion of floating wetland technology as a novel ecological engineering practice in the field of urban stormwater management. One ecological engineering approach used for treating polluted water containing high nutrients is treatment wetlands, where various aquatic plants are used for purifying the water and wastewater from excess nutrients. Floating wetland for handling urban stormwater impact is a new, innovative, cost-effective, and sustainable alternative in the context of Best Management Practices (BMPs).

Plants grow on floating mat rather than rooted in the sediments. Therefore, water depth is not a concern here. Free-floating macrophytes provide shading of the water column, thereby providing a cooler habitat for fish and macro invertebrates in what otherwise would be a warm water tropical environment. The hanging roots provide a large surface area for denitrifying bacteria creating an anaerobic environment, which can remove nitrate by denitrification process, and these roots entrap fine suspended particulates that would otherwise remain in suspension in a conventional pond system. Microbes that live on the surface of plant roots in a wetland remove lot more nitrate than do the plants themselves.

These microbes change nitrate nitrogen (NO_3-N) to ammonia nitrogen (NH_4-N) in a process called nitrate assimilation. To explore the ultimate removal efficiency of nitrogen and phosphorus, our floating treatment wetland project includes 11 mesocosms by using water tanks with various sizes, coverage of floating mats and sorption media, which replicate the field conditions of retention ponds. The test results may help us understand nutrient loading rate and total capacity associated with hydraulic conditions in real world systems. The field implementation will follow the best microcosm pattern selected in earlier time period. Ecological systems, however, do not have a common characteristic scale. Use of ecological concepts, measurements, and experiments are usually scale-dependent.

To verify the efficacy of floating wetland technology for stormwater management, actual pond sampling will be carried out in two phases at the 4M pond on campus of University of Central Florida (UCF). In this 1st phase, conductivity, pH, ammonia, nitrite, nitrate, total nitrogen, turbidity, total alkalinity, dissolved oxygen, water temperature, etc. will be monitored to support the possible mass balance calculations. Apart from routine water quality measurements, hydrological data will also be collected and recorded using equipment like rain gage, evaporation pan, pressure transducer and flow rate meter. In the second phase, when the whole floating wetland may be implemented, we monitored and tested all the necessary water quality and hydrological parameters continuously to address the differential effects. Research findings will contribute to the applications of BMPs and Low Impact Development (LID) in urban regions.

Contact Information: N. B. Chang, Stormwater Management Academy, University of Central Florida, Orlando, FL 32816, USA, Phone: 407-754-7521, Fax: 407-823-3315, Email: nchang@ucf.edu

PREDICTION OF PHOSPHORUS RELEASE FROM WETLAND SOILS

*Vimala D. Nair, **Mark W. Clark** and K. Ramesh Reddy*
University of Florida, Gainesville, FL, USA

At the landscape level, wetlands often form a critical interface between uplands and adjacent water bodies, as these ecosystems are hydrologically linked. Water and associated nutrients such as phosphorus (P) are transported from the uplands via surface or subsurface flow and eventually reach adjacent aquatic systems. In agricultural watersheds, ditches are often cut to connect isolated wetlands to improve drainage. Therefore, a tool to better predict P storage and release from uplands, ditches, streams and wetlands must be developed in order to assess potential risk in P loading to the receiving aquatic system.

Techniques such as the P saturation ratio (PSR; molar ratio of P to Fe and Al) and the soil P storage capacity (SPSC; a PSR-based calculation of the remaining soil P storage capacity that would consider risks arising from previous loading as well as inherently low P sorption capacity), originally developed for mineral upland soils, were found to be applicable to mineral soils of wetlands within Florida. The relationship between water soluble P (WSP) and SPSC showed that as long as SPSC values are positive, WSP is at a minimum, but when SPSC is negative, the release of P from the soil increases. The relationship also holds for SPSC and the equilibrium P concentration (EPC_0, defined as the point where adsorption equals desorption) determined on the same soils, i.e., when SPSC is positive EPC_0 is low, but EPC_0 increases as SPSC becomes increasingly negative. Organic matter in mineral soils of wetlands does not have any effect on short-term P retention and release when SPSC is positive. The relationship between SPSC and EPC_0 provides an alternate procedure to assess P release from a soil using P, Fe and Al in a soil test solution such as Mehlich 1 to determine EPC_0 without obtaining the Information from traditional P sorption isotherms.

Contact Information: Vimala D. Nair, Soil and Water Science Department, University of Florida, 106 Newell Hall, P.O. Box 110510, Gainesville, FL 32611-0510, USA, Phone: 3520392-1803 ext 324, Fax: (352) 392-3399, Email: vdn@ufl.edu

PHOSPHORUS CYCLING IN A SETTLEMENT POND OF A TREATMENT WETLAND

Santiago Clerici[1], *Michael Krom*[1], *Robert Mortimer*[1] and *Sally MacKenzie*[2]
[1] University of Leeds, Leeds, UK
[2] Wildfowl and Wetlands Trust, Slimbridge, UK

The Wildfowl and Wetlands Trust (WWT) in Slimbridge holds one of the largest collections of waterfowl in Europe. In 1995 a settlement lagoon and several reed beds were constructed to improve the quality of its out flowing water. The settlement lagoon has been effective in removing suspended and organic matter, but dissolved species, and especially phosphate, have been more difficult to treat. At least since 2007, the settlement lagoon has become an important source of Soluble Reactive Phosphorus (SRP) during the summer months, posing a risk to the river Severn downstream. The aim of this project is to quantify the performance of the settling pond during the summer months, regarding the removal or supply of phosphorus into the flowing water, and to understand the processes that lead to those fluxes.

Field work was carried out at the settlement lagoon during the spring and in summer of 2011. Water sampling was done at regular intervals during 24 hours cycles. Water was sampled from the inlet and near the outlets, and from specifically designed incubations. DET gels were deployed to measure porewater chemistry and fluxes, and undisturbed cores were taken. Established laboratory techniques were used in the analysis of the samples collected.

The results allowed the construction of box models showing the daily fluxes of P between reservoirs for each sample period. The spring algal bloom resulted in high levels of dissolved oxygen. SRP was being consumed by photosynthesis and the sediment-water interface was taking up phosphorus. In summer, the algal bloom was replaced by grazers and the levels of oxygen decreased to nearly zero. This caused an interruption to the photosynthetic uptake of SRP and the release of SRP from the sediments, both by inorganic processes and by bacterial respiration. The largest differences in SRP however came through the inlet, with levels in summer being 25 times higher than in spring. All this combined caused levels of SRP leaving the pond in summer to be 55 times higher than those of spring. The behaviour of particulate phosphorus did not change between spring and summer. During both seasons, the pond removed less than 15% of the mass of particulate phosphorus that flowed in.

Phosphorus speciation from sediment cores indicated that phosphorus is retained within the sediment mainly as organic P and apatite. During the summer, about half of the organic P accumulated the previous season was transformed into apatite. P was also stored in the sediment as iron bound, but less than in the organic or apatite phases. Polyphosphates were not important in the phosphorus budgets, but some patterns in the consumption of polyphosphates matched hypothesised behaviours of this not yet well understood form of P.

Contact Information: Santiago Clerici. School of Earth and Environment, University of Leeds, LS2 9JT, UK, Phone: 00-44-113-343-6461, Fax: 00-44-113-343-5259, Email: ear3sjc@leeds.ac.uk

NUTRIENT SPIRALING IN A BOTTOMLAND SUB-TROPICAL STREAM

Matthew J. Cohen[1], *Wesley Henson*[2], *Chris Pettitt*[3], *Valerie Burkett*[4], *Grant Weinkam*[4], *Joelle Laing*[1], *Courtney Reijo*[1] and *T. Elliott Arnold*[5]

[1]University of Florida, School of Forest Resources and Conservation, Gainesville, FL, USA
[2]University of Florida, Agricultural and Biological Engineering, Gainesville, FL, USA
[3]University of Florida, Department of Sociology and Criminology, Gainesville, FL, USA
[4]University of Florida, Environmental Engineering Sciences, Gainesville, FL, USA
[5]University of Florida, Geological Sciences, Gainesville, FL, USA

Nutrient retention is one of the most important functions of wetlands and streams. Streams that flow through bottomlands are particularly important for watershed nitrogen processing because of elevated biogeochemical reactivity in response to high organic matter availability. While the organizing principle for stream ecosystem nutrient processing for the last 30 years has been nutrient spiraling, few studies have been done on streams in the Southeastern US, and still fewer on streams passing through bottomland wetlands. Here we investigate the temporal dynamics of nitrogen uptake kinetics in Fern Valley Branch, a small (ca. 0.5 L/s) stream draining through a short hydroperiod bottomland hardwood swamp in north Florida. The stream starts at a seepage face that maintains constant flow and chemistry, the signature of which suggests an intermediate aquifer source. During flow through the wetland, water is confined to a shallow channel; the soils that define the channel are highly enriched in organic matter. The seepage water has comparatively low concentrations of nitrate ([NO_3-N] = 0.15 mg/L) which decline rapidly with distance downstream. We used the dynamic tracer addition for spiraling curve characterization (TASCC) method to determine nutrient uptake kinetics and spiraling lengths in a 25 meter reach of the creek. TASCC requires co-injection of conservative (chloride) and reactive (nitrate) solutes, and yields a kinetic curve that describes nutrient removal as a function of concentration. We employed the method of 2 occasions, and will be repeating the experiment bi-weekly to characterize the seasonal evolution of spiraling curve kinetics. Early results suggest a comparatively long residence time in this short reach (mean residence time = 39 min, mean velocity = 0.011 m/s), which yields short uptake lengths (maximum of 250 m) and high removal efficiency (only 80% of the 0.494 g N injected as nitrate was recovered). Of particular importance was the observation of hysteretic behavior through the solute injection breakthrough curve. We fitted separate uptake kinetics to the rising and falling limbs of the breakthrough curve and obtained dramatically different values for the half-saturation constant (K_m) and the maximum uptake rate (U_{max}) of the Michaelis-Menten removal function. Specifically, K_m was high (ca. 195 µg/L) for the rising limb, but much lower (85 µg/L) for the falling limb. Similarly, the uptake saturated at U_{max} = 260 µg/m^2/min in the rising limb, but was lower (U_{max} = 43 µg/m^2/min) in the falling limb. This hysteresis in spiraling kinetics is novel behavior. Our tentative explanation is that while high organic matter content of the substrate creates demand for electron acceptors, this demand is transient, and satiated by the high initial concentrations delivered by the breakthrough curve. While measurements are ongoing, we predict strong seasonality in both K_m and U_{max} associated with the changing sources and availability of light and organic matter.

Contact Information: Matthew J. Cohen, Ecohydrology Laboratory, University of Florida, School of Forest Resources and Conservation, University of Florida, 328 Newins-Ziegler Hall, PO Box 110410, Gainesville, FL 32611-0410, Phone: 352-846-3490, Fax: 352-846-1277, Email: mjc@ufl.edu

JUST HOW MUCH PHOSPHORUS DOES A BACTERIUM NEED?

James Cotner
University of Minnesota-Twin Cities, Saint Paul, MN, USA

How much P does a bacterium need to live and grow in natural ecosystems? It is well-known that a large fraction of the aquatic ecosystems on the Earth, from freshwater lakes and streams to regions of the open ocean, are limited by the availability of phosphorus (P). A great deal of work has been done examining how long-cultured organisms such as E. coli respond to organic carbon and P-limitation, but we know very little about how microbes from natural environments deal with low quantities of organic carbon and P in their environment. Even less is understood about how natural communities adapt to various levels of P-limitation. How much can they adjust how P is allocated internally and how does allocation into nucleic acids, phospholipids and poly-P affect P-availability to the rest of the ecosystem? It is important to know these things particularly in light of recent work that suggests that some bacteria may be able to substitute arsenic for P or even completely replace it. I will discuss work in our group where we are attempting to understand how much P a bacterium needs to grow. Furthermore, I will also discuss how bacteria and bacterial communities respond to variation in P in the environment. Do they maintain their P content when P varies in the environment or do they alter their biomass P content to match the environment?

Contact Information: James Cotner, University of Minnesota-Twin Cities, 1987 Upper Buford Circle, Saint Paul, MN 55117, USA, PH: 612-625-1706, Email: cotne002@umn.edu

UNCERTAIN SUPPLIES, SHIFTING DEMANDS, AND THE SUSTAINABILITY OF THE HUMAN PHOSPHORUS CYCLE

James Elser[1]*, Genevieve Matson*[2] and *Elena Bennett*[2]
[1]School of Life Sciences, Arizona State University, Tempe, AZ, USA
[2]Department of Natural Resource Sciences & McGill School of Environment, McGill University, Montreal, Quebec, Canada

Phosphorus is a critical limiting nutrient for plants and essential for generating and maintaining high yields in agriculture. To support expanding food production, humans have amplified the P cycle by more than 400% through large-scale mining of ancient P deposits to produce fertilizer. Recently, discussions have emerged about timelines for possible emerging P scarcity due to depletion of high-grade P reserves. Regardless of debates about the extent of geological P deposits, what is clear is that uncertainties remain about the continued supply of *affordable* P because of the rarefied geopolitical distribution of P reserves (Morocco contains more than 85% of currently known reserves) and unknown dimensions of future global demand. Indeed, estimates indicate that global food production will need to double by 2050 in order to provide adequate food security for the human population; what this means for overall P demand for production of that food is not yet well-constrained.

Beyond growing population sizes, changes in food consumption patterns also generate uncertainty about future P demands because different diets require significantly different amounts of P to produce. For example, growing global affluence implies increasing demand for P because increasing affluence is generally associated with increased meat consumption and meat production is highly P-intensive. To assess this demand dimension of the P problem, we performed a multi-country analysis of diet and associated P requirements. We converted the consumption of 82 food items on an annual *per capita* per country basis to the mined-P required to produce each diet, as well as the amount of manure-P produced by such a diet and manure reapplied to fields. These calculations were carried out for annual diets in 17 countries from 1961 to 2007. By considering how P-demand has changed via diet shifts in multiple countries over time we are able to better identify key factors that affect agricultural P demands as a function of economic development and other factors.

Such analyses may aid in developing improved forecasts of future P demand as well as increase our understanding of how diet mitigation may be used in a suite of tools for humanity to achieve P sustainability by decreasing demand and closing the human P cycle.

Contact Information: James Elser, School of Life Sciences, Arizona State University, Tempe, AZ 85287-4501, USA, Phone: 480-965-9747, Email: j.elser@asu.edu

WATER QUALITY ASSESSMENT IN THE EASTERN NIGER DELTA REGION OF NIGERIA

Medina O. Kadiri
University of Benin, Benin City, Nigeria

The Niger Delta which is one of the largest deltas in the world is located in the central region of Southern Nigeria. It is endowed with immense natural resources particularly crude oil which accounts for 90% of Nigeria's economy. Forty-two sites were selected for study. Samples were collected and analyzed for physical and chemical parameters such as pH, conductivity, salinity, color, turbidity, total dissolved solid, alkalinity, total hardness, dissolved oxygen, Ca, Mg, K, Si, Cl^-, SO_4, PO_4, and NO_3. The waters were essentially brackish, very slightly acidic, to neutral or only slightly alkaline. The variability in the waters was extremely high. Statistical analyses include principal component analysis and cluster analysis. Principal component analysis showed that the most defining environmental variables were conductivity and total dissolved accounting for over 96% variation. Cluster analysis revealed three distinct groups. Group 1 comprises waters with conductivities 4.22- 5.05 mS/cm, Group 2 is 5.78-9.28 mS/cm and Group 3, 11.96-18.26 mS/cm.

Contact Information: Medina O. Kadiri Department of Plant Biology & Biotechnology, University of Benin, Benin City, Nigeria, 300001, Phone: (+234)8023404118, Email: mokadiri@hotmail.com

WATER QUALITY MODELING OF GOLDEN GATE CANAL SYSTEM

Marcelo Lago[1] and *Moris Cabezas*[2]

[1]DHI Water and Environment, Saint Petersburg, FL, USA

[2]Atkins, Tampa, FL, USA

A water quality model was developed to simulate the eutrophication processes in the Golden Gate Canal System, Collier County, Florida. The model was built in MIKE11/ECOlab software by DHI. The MIKE11 module was used to solve the hydrodynamic and advection-dispersion transport processes in the canals. ECOlab is a template that allows simulations of the sink and sources in the advection-dispersion equations. For this application, the equations and parameters in the Ecolab template were made consistent with the the USEPA Water Quality Analysis Simulation Program (WASP). The runoff and baseflow volumetric rates in the canals were extracted from a regional MIKESHE/MIKE11 model for Collier County, from which the MIKE11 model for the Golden Gate area was telescoped. The simulation period was chosen as one year (i.e., from June, 2003 to June, 2004), where the annual precipitation rate is close to the historical average. The model results were compared to the observation data measured during this period (and also measured in other years) in order to adjust the eutrophication-related model parameters. The calibrated model was used to display the spatial and temporal variability of the water quality constituents. Two sensitivity tests were conducted by varying the runoff concentrations in order to evaluate the effect of the runoff loading on the dissolved oxygen concentration in the canal system. Results will be used to help develop the County's Basin Management Action Plan is compliance with the State of Florida Total Maximum Daily Load Program.

Contact Information: Marcelo Lago, DHI Water and Environment, 100 Second Ave. South, Suite 302 North, Saint Petersburg, FL 33701, USA, Phone: 813-831-4700, Email: mla@dhi.us

THE PURIFICATION EFFECT OF REED-DOMINATED RAISED FIELDS IN A FRESHWATER WETLAND IN NORTHERN CHINA

Yan Lan
Beijing Normal University, No.19 Xinjiekouwai Street, Beijing, China

As one kind of the most important foundations of ecosystem management, ecotones have become an increasingly important theme in the study of eco-environmental conservation. Raised fields are an aquatic-terrestrial ecotone, mainly existing near large rivers and lakes and serving as a buffer and filter zone between aquatic and terrestrial ecosystems. A field study was conducted to determine the purification effect of raised fields dominated by a reed community in a freshwater wetland in northern China. There are about 9400 ha of raised fields with more than 3700 ditches in Baiyangdian Lake, forming a characteristic agricultural and vernacular landscape. Raised fields can act as a naturally physical and biological filter to reduce nutrient contents and to control agricultural non-point source pollution. All the ditch water and the subsurface water samples were collected at -30, -20, -10, -5, 0, 5, 10, 20, 30, 50, 100, 150, 200, 250, 300 m away from the edge. In our research, the average removal efficiency in the ditches and platforms was 41.7% TN, 31.7% TP, 22.9% COD and 58.6% TN, 53.9% TP, 54.1% COD, respectively, throughout the test zone. The purification of ditches mainly happens within the initial 30 m and platforms happen within 5 m landward from the boundary. Since the area of raised field in the lake covers 22% of the whole, the reed beds and ditches serve as an instrument for the amelioration of surface water quality. The boundary layer effect of reed-dominated raised fields is crucial for improving the water quality of lake water, and it should be taken into account in regulating and managing wetlands.

Contact Information: Yan Lan, Beijing Normal University, No.19 Xinjiekouwai Street, Beijing, China, PH: 861058802079, Email: lanyan0410@gmail.com

BISCAYNE BAY NUTRIENT LOADS AND WATER QUALITY BOX MODEL

Frank E. Marshall[1], *William K. Nuttle*[2], *Henry O. Briceno*[3] and *Joffre Castro*[4]
[1]Cetacean Logic Foundation, New Smyrna Beach, FL, USA
[2]Eco-hydrology, Ottawa, Ontario, Canada
[3]Florida International University, Miami, FL, USA
[4]Everglades National Park, Homestead, FL, USA

This study estimated nutrient loads to Biscayne Bay in south Florida, USA from the contributing watershed and implemented a mass-balance water quality model to simulate the long-term average nutrient concentrations in the Bay. Nutrient loads for Total Phosphorous (TP), ammonium (NHx-N), nitrate-nitrite (NOx-N), and Dissolved Inorganic Nitrogen (DIN) were independently developed for all components of the water budget based on various existing sources of Information, including canals, un-gauged surface water, groundwater, atmospheric, and Atlantic Ocean contributions.

Calculations of nutrient concentrations in Biscayne Bay based on the estimated loads extended an existing, peer-reviewed hydrology/salinity box model. The model was calibrated against measured salinity to estimate the water fluxes between each box and validated against an independent set of salinity observations. Overall the hydrology/salinity model captured well the patterns of spatial and temporal variability in salinity in Biscayne Bay. Calibration and verification statistics show that the box model accounts for greater that 70 percent of the variability in measured salinity a mean error of between 2 to 3 psu, and errors are comparable between the calibration and verification time periods.

When the model was used for nutrient mass balance calculations, the results showed varied success at characterizing the link between nutrient loads and concentrations in the Bay. Average values for TP assuming no loss or transformation of TP exceeded average measured values by between 17 and 44 percent. Of particular interest, the calculated values of TP concentration reflect the effect of very large loadings of TP caused by hurricanes Katrina and Ernesto in 2005 and 2006. Average values for NOx-N concentrations without accounting for losses due to net denitrification exceeded measured values by about 1.5 - 4 times. This indicates the degree to which uptake, removal, and wash-out of nitrogen species may exert a significant influence over NOx-N concentrations in the Bay. When an average net denitrification rate of 0.3 month^{-1} was applied Bay-wide, calculated values for DIN concentrations were equal to or substantially less than observed values in all but one of the sub-basins. In general this means that the net denitrification rate in most areas of the Bay is capable of being estimated by the default or lower rate.

The mass-balance calculations provide Information on the processes contributing to the variation of nutrient concentrations in Biscay Bay. This study showed that the mass-balance nutrient calculations work well for an evaluation of estimated nutrient loads from the watershed by comparing the long-term average concentrations calculated based on these loads to the long-term average of concentrations measured in the Bay.

<u>Contact Information</u>: Frank Marshall, Cetacean Logic Foundation, Inc., 2022 Spyglass Lane, New Smyrna Beach FL 32169, USA, Phone: 386-451-9381, Email: clfinc@earthlink.net

NITROGEN AND PHOSPHORUS CYCLES IN CONSTRUCTED TIDAL FLAT IN TOKYO BAY

Kazuo Murakami[1], *Nana Sasaki*[1], *Yusuke Umeda*[1], *Tomohiro Kuwae*[2] and *Kouta Nakase*[3]
[1]Tokyo City University, Setagaya, Tokyo, JAPAN
[2]Port and Airport Research Institute, Yokosuka, Kanagawa, JAPAN
[3]Penta Ocean Construction, Bunkyo, Tokyo, JAPAN

Tidal flats are important fields for coastal environments. Because of the loss of tidal flats due to the constructions of man made island, a marine environment in coastal area in Tokyo Bay was abruptly deteriorated. The impacts of tidal flats on marine environment are dependent upon the characteristics of each tidal flat. We carried out field investigations in order to know the ability of water quality purification by each tidal flat. We estimated the Nitrogen and Phosphorus cycles of the tidal flat.

The study field is the tidal flat in Tokyo Port Wild Birds Park. This tidal flat has two channels, which connect to adjacent sea in Tokyo Bay. Water exchange between the tidal flat and the adjacent sea is conducted by only the two channels. We carried out the measurements of tidal velocity, the concentration of nutrients such as Nitrogen and Phosphorus, Chlorophyll-a, turbidity, etc. for two tidal cycles in Summer, 2006 to 2011 and in Winter, 2009 to 2011. Then we estimated the nutrient fluxes pass through the channels from the tidal flat to adjacent sea. From the field measurements of nutrient fluxes, it is found that the tidal flat has the functions of a net source of Phosphorus and a net sink of Nitrogen and Chlorophyll-a. In order to know the mechanism of the function conducted in the tidal flat, we carried out the sampling of benthos and bottom sediments and counting the individual numbers of water birds in the tidal flat. And we carried out the incubation test to estimate the nutrients flux between bottom sediment and overlying water. Furthermore, we estimated the Nitrogen flux from the sediments to atmosphere by denitrification and anammox by means of revised isotope paring technique. By this way, Nitrogen and Phosphorus Cycles in constructed tidal flat are estimated in the tidal flat in summer and winter conditions.

From the field studies, we found following conclusions. (1) From the field measurements of nutrient fluxes pass through the channels, the tidal flat has the function of a net source of Phosphorus and a net sink of Nitrogen and Chlorophyll-a. (2) Predominant species of water birds in the tidal flat is cormorant. The excretion of water birds is a source of Phosphorus, but the nutrient flux by the birds is not so large compare to nutrient flux of the channels. (3) The nutrient flux between bottom sediment and overlying water column in the flat is quite large. Phosphate Phosphorus and Ammonium Nitrogen are released from sediment to overlying water, and Nitrate Nitrogen and Nitrite Nitrogen are taken from overlying water to sediment. (4) The main factor of a net sink of Nitrogen in the tidal flat is denitrification and anammox.

<u>Contact Information</u>: Kazuo Murakami, Department of Urban and Civil Engineering, Tokyo City University, 1-28-1, Setagaya, Tokyo, 158-8557 Japan, Phone: 81-3-5707-1158, Fax: 81-3-5707-1158, Email: kmuraka@tcu.ac.jp

EFFECTS OF A LARGE MISSISSIPPI RIVER DIVERSION ON ESTUARINE SEDIMENT PHOSPHORUS CONCENTRATIONS AND INTERNAL LOADING

***Nhan Nguyen**, John R. White, Eric D. Roy* and *Sam J. Bentley*
Louisiana State University, Baton Rouge, LA, USA

The Bonnet Carré Spillway (BCS) is used as a flood release valve for the Mississippi River during high water events to protect the city of New Orleans. There are concerns that these events may promote harmful algal blooms in the receiving Lake Pontchartrain estuary. Field monitoring during the 2011 BCS opening indicates that phosphorus (P) ultimately limits phytoplankton growth in Lake Pontchartrain during these events due to the high molar N:P ratio (~50) in inflowing Mississippi River water. P availability is an important factor in the growth of nitrogen-fixing harmful algae in the estuary during summertime low-nutrient, N-limited conditions. The ability of sediments to retain P depends on the physiochemical characteristics of the sediments and oxidation-reduction conditions at the sediment-water interface. High external loading of inorganic P to estuaries can lead to P retention in sediments by oxides and hydrous oxides of iron and aluminum or calcium carbonate. Previous research indicates that internal loading of P from sediments by diffusion accounts for ~517 mt SRP-P y^{-1}, an amount similar to that loaded by BCS openings. Knowledge about the role of the internal sediment P load on surface-water P enrichment is limited.

The goal of this study was to analyze sediment P chemistry using a P fractionation scheme for Lake Pontchartrain sediments before and after the 2011 BCS opening to (1) determine locations where P release from sediments may be more significant than others and (2) investigate how the Bonnet Carré Spillway opening impacted sediment P chemistry spatially throughout the estuary. Sediment cores were collected from 17 sites in Lake Pontchartrain on May 12, 3 days after the BCS was opened, and again on July 7, 17 days after the Spillway was closed. Core sections from 0-5 cm and 5-10 cm intervals were characterized and a P fractionation procedure was used to quantify multiple P pools (readily available P, alkali extractable organic P, iron/aluminum-bound P, calcium/magnesium-bound P, and residual P). Net particulate total P loading to the lake as well as the potential for P release from this sediment pool to drive algal productivity was determined. The sediments in the lake contain about 25% refractory P while the remaining 75% is in various slowly available pools which can be released with pH shifts or anaerobic water column conditions. The TP before the BCS opening was 473mg/kg (0-5cm) and 513mg/kg (5-10cm). After the BCS was closed, TP was 595mg/kg (0-5cm) and 560mg/kg (5-10cm), an increase of ~17%. The most abundant P fraction was the Ca/Mg bound which increased from 248mg/kg (0-5cm) and 248mg/kg (5-10cm) in the pre-opening sediment to 292mg/kg and 298mg/kg (0-5cm and 5-10cm sediment, respectively). The most bioavailable P pool in the sediment, KCl [Pi], increased from 0.92mg/kg (0-5cm) and 1.6mg/kg (5-10cm) before the opening to 2 mg/kg (0-5cm) and 3.2mg/kg (5-10cm) after opening, a 200% increase. Results from this study provide evidence that BCS openings increase the bioavailable P in Lake Pontchartrain sediments that can be released to the water column and contribute to harmful algal blooms.

<u>Contact Information</u>: John R. White, Wetland & Aquatic Biogeochemistry Lab, Department of Oceanography & Coastal Sciences, School of the Coast & Environment, Louisiana State University, Baton Rouge, LA 70803 USA, Phone: 225-578-8792, Fax: 225-578-6423,Email: jrwhite@lsu.edu

EFFECTS OF SPECIES COMPOSITION AND DIVERSITY ON DISSOLVED NUTRIENTS IN STAIR-STEP MESOCOSMS

Samuel C. Pierce [1], *Robert Kröger* [1] and *Matthew T. Moore* [2]
[1]Department of Wildlife, Fisheries, and Aquaculture, Mississippi State University, Starkville, MS, USA
[2]USDA-ARS National Sedimentation Laboratory, Water Quality and Ecology Unit, Oxford, MS USA

A growing body of evidence links biodiversity and community composition to ecosystem processes. A relatively limited number of studies in experimental wetlands indicate that increasing the number of macrophyte species or types of plant species (e.g., reeds vs. grasses) can lower concentrations of nutrients in the water column. Because hydrologic factors are considered to be the main driver affecting wetland macrophyte composition, the concept of niche-partitioning would suggest that diversity and composition would have a greater effect in systems with some degree of microtopograhic heterogeneity. To test this assumption, a pilot study was conducted in flooded mesocosms with three soil-levels arranged in a stair-step fashion and utilizing three species of macrophytes with different growth habits: *Juncus effusus, Myriophyllum aquaticum,* and *Leersia oryzoides*. Treatments consisted of mesocosms planted with each of the three species, all three species, or no plants. On October 28, approximately three months after planting, water chemistry was analyzed for ammonium, orthophosphate, nitrate, and nitrite. Mesocosms were then amended with a 40 mg/L nitrate-N solution and sampled after a 72 hour exposure. Nutrient concentrations were analyzed individually using a one-way ANOVA with $\alpha = 0.1$. Orthophosphate in the pre-amendment samples was higher for *L. oryzoides* than for either treatments with all three species or for the unplanted control (Tukey's HSD, $p = 0.012$ and $p = 0.03$, respectively). When single-species treatments were combined and compared to multi-species and unplanted mesocosms, pre-amendment orthophosphate was significantly higher in single-species versus multi-species treatments (Tamhane $p = 0.085$). Although nitrite was initially below detection limits across treatments, following the nitrate amendment, concentrations of nitrite increased. Final mean nitrite concentration of the unplanted treatment was significantly higher than all planted treatments. When single-species treatments were combined and compared with multi-species and unplanted mesocosms, post-amendment ammonium concentrations were higher in unplanted versus single-species mesocosms, but the presence of additional species had no further effect. These results imply that presence of macrophytes in the system may be more important than diversity. Given the high potential for a Type II error with only four mesocosms per treatment and nitrite concentrations near the detection limit, the possibility of a diversity effect should not be discounted. Additionally, this study suggests that even when species diversity is low, increasing macrophyte functional diversity by selecting plants with differing growth habits can impact orthophosphate concentrations in the water column.

<u>Contact Information</u>: Samuel C. Pierce, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University, Box 9690, Mississippi State, MS 39762-9690, USA, Phone: 662-325-4722; Fax: 662-325-8726, Email: spierce@cfr.msstate.edu

NUTRIENT DYNAMICS AT THE ESTUARINE SEDIMENT-WATER INTERFACE DURING LARGE PULSES OF HIGH NITRATE MISSISSIPPI RIVER WATER

E.D. Roy and *J.R. White*

Wetland & Aquatic Biogeochemistry Lab, Department of Oceanography & Coastal Sciences, School of the Coast & Environment, Baton Rouge, LA, USA

Lake Pontchartrain is a shallow oligohaline estuary located in coastal Louisiana, U.S.A. that receives episodic, managed diversions of nutrient-rich Mississippi River water via the Bonnet Carré Spillway to alleviate flood threats to the city of New Orleans. Most recently, the Bonnet Carré Spillway was opened from May 9 to June 20, 2011. These events may lead to harmful algal blooms (HABs) in the estuary and it is therefore critical to understand nitrogen (N) and phosphorus (P) dynamics during high loading diversion events.

In this study, we integrate results from an extensive field monitoring effort during the 2011 event with laboratory experiments and empirical models to examine the interrelated dynamics of dissolved inorganic N (DIN) and P (DIP) at the sediment-water interface. Mississippi River water entering the typically N-limited Lake Pontchartrain was characterized by a DIN:DIP molar ratio of 50:1, indicating potential for eventual P-limitation on primary productivity. P-limitation was confirmed based on below detection DIP measurements at outflows and variations in N and P with distance from the inflow. Following the closure of the spillway, the DIN plume collapsed in 20 days due to assimilation, denitrification, and transport to the coastal ocean. Following the nitrate collapse, water column DIP concentrations rebounded linearly over time to ~0.08 mg DIP-P L^{-1} due to internal loading from sediments. Our results from sediment core incubations and empirical modeling indicate that diffusive flux of P from Lake Pontchartrain sediments has the potential to regenerate DIP in DIP-depleted waters to previously observed concentrations in <60 days and restore N-limited conditions. Observed rates of water column DIP regeneration following spillway openings in 2008 and 2011 suggest additional internal loading of DIP from sediments by advective processes. This sequence of events results in a return to N-limitation on primary productivity and may be an important contributor in promoting blooms of N-fixing harmful algae.

Our findings suggest that estuarine systems subjected to significant anthropogenic perturbation can experience oscillations in water column N and P limitation on primary production due to a combination of external forcing and internal feedbacks occurring at the sediment-water interface. We therefore conclude that the management of both N and P is critical in such systems to reduce the probability of deleterious effects of eutrophication, including HABs.

Contact Information: Eric D. Roy, 3221 Energy Coast & Environment Bldg, Department of Oceanography & Coastal Sciences, Louisiana State University, Baton Rouge, LA, USA, Phone: 225-578-1123, Fax: 225-578-6423, Email: eroy5@lsu.edu

TOWARD SUSTAINABLE PHOSPHORUS MANAGEMENT IN THE ANTHROPOCENE: QUANTIFYING POTENTIALLY RECYCLABLE POOLS AND FLUXES IN THE LANDSCAPE

J. Thad Scott[1]*, Andrew N. Sharpley*[1]*, Brian E. Haggard*[2] and *Helen P. Jarvie*[3]

[1]Department of Crop, Soil, and Environmental Sciences, University of Arkansas, Fayetteville, AR, USA
[2]Arkansas Water Resource Center, Fayetteville, AR, USA
[3]Centre for Ecology and Hydrology, Wallingford, U.K.

Earth's human population is approximately 7 billion and increasing, with growing demand for food and the resources needed to produce food. Phosphorus (P) is an essential nutrient needed to sustain crop (i.e., fertilizer) and animal (i.e., feed) production. However, finite resources of mineral P, primarily as P-rich geologic deposits, are being rapidly depleted, with supplies estimated to last from 50 to 300 years. Moreover, there has been very little effort to retain or recycle P within the landscape. This has contributed to an increase in P export from many sources to inland and coastal aquatic ecosystems, which has accelerated eutrophication and threatened important ecosystem services. Here we use Arkansas as a case study to demonstrate the location and magnitude of major P pools and fluxes in intensively managed landscapes. The objective of the study is to relate P pools and fluxes to human activities that could be managed to increase P recycling. This could, in turn, decrease the demand for newly-mined P and reduce the amount of P entering aquatic ecosystems. Urban and agricultural-intensive areas can be substantial P sinks, but these hotspots differ in their spatial and temporal extent and efficiency of P storage. Using readily available data, we will (a) quantify P stored in distinct landscape compartments, such as municipal solid sludge, agricultural soils, farm ponds, and river impounded reservoirs, (b) relate these storage compartments to potential losses from the landscape via river networks, and (c) identify opportunities to exploit P sinks to achieve more sustainable ecosystems.

<u>Contact Information</u>: Thad Scott, University of Arkansas, 115 Plant Sciences Bldg, Fayetteville, AR 72701, USA, Phone: 479-575-6337, Email: jts004@uark.edu

MODELING DISSOLVED ORGANIC CARBON (DOC) DYNAMICS IN FLOODED WETLANDS

Amirreza Sharifi[1], *Latif Kalin*[1] and *Mohamed M. Hantush*[2]
[1]School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL, USA
[2] US.EPA National Risk Management Research Lab, Cincinnati, OH, USA

Wetlands play an important role in the global carbon cycle and are recognized for their considerable potential to sequester carbon. Wetlands contain the largest component (18-30%) of the terrestrial carbon pool and are responsible for about a quarter of the global methane emissions to the atmosphere. Carbon sequestration and greenhouse gas emission from wetlands has been the subject of many studies and modeling efforts in the past and in recent years. Yet, export of dissolved organic carbon (DOC) from wetlands to receiving water bodies is a component in wetland carbon cycle that has not captured much attention. At high concentrations, DOC can react with chlorine during drinking water treatment and form carcinogenic disinfection byproducts. In this study, we tested and evaluated a recently developed process-based numerical model for simulating carbon dynamics and DOC export in flooded wetlands. The model was evaluated using water quality data collected from a small restored wetland located on Kent Island, Maryland. The study wetland received runoff from an agricultural field. Model calibration showed that more than 90% of the incoming total carbon load to the wetland was in dissolved form. The time series plots of observed and simulated DOC concentrations and loads in general compared well. Dominant processes in the carbon cycle of the study wetland were examined through qualitative and quantitative sensitivity analysis. Results showed that temperature has a significant impact on DOC fate and transport in the study wetland.

<u>Contact Information</u>: Amirreza Sharifi, School of Forestry and Wildlife Sciences, Auburn University, 602 Duncan Dr., Auburn, AL 36849, USA, Phone: 334-329-4485, Fax: 334-844-1084, Email: Sharifi@auburn.edu

DOES PHOSPHORUS STATUS IN *SPARTINA ALTERNIFLORA* REGULATE OXIDIZED RHIZOSPHERE?

P.V. Sundareshwar
South Dakota School of Mines and Technology, Rapid City, SD USA

In wetland plants there are many physiological responses to stressors such as nutrient limitation such as P and Fe as well as waterlogging. It has been suggested that wetlands plants transport air to the roots in response to waterlogging. This process increases the transport and release of oxygen from the roots. Radial oxygen diffusion in wetland plants leads to the formation of oxidized rhizosphere which, in the presence of soluble iron appears as rust colored deposits on the roots. Due to the reactivity of iron and phosphates, iron plaque on the roots serve as a strong sink for phosphates from the surrounding bulk soil. Reports suggest that this phosphate is available to plants. Phosphorus is the one of the critical elements that is also a frequently limiting macronutrient for plant growth. Since phosphorus is essential for many processes and is a component of key molecules such as nucleic acids, phospholipids, and ATP, organisms have evolved various mechanisms and processes that regenerate P from organic and mineral phases. This presentation will focus on P biogeochemistry in soils and its uptake by plants. Specifically, I will explore the idea that phosphorus limitation in *Spartina alterniflora* leads to a change in oxidized rhizosphere, eventually enhancing P acquisition. It is well established that P starvation stimulates many physiological and morphological changes in a variety of organisms from bacterial to higher plants. P starvation promotes stalk elongation in bacteria such as *Caulobacter crescentus*. These stalks harbor high affinity phosphate transporters that may be active in providing access to this limiting nutrient. Similarly, recently it was shown that freshwater diatom *Didyomosphenia geminata* also produces longer mucopolysaccharide stalks under P starvation and many play a role in P acquisition. Similar response is also well established in higher plants, where P limitation stimulates lateral root hair growth which serves to enhance P acquisition. I will present evidence from literature and preliminary experimental results that suggest that in wetlands plants such as *Spartina alterniflora*, the physiological response to waterlogging is similar to P starvation, and that active regulation of the oxidized rhizosphere may be another phosphorus acquisition strategy.

Contact Information: P.V. Sundareshwar, South Dakota School of Mines and Technology, MI Bldg., 501 E St. Joseph St, Rapid City, SD 57702, USA, Phone: 605-394-2492, Email: pvs@sdsmt.edu

CRYPTIC PHOSPHORUS IN THE ENVIRONMENT: COMPOSITION, BEHAVIOR, AND ECOLOGICAL SIGNIFICANCE

Benjamin L. Turner
Smithsonian Tropical Research Institute, Apartado 0843–03092, Balboa, Ancon, Republic of Panama

Biogeochemical studies often consider only inorganic phosphate to be biologically available, yet much of the phosphorus in soils and sediments occurs in "cryptic" forms that are rarely considered and remain poorly understood. Wetlands in particular contain a large proportion of their phosphorus in cryptic forms, so detailed Information on the dynamics of these compounds is central to understanding wetland ecosystems. Cryptic phosphorus forms include a variety of organic and inorganic compounds, such as phosphomonoesters, phosphodiesters, phosphonates, and polyphosphates. These compounds are not identified by conventional colorimetric procedures, but can be quantified simultaneously by alkaline extraction and solution ^{31}P NMR spectroscopy. This yields key insight into the behavior and fate of cryptic phosphorus in the environment. Plants have evolved a variety of mechanisms to acquire phosphorus from organic compounds, including the synthesis of phosphatase enzymes, formation of mycorrhizal associations, and secretion of organic anions. Differences among plant species in the ability to access cryptic phosphorus forms may promote species co-existence at a site and is likely to regulate the response of plant communities to future changes in atmospheric carbon dioxide concentrations or nitrogen deposition. This is likely to be of particular significance in freshwater wetlands, where productivity and species distributions are linked strongly to the availability of soil phosphorus.

Contact Information: Benjamin L. Turner, Smithsonian Tropical Research Institute, Apartado 0843–03092, Balboa, Ancon, Republic of Panama, Phone: 011-507-212-8171; Fax: 011-507-212-8148; Email: TurnerBL@si.edu

TOTAL PHOSPHORUS CALIBRATION OF THE SIMPLE REFUGE SCREENING MODEL VERSION 4 USING OPTIMIZATION

Michael G. Waldon[1], *Chunfang Chen*[2] and *Ehab A. Meselhe*[2]
[1]A.R.M. Loxahatchee NWR, Boynton Beach, FL, USA
[2]University of Louisiana-Lafayette, USA

The Simple Refuge Screening Model (SRSM) Version 4 models stage, and concentrations of chloride sulfate, and total phosphorus (TP) in the Arthur R. Marshall Loxahatchee National Wildlife Refuge using Berkeley-Madonna simulation software. The model is structured with one canal compartment and three concentric marsh compartments. The SRSM initially used TP parameters calibrated for other wetlands using the DMSTA model. Two of the five parameter sets, termed PEW and EMG, available from the 2005 DMSTA calibration were applied in SRSM V4. The SRSM using either set qualitatively follows observed seasonal TP, and often quantitatively fits observed data. However, at more interior sites even the better fitting EMG set predicts TP below observed values. This poster describes preliminary application of the optimization feature of Berkeley-Madonna to estimate a new parameter set for TP dynamics, the Loxahatchee Refuge Interior (LRI) set.

This parameter optimization was performed on three parameters, K1 (maximum uptake rate), K2 (recycle rate), and K3 (burial rate). Optimization compared the model TP with monthly observed geometric mean (GM) of 14 sites within the Refuge, the LOX sites. Observed values were only used when seven or more sites were sampled. These observed GM values were compared to the GM of the 2 most interior SRSM cells on the day (or average of days) for the monthly samples. The absolute value of the difference between the modeled and observed GM was integrated to give the integral absolute error (IAE) over the calibration period. The Berkeley-Madonna simulation program re-ran the SRSM over 150 times searching for a parameters that minimized IAE. Calibration simulated 1995, to 2006; comparison to observed data began in 1998. The remaining period currently available for modeling from 2007 to 2009 is used for model verification. The long calibration period was required because TP storage changes in the model over several years, and a shorter calibration period of five years that was initially used gave apparently anomalous results when the simulation was run for the entire simulation period. The longer calibration period also reduces the calibration's dependence on selected initial values.

Parameter values estimated in the LRI parameter set differ from those in either the PEW or EMG parameter sets. The IAE at the completion of the calibration period was 0.201 µg-day/L for the LRI set, and 0.281 µg-day/L and 0.369 µg-day/L for the EMG and PEW sets, respectively. Agreement with observed values of the LRI model run is visually improved. The LRI 1998-2006 simulation has a low bias of -0.15 ug/L, but a negative efficiency of -0.53. The model captures general trends and average values well, but is not reliable in predicting individual daily values for the geometric mean TP at the LOX monitoring sites.

<u>Contact Information</u>: Michael G. Waldon, A.R.M. Loxahatchee NWR, c/o USFWS, 646 Cajundome Blvd, Lafayette, LA, USA, Phone: 337-482-3668, Fax: 337-291-3139, Email: mike@mwaldon.com

LONG-TERM MACRONUTRIENT ACCUMULATION IN ISOLATED SUBTROPICAL WETLANDS

***Yu Wang**, E. J. Dunne, M. W. Clark* and *K. R. Reddy*
Wetland Biogeochemistry Laboratory, Soil and Water Science Department, University of Florida, Gainesville

Accretion of organic matter has been reported as a major mechanistic sink for macronutrients (C, N, and P) in wetlands. Wetland soils tend to accumulate organic matter due to the production of detrital material from biota and the suppressed rates of decomposition. Small historically isolated wetlands, which are a common feature throughout the Lake Okeechobee Basin (LOB) cover about 12,000 ha of the four priority sub-basins. These systems (about 50%) are presently ditched and drained. Hydrologic restoration of these wetlands may help to provide water storage and long-term P retention within LOB's four priority basins—the S-191, S-1154, and Pools D and E in the Lower Kissimmee River as defined by the Northern Everglades and Estuaries Protection Program (Chapter 373.4595, Florida Statutes). There is interest in using these systems to store water and nutrients in the landscape, as the P load to Lake Okeechobee still needs to be reduced to achieve its target Total Maximum Daily Load TMDL of 140 metric tons of P by 2015. Restoring the hydrology of these presently ditched and drained wetlands store increased amounts of water and associated nutrients including P, could help mitigate nutrient losses from surrounding agricultural pasture within the Okeechobee Basin. However, the surrounding cow-calf grazed, pasture- and subsequently wetland soils have been P loaded for many years. The ability of the restored wetland soils to store more P may be confounded by the legacy of P already in soil and transformations of associated nutrients (C and N). Therefore, it is important to understand the transformations regulating long-term storage of P and associated nutrients. Overall objective of the study was to determine long-term macronutrient storage and its stability along hydrologic gradient in isolated wetlands of the Okeechobee Drainage Basin,

The two wetlands on Larson Dixie cow-calf ranch were again selected to for this study. Three transects were sampled (2004-2011) in the center, edge, and upland with respect to above and below ground productivity and nutrient storage and soil nutrient characteristics (0-10 cm). Carbon and N accumulation was strongly coupled with accumulation rates in the range of 83 to 308 g C $m^{-2}year^{-1}$ and 4 to 20 g N $m^{-2}year^{-1}$, respectively. Phosphorus accumulation rates ranged from 0.7 to 1 g P $m^{-2}year^{-1}$. Accumulation of C, N, and P were highest in the edge of the wetland as compared to center of wetland and adjacent upland. Approximately 0.07 g N per g C and 0.004 g P per g C was stored in this ecosystem. Carbon and N accumulation were tightly coupled (R^2 = 0.96) as compared to C and P accumulation (R^2). Results suggest that organic matter accumulation is one main regulator of C, N, and P accumulation in isolated wetlands.

Contact Information: Yu Wang, University of Florida, 106 Newell Hall, Gainesville, FL 32611, USA, Phone: 352-392-1804, Email: yuwang@ifas.ufl.edu

CHAOTIC, NON-LINEAR DYNAMICS OF WATER CHEMISTRY IN A FLORIDA FRESHWATER SPRING

Danielle L. Watts*, Matthew J. Cohen* and *Ray G. Huffaker*
University of Florida, Gainesville, FL, USA

As important ecological and economic drivers for local areas, recent changes to the ecology of Florida springs have sparked much legal and scientific interest. While increased nitrogen loads in the springs has been often cited as the mechanism behind algal replacement of macrophytes in spring runs, more recent evidence of complex interactions between dissolved oxygen and grazer communities, among other potential mechanisms, has suggested the nitrogen narrative may be overly simplistic. Thus novel techniques for understanding the underlying structure of nutrient and metabolic responses in springs has become of increasing necessity.

Here we examined NO_3 (15-minute measurements), dissolved oxygen, and specific conductance (both hourly) data during 2010 near the Itchetucknee Springhead, Florida, using a technique for nonlinear time series analysis that includes phase-space reconstruction (PSR) and surrogate data analysis. These analyses provide Information for the fractal dimension of a data set as well as the testing for chaotic interactions. Phase space reconstruction can uncover deterministic non-linear structure in time- series, and chaotic effects suggest that the evolution of a time series exhibits strong sensitivity to initial conditions. Results of this analysis suggest that the above-mentioned biochemical markers exhibit chaotic behavior with an underlying deterministic structure, indicating the presence of a strange attractor. The low fractal dimension in all three parameters suggests that predicting nutrient and metabolic cycles may be achieved using a few, deterministic parameters rather than more complicated, high-dimensional models.

Contact Information: Danielle L. Watts, School of Natural Resources and Environment, University of Florida, 327 Newins-Ziegler Hall, Gainesville, FL 32611-0410, USA, Phone: 352-318-0676, Fax: 352-846-1277, Email: tropical@ufl.edu

EFFECTS OF AGRICULTURAL ACTIVITY ON TEMPOROSPATIAL VARIATION OF WATER QUALITY IN A BOG POOL, LAKE MIYAJIMA-NUMA, NORTHERN JAPAN

***Makoto Yokoyama*[1]**, *Hiroyuki Yamada*[2] and *Yutaka Kaizu*[2]
[1] Graduate School of Agriculture, Hokkaido University, Sapporo, JAPAN
[2] Research Faculty of Agriculture, Hokkaido University, Sapporo, JAPAN

Lake Miyajima-numa, a bog pool that has been registered under the Ramsar Convention, shows remarkable deterioration of water quality. Therefore, monitoring of hydrochemical conditions is urgently necessary for the conservation of its ecosystems. However, although recent studies have increasingly examined spatial variation of water quality associated with development of monitoring techniques such as automatic survey and sensor systems, few studies have examined shallow lakes. We have developed a water quality monitoring system using unmanned air boats for monitoring of shallow lakes. This study was undertaken to evaluate temporospatial variation of the water quality using the system.

Lake Miyajima-numa is located in the Ishikari Peatland (43°19'56"N, 141°42'49"E), Hokkaido Island. It has 260,700 m^2 water surface, and 0.8 m mean depth in the irrigation season. We set 121 measuring plots for evaluation of spatial variation of water quality using sensors (pH, electric conductivity, dissolved oxygen, turbidity, temperature, and chlorophyll a), and set 43 plots of sampling surface layer water for ion analyses. These measurements were conducted every month during May–September in 2011.

Generally, water of bog pools is weakly acidic because of dystrophic lake water. However, Lake Miyajima-numa was classified as an alkaline trophic lake because its pH was higher than 9. Additionally, eutrophication has progressed because the concentrations of mineral, such as Ca^{2+}, were higher than those in other bog pools. Spatial variation of water quality was large: it varied according to agricultural activity. Particularly, some concentrations, such as electric conductivity, were high at the fringe of inflow ditches during the irrigation period. Furthermore, the turbidity was higher at fringes of the inflow ditches during paddy field puddling. These results suggest that temporospatial variation of water quality was determined by agricultural activity. Generally speaking, the spatial variation is small in shallow lakes because of stirring effects caused by wind. However, results suggest that the spatial variation is large in shallow lakes that are impacted by agricultural activities. Moreover, results show that the monitoring of temporospatial variation of water quality is useful to evaluate water pollution effects.

<u>Contact Information</u>: Makoto Yokoyama, Graduate School of Agriculture, Hokkaido University, Kita 9 Nishi 9, Kita-ku, Sapporo, 060-8589, JAPAN, Phone: +81-11-706-4183, Fax: +81-11-706-4183, Email: dachshund-qoo@ec.hokudai.ac.jp

ENHANCEMENT OF PURIFICATION FOR EUTROPHIC WATER BY DPAOS INOCULATED STEREO FLOATING BED

Fengliang Zhao[1], ***Ning Yu***[1,2], *Hong Li*[1], *Weidong Yang*[1], *Shu Xi*[1], *Jianjian Li*[1] and *Xiao-E Yang*[1]

[1]MOE Key Lab of Environmental Remediation and Ecosystem Health, College of Environmental and Resources Science, Zhejiang University, Hangzhou 310058, China

[2]Ningbo Drinking Water Source Group Ltd., Ningbo 315195, China

Water eutophication has become a most severe environmental problem in China and worldwide, and high loading and accumulation of nutrients in water has been considered as one of major causes for water eutrophication. Developing effective technologies to remove nutrients from water bodies is of great importance. Ecological engineering, leading to low cost methods to remove pollutants, is an emerging field dedicated to the design and construction of sustainable ecosystems that provide a balance of natural and human values. Macrophytes have been widely applied in ecological engineering for the remediation of surface water and wastewater due to their efficacy in assimilating nutrients and creating favorable conditions for the microbial decomposition of organic matter.

The objectives of this paper were to determine the feasibility of using enhanced floating bed of tall fescue (*Festuca arundinacea*) and denitrifying polyphosphate accumulating microbes (DPAOs) to remove nitrogen and phosphorus from hyper-eutrophic water. The results indicated that tall fescue accomplished much better removal of NH_4^+-N, NO_3^--N, total N (TN) and ortho-phosphorus,(Ortho-P) and the associated microorganism (IM) enhanced the removal of NO_3^--N, TN and Ortho-P. The average removal rates of NH_4^+-N, NO_3^--N, NO_2^--N, TN, TP and Ortho-P by tall fescue stereo floating bed inoculated by DPAOs were 86.32%, 93.60%, 93.74%, 90.12%, 72.09% and 84.29%, respectively. Moreover, the stereo floating beds tended to modify pH and electrical conductivity in water column towards bio-favorable conditions. Enhanced stereo-floating beds with inoculated DPAOs have great potential for removing nutrients from eutrophic water.

Contact Information: Ning Yu, Zhejiang University, College of Environment and Natural Resources, Hangzhou 310058, China, Phone/Fax: 0086-571-88982907, Email xyang571@Yahoo.com

WATER QUALITY/CONTAMINANTS - OIL SPILLS

SALT MARSH RESTORATION FOLLOWING AN OIL SPILL: ECOSYSTEM CONSEQUENCES OF GENETIC VARIATION

Brittany M. Bernik[1], *Thomas Azwell*[2], *Allyse M. Ferrara*[3] and *Michael J. Blum*[1]
[1]Tulane University, New Orleans, LA, USA
[2]University of California, Berkeley, CA, USA
[3]Nicholls State University, Thibodaux, LA, USA

As the significant shoreline cleanup efforts following the Deepwater Horizon oil spill reach conclusion, many affected marshes have been characterized by exposed, denuded shoreline needing vegetative restoration. Bay Jimmy, one of the areas most heavily impacted by the spill, represents a singular opportunity to collect data on the relative success of marsh recovery using various re-vegetation techniques.

Following the Deepwater Horizon oil spill, alternative shoreline cleanup treatments were tested adaptively by NOAA's Scientific Support Team in Bay Jimmy, Louisiana. A Shoreline Treatment Recommendation (STR) was developed and approved in February 2011 for field implementation of aggressive raking, cutting, and debris removal. Experimental re-vegetation of impacted marshes using smooth cordgrass (*Spartina alterniflora*) was implemented alongside remediation treatments to evaluate its efficacy in minimizing compounding damages, such as erosion of denuded shoreline.

Marsh restoration often relies on a few genotypes of smooth cordgrass developed for easier propagation, such as the cultivar *Vermilion*. However, smooth cordgrass is an ecosystem engineer that exerts influence over its environment. Population genotypes differ in ways that cascade to affect marsh properties and ecosystem function. To examine differences in marsh recovery across genotypes of smooth cordgrass, five treatment plots (3m x 3m) were established using transplanted material from each of four source populations: local Bay Jimmy genotypes, nearby Catfish Lake genotypes, cultivated Vermilion genotypes, and genotypes cultivated for high seed set and germination.

Ecosystem effects are quantified for oil properties such as hydrocarbon contamination, rate of decomposition, and microbial activity. Accretionary processes are characterized by measuring shoreline erosion, mineral sedimentation, organic deposition, and soil stabilization. Disturbances such as storm events allow for comparison of marsh resilience among sites by measuring changes in soil petroleum hydrocarbon content, vegetation cover, vegetation composition, canopy height, and the recovery rate of vegetation.

Reintroducing plants alongside shoreline cleanup has the potential to mitigate land loss and accelerate the recovery of ecosystem function. Selection of plant genotypes will influence the characteristics of restored marshes, including the provisioning of ecosystem services. Data collected from continued monitoring of oil-impacted marsh remediation and restoration experiments will inform future shoreline restoration efforts for the long-term protection of the Gulf coast.

Contact Information: Brittany M. Bernik, Department of Ecology and Evolutionary Biology, 400 Boggs Building, Tulane University, New Orleans, LA 70118, USA, Phone: 504-865-5191, Email: bbernik@tulane.edu

ECOLOGICAL IMPACTS OF A MAJOR OIL SANDS PIPELINE SPILL INTO THE KALAMAZOO RIVER AND ITS FLOODPLAIN (MICHIGAN)

M. D. Desotelle and *S. K. Hamilton*
W. K. Kellogg Biological Station, Michigan State University, Hickory Corners, MI, USA

A July 2010 oil sands (tar sands) release from an Enbridge-owned pipeline into the Kalamazoo River of southwest Michigan was one of the largest oil spills to occur in a North American river and the first major oil sands spill into a freshwater environment. The estimated recovery of oil so far totals 1.1 million gallons. The spill occurred during a period of unusually high river levels for the summer, which allowed the oil to be deposited in the largely forested floodplain once the river dropped.

Immediately after the spill, the response focused on recovery of wildlife. No fish kills were attributed to the oil. A major wildlife rehabilitation effort ensued and ultimately became focused on river turtles, which were by far the most common oil-impacted vertebrate collected in the river. Thousands of turtles were cleaned and released, as were hundreds of water birds (ducks and geese). A few mammals such as muskrats were recovered, and survival was low. Limited evidence suggests that some river macroinvertebrates were reduced in abundance by the oil spill, and fish recruitment may also have been reduced.

Cleanup efforts included manual stripping of oiled vegetation along the river corridor. Many islands were cleared of vegetation, and oil-contaminated soil was removed on islands and in the floodplain along the river. While care was taken during the clean-up, the intensity of activity has led to concerns about impacts to sensitive habitats. Wetlands are being replanted with native plant species and are to be monitored for increases in invasive species.

The pipeline break occurred 10 feet underground within a fen wetland that drains into a small tributary of the Kalamazoo River. Those wetland sediments were heavily contaminated, and clean-up involved extensive removal of oil-contaminated sediment along two miles of the tributary. Even after one year, oil has been found seeping from the subsurface into the creek. Remediation activities continue along this tributary of the Kalamazoo River.

Submerged oil has evidently been more of a problem because of the higher density of the compounds from oil sands. Dredging and aeration of sediments in the river have been conducted to recover submerged oil along the bottom of the river. The river has been noticeably more turbid than in the past as a result of clean-up activity. Other impacts of this submerged oil clean-up activity are not well understood.

Nearly 200 significant deposits of oil remain on the floodplains, and there are approximately 200 acres of submerged oil in depositional areas of the river as of Fall 2011. Clean-up will continue into summer 2012, but different options are being considered, and the potential harm to the environment from clean-up activities will be judged against the ecological risk posed by the remaining oil. In this paper, we summarize what is known about the major environmental impacts of this oil on the riverine and floodplain ecosystems, and point out research needs to better understand oil spills in floodplains and rivers.

Contact Information: Micaleila Desotelle, W. K. Kellogg Biological Station, Michigan State University, 3700 East Gull Lake Drive, Hickory Corners, MI 49060, USA, Phone: 269-671-2233, Email: desotell@msu.edu

DETERMINING THE EFFECT OF OIL WEATHERING AND DOSAGE ON JUNCUS ROEMERIANUS: A WETLAND MESOCOSM EXPERIMENT

Thomas A. Hess and *Christopher J. Anderson*
Auburn University, School of Forestry and Wildlife Science, Auburn, AL, USA

Substantial research has focused on salt marshes along the Gulf of Mexico (GOM) and their response to oil, with most studies focused on *Spartina alterniflora*. A wetland mesocosm study was conducted in 2011 to examine the effect of oil dosage and weathering on *Juncus roemerianus*, another dominant marsh plant along the GOM that has been less studied.

The study was conducted in Auburn, AL using *Juncus* sod previously harvested and transported from coastal Alabama. A total of 32 mesocosms were established in March using plastic containers (78 L) and managed to be tidally pulsed with brackish water (5-10 ppt) 3-4 times per week. Sweet Louisiana crude oil was acquired and experimentally weathered for one of three durations (0 days, 3 days, and 21 days). Oil was weathered by pouring it into metal tubs and exposing it to summer sunlight/ weather along with periodical stirring. In July, oil of each weathered type was put into mesocosms based on three experimental doses: low (6 L m^{-2}), medium (12 L m^{-2}), and high (24 L m^{-2}). Each combination of dose and weathering was replicated 2-3 times. Eight mesocosms were left untreated with oil and served as controls. Mesocosms were dosed with oil in July 2011. *Juncus* stem survival and average height were measured monthly through November and compared to pre-oiled measures.

Initial results indicate that *J. roemerianus* was sensitive to oil exposure and responded to dosage more than weathering. Average stem survival rates (relative to pre-oil counts) ranged from 43.8 ±12.1% (n=3) for low dose, 21-day weathered oil to 2.9±1.7% (n=3) for high dose, 3-day weathered oil. Control wetlands (n=8) continued to grow through the study period and had stem survival of 127.9 ±7.1% of the original June count. Photosynthetic rates of representative stems were measured on a biweekly basis to complement data collected on stem survival and growth. The results of this study will help determine the potential impacts future oil spills may have on *J. roemerianus* marshes.

Contact Information: Thomas Hess, School of Forestry and Wildlife Science, 602 Duncan Drive, Auburn, AL 36830, USA, Phone: 334-728-5153, Email: hesstho@auburn.edu

SILENT SPRING REVISITED: INSECTS AND SPIDERS IN LOUISIANA'S SALTWATER MARSHES AFTER THE MACONDO BLOWOUT

Linda M. Hooper-Bùi, *R. M. Strecker, O. Osisioma, B .J. Adams, X. Chen, E. Overton* and *R. E. Turner*
Louisiana State University, Baton Rouge, LA, USA

The sounds of a healthy saltwater marsh community include buzzes, clicks, chirps, and splashes. Healthy ecosystems can handle small disturbances or stressors such as small pulses of oil from deep seeps in the Gulf of Mexico (GOM), USA. Stressed ecosystems such as the saltwater marshes that fringe the northern GOM experienced a huge pulse of additional disturbance as a result of escaping oil from the Macondo blowout and the subsequent cleanup efforts. We studied the effect of crude-Corexit-water emulsion on the insects and spiders in saltwater marshes and compared them to the same taxa in unaffected marshes. We also compared insect and spider species richness and abundance from May 2010 – before the emulsion made landfall – to those species collected in May 2011. In most areas, we sampled for insects, spiders, and hydrocarbons not only on the edge – where we could visibly see oil – but also 20m deep into the marsh. Selected paired sites – oiled and unoiled – were sampled 100m into the marsh in 2011. All sampling had contemporaneous unoiled controls and comparable samples before the emulsion made landfall. We also conducted a 'common garden' experiment where we placed insects in floating cages 20m from the streamside edge of oiled and unoiled saltwater marshes.

Our sweep-net collections showed decreases in abundance of native grasshoppers, ants, green seedbugs, and spiders in response to the intrusion of crude-Corexit-water emulsion into the marsh and to the subsequent efforts to remediate the pollution. Conversely, cordgrass bugs increased 10x in oiled saltwater marshes compared with unoiled marshes. This may provide indirect evidence of plant stress in response to a large-pulse oiling event. Insects in cages in oiled marshes exhibited a greater mortality than those in unoiled marshes indicating that volatile compounds, possibly from the emulsion, play a role in insect/spider mortality in oiled marshes. Seventeen months post-spill, caged insects in the marsh exhibited greater mortality than controls. Our results and observations indicate widespread 'silencing' of insect and spider activity in Louisiana saltwater marshes affected by the BP Macondo blowout.

Contact Information: Linda M. Hooper-Bùi, Department of Entomology, Louisiana State University, 404 Life Sciences Building, Baton Rouge, LA 70803, USA, Phone: 225-578-7149, Fax: 225-578-7504, Email: lhooper@agcenter.lsu.edu

TOXICITIES OF OILS, DISPERSANTS AND DISPERSED OILS TO AQUATIC PLANTS: SUMMARY AND DATABASE VALUE TO RESOURCE SUSTAINABILITY

Michael Lewis and *Rachel Pryor*
U.S. Environmental Protection Agency, Gulf Breeze, FL, USA

Understanding the phytotoxicities of crude and dispersed oils is important for near-shore ecosystem management, particularly post-oil spills. One source of Information is toxicity data summaries which are scattered and outdated for aquatic plants and petrochemicals. As a result, a current review is needed to determine any advances in the published toxicity database and if risk assessments and phytotoxicity predictions can be achieved without additional data generation.

Toxicity results are summarized for oils, dispersants and dispersed oils on non-vascular and vascular plants specifically of those representative in open water and near-shore wetlands, seagrass meadows and mangrove habitats. Aquatic plants have varied morphologies, physiologies and life history characteristics that have impacted the experimental design and relevancy of phytotoxicity test results. The phytotoxicity database is historically uneven and dominated by Information generated largely as a reactive response to large oils spills. Toxicity investigations have been conducted for 3hrs to 3 yrs with at least 33 crude oils and 54 dispersants in laboratory, greenhouse and *in-situ* studies. Most toxicity Information is for weathered crude oils and dispersants no longer in use. As many as 71 structural response parameters have been determined post-petrochemical exposure for 83 species of micro- and macroalgae, 27 wetland plants, 14 mangrove species and 9 seagrasses. Most toxicity tests have been conducted with single test species, test compounds and doses. The magnitude of inhibition, stimulation and recovery observed after exposure to oils, dispersants and dispersed oils has varied with test species, life stages, test durations, types and forms of oils and dispersants, response parameters, oil-dispersant ratios, media dosed and dose application methods. As a consequence, toxic effect concentrations vary by orders of magnitude (effect concentration range = 0.025 to 10,000 ppm) which limits a relevant ranking of most oil and dispersant toxicities, sensitive plant species and response parameters. This lack of Information restricts use of species-sensitivity distributions, pre- and post oil spill phytotoxicity predictions, natural resource damage assessments and restoration efforts needed to sustain plant-dominated ecosystems. Therefore, evidence-based risk assessments for most aquatic plants and oils, dispersants and dispersed oils are not supported by the current scientific literature. This limitation was recognized over 30 years ago indicating a lack of research progress. A proactive and experimentally-consistent approach is recommended to provide baseline acute, chronic and threshold toxic effect concentrations for these contaminants and sensitive life stages of aquatic plants inhabiting diverse near-coastal habitats. Included in this effort is the need for determinations of mixture- and oil-contaminated sediment toxicities and field validation of laboratory-derived toxicity test results.

Contact Information: M. Lewis, USEPA, Gulf Breeze, FL 32561 USA, Phone 850-934-9382, Fax: 850-934-9201, Email: lewis.michael@epa.gov

IMPACTS OF THE *DEEPWATER HORIZON* OIL SPILL AND RECOVERY OF STRUCTURE AND FUNCTION IN COASTAL SALT MARSHES

Qianxin Lin and *Irving A. Mendelssohn*
Department of Oceanography and Coastal Sciences, School of the Coast and Environment, Louisiana State University, Baton Rouge, LA, USA

The *Deepwater Horizon* (*DWH*) oil spill was unprecedented in the volume of oil spilled, its differential weathering, the large geographical region that was affected, and the fact that nearly 40 percent of the coastal wetlands in the contiguous United States was at risk. The *DWH* event oiled more than 650 miles of Gulf coastal habitats. Louisiana's fragile delta habitats bore the brunt of the damage, especially in northern Barataria Bay. We conducted a series of field and greenhouse experiments to assess impacts of Macondo 252 oil on coastal wetlands. In the field, we established stations in northern Barataria Bay where coastal salt marshes have been differentially oiled. Replicated field plots that received heavy, moderate and no oiling were sampled to investigate the impact of the *DWH* oil on the ecological structure and function of coastal salt marshes. To better understand the processes controlling oil impacts to coastal wetlands, we experimentally exposed in the greenhouse marsh sods of *Spartina alterniflora* and *Juncus roemerianus*, dominant salt marsh plant species, to six oil treatments that simulate likely oiling scenarios: (1) 100% coverage of shoots with weathered *DWH* source crude oil, (2) 70% oil coverage of shoots, (3) 70% repeated oil coverage of shoots, (4) 30% oil coverage of shoots, (5) oil coverage of the soil surface and associated soil penetration, and (6) no oil as a control.

Impacts of Macondo oil to coastal wetlands have been severe in some areas and moderate in others in northern Barataria Bay. Average concentration of total petroleum hydrocarbons (TPH) of surface soil in heavily oiled marshes was as high as 510 mg g^{-1} seven months after landfall of Macondo oil along shoreline salt marshes. However, TPH concentration deceased by more than 50% after 16 months. Heavy oiling almost completely killed marsh plants, and left many bare, un-vegetated shoreline marshes in the Bay Jimmy area of northern Barataria Bay. The *DWH* oil spill primarily impacted fringing coastal marshes with heavy oiling not usually occurring more than 10 m from the shoreline. There has been negligible recovery in heavy oiled shoreline marshes even 16 months after oil landfall. Without healthy vegetation, live belowground biomass was significantly reduced, and consequently shear strength of the marsh soil has decreased, which could make marshes more vulnerable to erosion and wetland loss.

However, in moderately oiled sites, the impact was species-specific, i.e. greater impact on *J. roemerianus* than *S. alterniflora*. Live plant aboveground biomass and live plant stem density were both significantly lower for *J. roemerianus* than for *S. alterniflora* at moderately oiled sites compared to the reference sites. Our parallel greenhouse mesocosm study supported field results and indicated that *S. alterniflora* was much more tolerant to shoot oil coverage and repeated oiling than *J. roemerianus*. *Spartina* recovered from as much as 100% oil coverage of shoots in 7 months, however, *Juncus* recovery was much reduced even one year after oil exposure. Ultimate impact, recovery and sustainability of the oil-impacted wetlands will likely be controlled by a number of environmental and biotic factors.

Contact Information: Qianxin Lin, Louisiana State University, School of the Coast and Environment, Baton Rouge, LA 70803, USA, Phone: 225-578-8889, Email: comlin@lsu.edu

EFFECTS OF OIL ON THE RATE AND TRAJECTORY OF LOUISIANA MARSH SHORELINE EROSION

Giovanna McClenachan and *R. Eugene Turner*
Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, LA, USA

Oil can have long-term detrimental effects on marsh plants above- and below ground. However, there is little data available that quantifies the accelerated erosion that oil may cause to marshes and the trajectory of change. We collected data on soil strength, shoreline erosion, and soil decomposition at 30 closely spaced oiled and non-oiled sites in Bay Batiste, Louisiana. These sites were sampled bi-monthly since November 2010 and compared to data from another 80 sites sampled in May and September 2010/2011. All oiled sites in Bay Batiste are contaminated with Macondo 252 oil (oil from the BP oil spill 20 April – 15 July 2010). Preliminary results suggest that the oil is weakening the soil and causing an accelerated rate of shoreline erosion. There is no 'threshold' effect where soil parameters change dramatically with a relatively small increase in oil concentration in the soil. We will also discuss separating the influence of the background erosion rate occurring before the spill from the increased erosion due to the marsh oiling.

Contact Information: Giovanna McClenachan, Department of Oceanography and Coastal Sciences, 1231 Energy, Coast and Environment Building, Louisiana State University, Baton Rouge, LA 70803, USA, Phone: 202-907-9585, Email: gmccle2@lsu.edu

FRESHWATER DIVERSIONS PROVIDED PULSED HYDROLOGY TO COASTAL SWAMPS FOR REMEDIATION

Beth A. Middleton[1] and *Brian Roberts*[2]
[1]U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, USA
[2] Louisiana University Marine Consortium (LUMCON). Chauvin, LA, USA

Hydrological remediation to minimize oil intrusion onto the Mississippi Delta or coastal Louisiana after the Deepwater Horizon incident may have influenced functional processes in coastal wetlands. We studied ecosystem processes related the resilience of the coastal baldcypress swamps including production, decomposition and tree growth (Middleton). We also studied the emission of gases (e.g., CO_2, N_2O, CH_4; Roberts). The hypotheses tested included that in comparison to control swamps, hydrologically-remediated swamps would increase in peat accumulation, above- and below-ground production, decomposition, atmospheric emissions and elevation. Five hydrologically-remediated sites were located in Jean Lafitte NHP&P (Louisiana), and control sites included ten swamps including Big Thicket National Preserve (Texas) and St. Marks National Wildlife Refuge (Florida; five swamps in each region). We found that after the water flow rate was increased from the Davis Pond Diversion into Jean Lafitte NHP&P in 2010, the rates of tree diameter growth increased and annual root production decreased. Our research represented an opportunity to capture key shifts in processes after the remediation of the Deepwater Horizon Incident. The project was funded by a National Science Foundation RAPID award and the U.S. Geological Survey Ecosystems program.

Contact Information: Beth A. Middleton, U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA 70506, USA, Phone: 337-266-8618, Fax: 337-266-8586, Email: middletonb@usgs.gov

DISTURBANCE AND RECOVERY OF SALT MARSH ARTHROPOD COMMUNITIES FOLLOWING BP DEEPWATER HORIZON OIL SPILL

Brittany D. McCall and ***Steven C. Pennings***
University of Houston, Houston, TX, USA

Oil spills represent a major environmental threat to coastal wetlands, which provide a variety of critical ecosystem services to humanity. The U.S. Gulf of Mexico is a hub of oil and gas exploration and production with recognized consequences on intertidal habitats, such as the salt marsh. Following the BP Deepwater Horizon oil spill, we sampled the marine invertebrate and the terrestrial arthropod community found in stands of *Spartina alterniflora*, the most abundant plant in coastal salt marshes, in 2010 as oil was washing ashore and a year later in 2011. In 2010, intertidal crabs and terrestrial arthropods (insects and spiders) were suppressed by oil exposure even in seemingly unaffected stands of plants; however, *Littoraria* snails appeared unaffected. One year later, crab and arthropods appeared to have largely recovered. Our work is the first attempt that we know of assessing vulnerability of the salt marsh arthropod community to oil exposure, and it suggests that arthropods are both quite vulnerable to oil exposure, and quite resilient, able to recover from exposure within a year if host plants remain healthy.

Contact Information: Steven C. Pennings, Department of Biology and Biochemistry, University of Houston, Houston TX 77204, USA, Phone: 713 743 2989, Email: spennings@uh.edu

COASTAL WETLAND NATURAL RESOURCE DAMAGE ASSESSMENT PLAN FOR THE DEEPWATER HORIZON OIL SPILL

Mark W. Hester[1], *Jonathan M. Willis*[1] and ***Marla Steinhoff***[2]
[1]University of Louisiana, Lafayette, LA, USA
[2]National Oceanic and Atmospheric Administration, Seattle, WA, USA

The Deepwater Horizon oil spill affected an array of coastal environments, including the diverse coastal wetland habitats that occur along the northern Gulf of Mexico. As a part of the Natural Resource Damage Assessment (NRDA) for the Deepwater Horizon oil spill, a spatially-extensive evaluation of the coastal wetland habitats of Louisiana, Mississippi, and Alabama was initiated in the fall of 2010. This evaluation, which is ongoing as described below, is based on the assessment of specific plant and soil response metrics, which if desired can be related to corresponding ecological processes and resultant ecosystem services.

Five (5) vegetation oiling categories were initially established based on the percentage of aboveground stem height that was oiled as follows: reference (no oil observed from this spill), trace to <10%, 10% to <50%, 50% to <90%, 90% to 100%. Coastal wetlands were classified into the following habitat types: mainland salt marsh, backbarrier salt marsh, coastal black mangrove marsh, Mississippi River Delta *Phragmites* marsh. Within each habitat type by oiling category combination, a minimum of seven (7) sites (replicates) were randomly selected from a pool of potential sites where property access rights were granted. At each site, a shore-perpendicular transect was established that extended into the marsh 20m or 30 m depending on the degree of oil penetration. Three (3) sampling zones were established at each transect. Paired permanent plots were established at each zone for non-destructive cover plot determinations as well as productivity plots for destructive sequential biomass harvesting. In summary, 164 transects were established in Louisiana. In Mississippi and Alabama transects were established to the extent possible.

A suite of plant and soil metrics that are representative of specific wetland ecological processes and associated ecosystem services were measured. Ecosystem services of coastal wetlands include primary production, provision of marsh habitat, marsh sustainability, carbon sequestration, nutrient cycling, and biogeochemical processes. Examples of specific vegetation metrics include live and dead plant cover by species, live and dead aboveground biomass and stem density by species, belowground biomass, percentage of plant stems oiled, percentage of soil surface oiled, vegetation condition index, leaf chlorophyll index, leaf quantum efficiency of photosystem II, and average canopy height of dominant species. Black mangrove habitats also include determinations of pneumataphore oiling, tagged seedling and adult tree survivorship, heights, trunk diameter, canopy area, and fall propagule production. Edaphic (soil) metrics include soil hydrocarbon analyses, soil bulk density, soil organic matter, soil grain size distribution, soil interstitial pH, salinity, ammonium, nitrate/nitrite, phosphorous, sulfate, and specific cations and trace metals. Associated measurements at each transect include change of shoreline position (erosion), and plot and transect profile elevations (NAVD88). To date, sampling has occurred in fall 2010, spring 2011, and fall 2011.

Contact Information: Marla Steinhoff, 7600 Sand Point Way NE, Bldg 1 DARC, Seattle, WA 98115, USA, Phone: 206-526-6341, Fax: 206-526-6665, Email: Marla.Steinhoff@noaa.gov

DEEPWATER HORIZON OIL SPILL: SALT MARSH TREATMENT TESTING AND MONITORING, NORTHERN BARATARIA BAY

Scott Zengel[1,2], *Jacqueline Michel*[1,3] and *Eric Schneider*[1,2]

[1]NOAA Scientific Support Team, DWH SCAT Program, New Orleans, LA, USA
[2]Atkins North America, Tallahassee, FL, USA
[3]Research Planning, Inc., Columbia, SC, USA

The Deepwater Horizon oil spill resulted in heavy oiling conditions in the *Spartina alterniflora* and *Juncus roemerianus* dominated salt marshes of Northern Barataria Bay, Louisiana, more so than in any other location in the Gulf. Persistent marsh oiling included heavily oiled vegetation mats and wrack that overlaid a thick layer of emulsified oil (mousse). Oiling bands were typically 10 m wide and continuous (91-100% cover). The mousse layer averaged 2-3 cm in thickness and did not appear to be weathering or degrading where trapped below the oiled vegetation mats and wrack.

Due to the degree and nature of oiling, typical marsh cleanup methods were not effective. There was concern that long-term oiled marsh recovery could be at risk without some form of treatment. The competing concern was that aggressive cleanup could cause further damage, delaying or limiting recovery, as has been observed following many previous spills. Due to these factors, an adaptive marsh treatment testing program was conducted using 6 m x 10 m test plots. Treatment methods that showed promise were replicated, as were a set of natural recovery (no treatment) and reference plots. All plots were monitored monthly for one year (to date). Vegetation, oiling conditions (excluding the reference plots), and the degree of wave exposure were similar among plots.

The initial treatment tests and monitoring ruled out several treatments, and supported the cancellation of some on-going cleanup, due to ineffectiveness and marsh damage. Subsequent treatment tests indicated that a combination of raking and cutting effectively removed the oiled vegetation mats and wrack, reduced the mousse layer, and resulted in the predominance of weathered surface oil residue, rather than mousse, on the marsh surface; without obvious detrimental effects to the marsh.

Longer-term monitoring confirmed the desirable changes in oiling conditions, and indicated that the raking and cutting treatments aided the early stages of vegetation recovery, as well as initial recovery for some intertidal fauna such as fiddler crabs (*Uca* spp.), as compared to other treatments. Sediment sampling indicated that oil was not mixed into the underlying sediments as a result of treatment, as has been observed during past spills. Raking and cutting also enhanced the weathering of residual oil in the marsh. Monitoring indicated that storm-driven oil remobilization from the marsh into previously un-oiled areas was minimized for the raking and cutting treatments versus no treatment.

The treatment tests and monitoring results were used to develop an operational-scale cleanup plan. This plan was implemented over 11 km (7 mi.) of marsh shoreline. 6,429 cubic yards and 536 tons of oil and vegetation/debris were removed during cleanup operations. The intensive treatment methods used in this case would not be appropriate for the majority of oil spills in salt marsh, and in many cases, could result in further damage. Even during this spill, only the most heavily oiled marshes were intensively treated; a small fraction (~1%) of the nearly 500 miles of marsh shorelines oiled across the Gulf. Natural recovery was the appropriate approach for the majority of oiled marshes.

Contact Information: Scott Zengel, Atkins North America, 2639 North Monroe Street, Building C, Tallahassee, FL 32303, USA, Phone: 850-575 1800, Cell: 850-212-3155, email: scott.zengel@atkinsglobal.com

WATER QUALITY/CONTAMINANTS - SALINITY

MONITORING OF FLORIDA ESTUARIES WITH A FLOW MAPPING SYSTEM

Mayra Ashton, *Cecilia Conrad* and *Barbara Welch*
South Florida Water Management District, West Palm Beach, FL, USA

Water quality parameters (salinity, chlorophyll, turbidity and dissolved oxygen) were monitored and mapped in the Caloosahatchee and St. Lucie Estuaries using a flow mapping system to characterize the effects of different freshwater flow scenarios with emphasis on the low salinity zone. The flow mapping system was used to create high resolution maps of these water quality parameters. Results will show the location of the low salinity zone (1.0 – 10 ppt), in addition to the location and intensity of the chlorophyll and turbidity maximum zones during different seasons (dry and wet) and flow conditions (volume and timing). Study findings will guide implementation of low level freshwater releases during the dry season to the Caloosahatchee and St. Lucie Estuaries according to the Lake Okeechobee Regulation Schedule (USACE, 2008). Information generated by this study will also support the operation of other projects such as Ten Mile Creek, IRL South and the C-43 West Basin Storage Reservoir.

Contact Information: Mayra Ashton, Coastal Ecosystem Sciences Section, South Florida Water Management District, 3301 Gun Club Road, West Palm Beach, FL 33406, USA, Phone: 561-682-2168, Email:mashton@sfwmd.gov

VARIATION IN SALINITY TOLERANCE OF LARVAL AMPHIBIANS: IMPLICATIONS FOR COMMUNITY COMPOSITION IN COASTAL WETLANDS

M.E. Brown and *S.C. Walls*
[1]U.S. Geological Survey, Gainesville, FL, USA

Amphibians in freshwater coastal wetlands bordering the Gulf of Mexico periodically experience acute exposure to salinity from hurricane-related overwash events, as well as chronic exposure associated with rising sea levels. In a comparative experimental approach, we tested the hypothesis that seven species of amphibians vary in their tolerance to changes in salinity. In a laboratory study, we exposed larval *Hyla cinerea* (Green Treefrog), *H. squirella* (Squirrel Treefrog), *Lithobates catesbeianus* (American Bullfrog), *L. sphenocephalus* (Southern Leopard Frog), *Anaxyrus terrestris* (Southern Toad), and *Gastrophryne carolinensis* (Eastern Narrow-mouthed Toad) from an inland population in Gainesville, Florida and *Osteopilus septentrionalis* (Cuban Treefrog) tadpoles from Picayune Strand State Forest, Collier County, Florida, USA to acute salinity for three days. For each species, we exposed tadpoles to 0.2 (control), 5, 10, 12, 14, and 16ppt with 30 replicated trials of each treatment. In all species tested, tadpoles reared in the control and 5 ppt treatments had 96.7 – 100% survival, yet no individual survived in the 14 or 16 ppt treatments. Survival varied among species in the intermediate treatments (salinities of 10 and 12 ppt). At 10 ppt, survival in native species ranged from 46.7 to 80%, except for Narrow-mouthed Toad tadpoles, of which none survived at salinities of $\geq$10 ppt. In contrast, survival was 100% for the invasive, nonindigenous Cuban Treefrog at this salinity. At 12 ppt, survival in all native species was 0% except for the Green Treefrog, of which only 3.3% survived. Survival of Cuban Treefrogs remained relatively high (75.9%) at this salinity. Our results illustrate that the non-native Cuban Treefrog has a higher salinity tolerance than do native species, which may contribute to its invasion potential. Moreover, species commonly associated with coastal freshwater wetlands differ in their salinity tolerances, suggesting that salt water intrusion due to storm surges and sea level rise may affect the species composition of these ecosystems.

Contact Information: Mary Brown, United States Geological Survey, Southeast Ecological Science Center, 7920 NW 71st Street, Gainesville, FL 32653 USA, Phone: 352-264-3534; Fax: 352-395-6608, Email: mbrown@usgs.gov

WATER-QUALITY MAPPING AND MONITORING EFFORTS IN THE TIDAL CALOOSAHATCHEE RIVER AND DOWNSTREAM ESTUARIES

Amanda C. Booth, presented by: ***Eduardo Patino***
U.S. Geological Survey, Fort Myers, FL, USA

Historically the Caloosahatchee River was a shallow, meandering river with headwaters near Lake Hicpochee. The modern Caloosahatchee River (C-43) has been channelized and connected to Lake Okeechobee, significantly increasing its watershed. Three control structures (S-77, S-78 and S-79) regulate flow and stage. The Franklin Locks (S-79) control the flow of the Caloosahatchee River into its tidal reach and downstream estuaries.

The U.S. Geological Survey initiated a study with funding from the Greater Everglades Priority Ecosystem Science (GEPES) program and in collaboration with the U.S. Fish and Wildlife Service, to address hydrologic and water quality Information needs in the area. Data collection began in March 2010 with the collection of continuous stage, discharge, and water-quality sensor data at McIntyre Creek, located within J.N. "Ding" Darling National Wildlife Refuge, Sanibel Island. Beginning in June 2011, these data were augmented through water-quality surveys conducted on a quarterly basis and in response to environmental events such as freshwater releases, algal blooms and hypoxia. Salinity, temperature, dissolved oxygen, pH, turbidity, chlorophyll a, cyanobacteria (phycoerythrin) and colored dissolved organic matter were collected at McIntyre Creek Station and during moving boat surveys. Geo-referenced data were measured at 10 second intervals during moving boat surveys in order to create high resolution water-quality maps of the study area.

Freshwater releases at S-79 precede salinity reductions in the tidal Caloosahatchee River and downstream estuaries. Mean discharges at S-79 were 4,872 cfs in July 2010 and 211 cfs in January 2011; corresponding monthly mean salinities at McIntyre Creek were 25 and 32 ppt. On June 3, 2011 salinities were 16 ppt near S-79, and 30-32 ppt at the Cape Coral Bridge. In contrast salinities were ≤ 2 ppt from S-79 to the Cape Coral Bridge on October 21, 2011. Dissolved oxygen levels in the Caloosahatchee River and neighboring estuaries reach hypoxic levels (<2 mg/L) intermittently. The lowest dissolved oxygen recorded at McIntyre Creek was 1.1 mg/L on June 17, 2010 and August 10, 2011. Dissolved oxygen levels were <2 mg/L near S-79 on September 30, 2011.

Additional freshwater sources, including the Cape Coral Spreader Canal system, affect water-quality in the estuary, specifically in Matlacha pass. Freshwater discharges from the Cape Coral Spreader Canal System, as observed during multiple surveys in the fall of 2011, enter Matlacha Pass and eventually mix with the waters of the Caloosahatchee estuary. Moving boats surveys have detected elevated chlorophyll a levels during multiple sampling events as well as low dissolved oxygen levels (<3 mg/L) on September 30, 2011. Preliminary observations indicate the need for additional monitoring at the outflow of the Cape Coral Spreader Canal System and within Matlacha Pass.

Contact Information: Amanda Booth, Florida Water Science Center, U.S. Geological Survey., 1400 Colonial Blvd., Suite 70, Fort Myers, FL 33907 USA, Phone: 239-275-8448, Fax: 239-275-6820, Email: acbooth@usgs.gov

WATER QUALITY/CONTAMINANTS - TOXIC ORGANICS

POLYCYCLIC AROMATIC HYDROCARBON (PAH) CONTAMINATION IN THE CARONI SWAMP, TRINIDAD, WEST INDIES

La Daana Kada Kanhai[1], *Judith Gobin*[1], *Azad Mohammed*[1] and *Denise M. Beckles*[2]

[1]Department of Life Sciences, University of the West Indies, St. Augustine, Trinidad and Tobago

[2]Department of Chemistry, University of the West Indies, St. Augustine, Trinidad and Tobago

Wetlands rank amongst the most highly productive ecosystems in the world. They provide several important ecosystem services and are vital to human well-being. However, these ecosystems are facing anthropogenic degradation as a result of the entry of pollutants such as hydrocarbons. Currently, a knowledge gap exists regarding the status of tropical wetlands. Consequently, studies on the assessment of priority pollutants in tropical wetlands and their potential impacts are essential.

This study focused on the Caroni Swamp; the largest mangrove ecosystem in Trinidad and Tobago. Overall, the aims of this study were (i) to investigate the extent of PAH contamination in the swamp and (ii) to assess the potential threat which PAHs may pose to aquatic life and human health. PAH levels were determined in the sediments, mangrove oysters (*Crassostrea rhizophorae*) and Madamango sea catfish (*Cathorops spixii*) at 10 sites in the Caroni Swamp and at one site in the Nariva Swamp (reference site). The potential threat to aquatic life posed by sediment PAH levels was assessed using the Canadian Sediment Quality Guidelines (CSQGs). Additionally, the potential health threat posed by PAHs in mangrove oysters and Madamango sea catfishes to human consumers was assessed using international guidelines proposed for fish/fishery products (Ministry of Lands and Parks, British Columbia 1993; EU 2006).

Overall, univariate and multivariate analyses revealed that for the majority of sites in the Caroni Swamp, there was no significant difference in PAH levels in the sediments and biota. However, certain sites were distinctly characterised by high PAH levels in either the sediments or biota. These sites were influenced primarily by riverine inputs (from the Caroni and Cunupia Rivers) and anthropogenic activities within the swamp (e.g. the operation of boats). Results indicated that PAHs (USEPA's 16 priority PAHs) posed a low to medium risk to aquatic life in the Caroni Swamp. Additionally, benzo[a]pyrene levels in mangrove oysters presented a significant health threat to human consumers of shellfish. This study emphasized that PAH contamination in the Caroni Swamp was capable of adversely affecting aquatic life in the swamp and more importantly threatening the health of human consumers of shellfish.

<u>Contact Information</u>: La Daana Kada Kanhai, Department of Life Sciences, University of the West Indies, St. Augustine, Trinidad and Tobago, Phone: +1 (868) 662 2002 x82047, Fax: + 1 (868) 663 5241, Email: ladaanakada@yahoo.com

THE ROLE OF GROUNDWATER FLOW IN EVERGLADES LANDSCAPE RESTORATION

René M. Price[1&2], *Pamela L. Sullivan*[1], *Michael S. Ross*[1&2], *Leonard J. Scinto* [1&2], *Eric Cline*[3], *Thomas Dreschel*[3] and *Fred Sklar* [3]

[1]Department of Earth and the Environment, Florida International University, Miami, FL, USA

[2]Southeast Environmental Research Center, Florida International University, Miami, FL, USA

[3]South Florida Water Management District, Everglades Systems Assessment Section, West Palm Beach, FL, USA

Hydrologic conditions in the Florida Everglades (USA) have been drastically altered over the last century by the construction of canals, dikes and levees used to provide agricultural land, water storage areas, and flood protection to the residents of South Florida. The constructed physical structures have interrupted the natural flow of surface water across the Everglades resulting in a homogenization of the characteristic ridge-slough-tree island landscape as well as a loss of over 80 percent of the tree islands in some areas. To gain a better understanding of the hydrologic conditions necessary to maintain and restore the Everglades landscape, the South Florida Water Management District, in conjunction with the Army Corps of Engineers, created the Loxahatchee Impoundment Landscape Assessment (LILA) in 2002. LILA serves as a large physical model of the Everglades, spanning over 34ha in size and consisting of four 8ha macrocosms that mimic the ridge-slough-tree island topography. Each macrocosm consists of two islands constructed of differing geologic material (peat or limestone and peat) located in a slough with an adjacent ridge. Trees saplings were planted on the islands in 2006 and 2007. The objective of this research was to identify groundwater flow patterns across the constructed Everglades landscape in response to tree growth. Since 2007, groundwater and surface water levels were monitored across LILA. Within 1.5 – 2 years after planting of the tree saplings, a depression in the groundwater table was observed under the tree islands during the dry season in response to increased transpiration by the trees. The depth of the water table depression was greatest under islands composed of limestone and peat, compared to those composed entirely of peat. During extreme drought conditions, the water table depression under the islands was greatest, causing groundwater to flow from the ridge, beneath the slough, and towards the tree island. We conclude that aboveground vegetation on tree islands plays a significant role in local groundwater flow paths within the Everglades landscape.

Contact Information: René M. Price, Department of Earth and Environment, Florida International University, ECS 347, 11200 SW 8th Street, Miami FL, 33199, USA, Phone: 305-348-3119, Fax: 305-348-4096, Email: pricer@fiu.edu.

HISTORICAL DEPOSITION OF PAH, PESTICIDE, AND METAL CONTAMINANTS IN CLAM BAYOU, ST. PETERSBURG, FLORIDA

Renee A. Price[1], *Thomas J. Whitmore*[2], *Melanie A. Riedinger-Whitmore*[1], *William F. Kenney*[2] and *James G. Flocks*[3]

[1]University of South Florida St. Petersburg, St. Petersburg, FL, USA
[2]University of Florida, Gainesville, FL, USA
[4]U.S. Geological Survey, St. Petersburg, FL, USA

Polycyclic aromatic hydrocarbon (PAH), pesticide, and metal contamination in estuarine sediments often results from runoff of residential and commercial developments in coastal areas. We conducted a survey of surface sediments in Clam Bayou, St. Petersburg, Florida to examine the spatial distribution of contaminants, and to relate contaminant concentrations to sediment type. We also collected 5 sediment cores and endeavored to date the cores with 210Pb to assess changes in contaminant deposition over time.

The surface survey examined contaminant concentrations in sediments from mangroves, storm water channels, and open-water areas within the estuary. PAH, pesticide, and metal concentrations as well as organic matter content were assayed in the top 5 cm of sediment in the surface survey, and at 4-cm intervals in sediment cores to a depth of approximately 60 cm in each core.

Sites with greatest contaminant inventories had closest proximities to channelized storm water inputs. Higher contaminant concentrations were observed in mangrove areas, where organic-rich sediments preserved better records of contaminant delivery. Maximum PAH, pesticide, and metals concentrations (e.g., benzofluoranthene 8800 µg/kg; fluoranthene 9900 µg/kg; chrysene 6300 µg/kg; chlordane 440 µg/kg; sum DDE 37 µg/kg; lead 159 mg/kg) at certain mangrove sites exceeded guidelines for residual contaminant levels in soils at non-industrial sites for direct pathway Contact, and probable effects concentrations (PECs) for toxicity to aquatic benthic fauna.

Contaminant concentrations in sediment cores increased over time with sediment deposition because of storm water runoff from developments along the coastline. As waters shoaled and mangroves proliferated, increased deposition of organic matter from sediment trapping and leaf litter accumulation contributed to greater trap efficiency of contaminants in sediments.

Contact Information: Renee A. Price, Environmental Science and Policy, University of South Florida St Petersburg, St. Petersburg, FL 33701, USA, Phone: 813-873-4971, E-mail: reneeprice@mail.usf.edu

WETLAND ASSESSMENT & REGULATION
- CREATION MITIGATION AND MONITORING

BENEFITS OF TREE SPADING WHEN CREATING CYPRESS SYSTEMS IN WEST CENTRAL FLORIDA

Eva E. Bailey
Cardno ENTRIX, Riverview, FL, USA

In Florida the scoring system used by the State and many county regulatory agencies or development plan review groups, factors in time lag (the time from planting to maturity) when calculating the value of mitigative efforts to offset unavoidable wetland impacts. For forested systems the time lag factor can significantly increase the size of on-site created wetlands when this form of compensation is the most appropriate or feasible. To eliminate or greatly reduce the time from planting to a more fully functional forested wetland, mature trees can be moved by spading. The obvious advantages are essentially instant success, and preservation of uplands that would have been used to create larger compensatory wetlands.

Several cypress wetlands were built in this manner in conjunction with the creation of a large residential development in west central Florida (Pasco County). During the spading operation other plants were moved with the trees, along with the soil around each tree in the spade. An effort was also made to move clumps of shrubs to the created wetland. While doing permit-required monitoring of these wetlands it has become apparent that this "instant success" was much more comprehensive than just the presence of large trees and decreased time lag. Other less obvious advantages observed are:

The immediate presence of a suite of plant species more like a mature natural cypress wetland,
Rapid cover by desirable groundcover species, and
Tree reproduction/recruitment.

To determine if these other advantages exist, comparisons were made between these spaded cypress wetlands and natural mature cypress wetlands, and between the spaded wetlands and typical created cypress wetlands planted with nursery material. Comparisons were made with created and natural cypress wetlands in the vicinity of these spaded wetlands only.

If these "instant wetlands" are as similar to natural systems as they appear, then this method of moving parts of wetlands should be used more frequently and given more credit. In addition, spading doesn't have to be limited to forested creation. Any created wetland could benefit by introducing species found in mature systems, by-passing years of early colonizer species and perhaps reducing the need for herbicide application to control nuisance/exotic plants.

Contact Information: Eva E. Bailey, Cardno ENTRIX, 3905 Crescent Park Drive, Riverview, FL 33578, USA, Phone: 813-664-4500, Fax: 813-664-0440, Email: eva.bailey@cardno.com

EFFECTS OF WELL DESIGN AND SENSOR TYPE ON THE MEASURED HYDROPERIOD OF A HIGH CLAY CREATED WETLAND SOIL IN VIRGINIA, USA

W. Lee Daniels*, Michel Beck, Nicole Troyer, John Galbraith* and *Gaber Hassan*
Dept. of Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA

Accurately monitoring depth to saturation in clayey compacted soils within created wetlands is complicated by a number of factors including the capillary fringe, soil structure effects, and presumably, slow water level response time in wells and piezometers. Furthermore, current created wetland designs in the eastern USA frequently rely on a heavily compacted subsoil layer to limit groundwater seepage losses which frequently creates epiaquic conditions where the surface saturated zone is intermittently "perched" above deeper unsaturated zones. Standard monitoring wells are often open-screened from – 15 to – 45 cm and that open screened increment may include both unsaturated and saturated zone, resulting in an erroneous estimation of the actual depth to saturation (zero potential surface). The overall objective of this research program is to determine the most accurate combination of well design and sensor technology for monitoring the actual height/depth of saturation in high clay soils in created wetlands.

First, we investigated the accuracy and response time of standard USCOE wells, nested piezometers, tensiometers and TDR probes in greenhouse mesocosms filled with a uniformly compacted and structureless sandy clay loam soil as we precisely varied depth to saturation. All designs/devices tested were relatively accurate at predicting depth to saturation and their response time was surprisingly rapid. In a follow-up study at a created wetland with a compacted high clay subsoil in Prince William County, Virginia, we monitored over 140 wells, piezometers and tensiometers of varying design for over one year. At each of three replicate locations, we monitored standard USCOE wells, piezometer nests, tensiometer nests and 12 different well/piezometer designs where we varied soil boring and well diameter, installation depths, screen and filter pack specifications, and other parameters. All wells and sensors were monitored for 15 months and the central array of automated wells was monitored for 30 months.

Overall, this site exhibited a very complex seasonal hydroperiod where during the winter months it remained ponded and fully saturated to - 1.0 m. During the spring and early summer, the site dries from the surface and water levels drop regularly. However, summer and fall storms generate frequent perching events where as much as 20 cm of ponded/saturated soil is maintained for extended periods above an unsaturated subsoil. In the fall, the site is typified by a perched (epiaquic) system until sufficient slow percolation plus local groundwater inputs saturate the subsoil and lead to a fully reconnected saturated zone with depth. Standard USCOE monitoring wells generated a similar water level response to both shallow (15 cm) and moderate depth (45 cm) piezometers, but as expected, projected an integrated water/head level between the two piezometers during the drier summer period. While all of the 12 different well/piezometer designs generated a similar overall seasonal response, they varied as much as 10 to 15 cm in measured water levels during the wet ponded winter period and even more strongly during summer wet/dry cycles. The relative response of certain designs (e.g. open auger hole vs. ceramic cap piezometers) varied strongly among the three replicate sites.

Contact Information: W. Lee Daniels, CSES Dept., 0404, Virginia Tech, Blacksburg, VA, 24061, USA. Phone: 540-231-7175; Fax: 540-231-7630; Email: wdaniels@vt.edu

PIONEERING LARGE-SCALE COASTAL WETLAND AND PRAIRIE RESTORATION DESIGN IN SOUTHEASTERN TEXAS

***Pamela J. Fetterman*[1]**, *Richard W. Earp*[2], *Peter K. Partlow* and *Ryan Mitchell*[2]
[1]E Sciences, Inc., Sarasota, FL, USA
[2]E Sciences, Inc., Orlando, FL, USA

Located in southeastern Texas near Winnie and surrounded by the Anahuac National Wildlife Refuge (ANWR), the Gulf Coastal Plains Wetland Mitigation Bank is the first brackish and intermediate tidal bank permitted in the Galveston District of the United States Army Corps of Engineers. This large-scale wetland restoration mitigation bank, in addition to tidal wetlands, will also establish freshwater depressional wetlands and coastal upland prairie to former rice farms. The bank comprises 1,851 acres of leeved farm land at the confluence of East Bay Bayou on the western property boundary and Elm Bayou on the eastern boundary. Prior to agricultural conversion in the 1940s, the northern half of the site contained a matrix of depressional wetlands, coastal prairie and pimple mounds with multiple tributaries and shallow, ephemeral internal drains that eventually fed into East Bay and Elm Bayous. The southern half of the bank site likely contained tidally influenced intermediate wetlands. The elevation of the area is relatively flat between these tributaries, thus historically large expanses of intermediate wetland grading to multiple, shallow, freshwater, depressional wetlands with transitional wet prairie occurred throughout the landscape and held large quantities of fresh water for waterfowl and other wildlife.

The restoration design utilized surveyed topographic data of the site and of existing reference wetlands and tidal creeks within the surrounding ANWR, as well as black and white aerial imagery from the 1930s that was photo-interpreted to determine historic hydrology and wetland features prior to conversion into agriculture. Thirty years of historic water level data for East Bay Bayou from the Trinity Bay Conservation District was correlated to NOAA tidal gages to ascertain long-term trends in seasonal low and high tidal stages in East Bay Bayou. Salinity regimes were also measured in East Bay Bayou concurrently with water level measurements. Tidal marsh platform elevations and stream plan and profiles were determined relative to expected mean high and low tidal stages and ANWR reference wetland data. The speciation for targeted wetland community types within the southern, tidal portion of the bank is relative to the expected salinity gradient and design hydrography. Background water level gages were also strategically located and installed throughout the northern, freshwater portion of the site and data from these gages were analyzed to determine expected hydroperiods and stages for freshwater wetlands. Depressional, freshwater wetland slope and depth were designed to function across a range of hydrologic regimes from temporary to permanently flooded by ponding of internal and offsite surface water flow through shallow, interconnecting sloughs and through intercepting the water table during seasonal high water levels. The intended result of the freshwater design is to create a gradual species zonation similar to natural, coastal prairie depressional wetlands. The water regimes and expected community types were categorized utilizing the United States Fish and Wildlife Service Hydrogeomorphic Classification System (Cowardin et al, 1970).

<u>Contact Information</u>: Pamela J. Fetterman, E Sciences, Inc. 2831 Ringling Boulevard, D-116, Sarasota, FL 34239, USA, Phone: 941-955-4616, Cell: 941-321-8107 Email: pfetterman@esciencesinc.com

TWO YEAR SURVIVAL AND GROWTH OF SEVEN WETLAND TREE SPECIES IN THREE HYDROLOGICALLY DISTINCT HABITATS

H. W. Hudson, III and *J. E. Perry*
Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, VA, USA

Success criteria for forested wetland compensation for Virginia, USA, mitigation banks requires 1) a tree density of >495 stems/ha and 2) a minimum increase in height of 10% per year. The purpose of this study, in part, was to investigate the survival and growth of different woody species and planting types. A long term large-scale mesocosm study consisting of three hydrologically distinct cells (Ideal, Saturated, and Flooded) was established in New Kent, Co., Virginia, USA. Plantings consisted of seven woody species (*Betula nigra, Liquidambar styraciflua, Platanus occidentalis, Quercus bicolor, Q. palustris, Q. phellos,* and *Salix nigra*) and three planting types (bare root, tubeling and 1 gallon). A total of 2772 saplings (44 trees of each species planting type combination for a total of 924 saplings per cell) were planted in the Spring of 2009. Survival and growth (height, canopy diameter, and basal diameter) of all trees were measured three times per year. There was significant three-way interaction among cell, species and planting type when analyzing both probabilities of survival ($p<0.0001$) and relative growth rates (RGR) at 18 months ($p<0.0001$). Therefore, additional comparisons were performed within each cell resulting in significant two-way interaction among species and planting type, suggesting that survival and growth was not uniform across species and planting types. Gallon planting type had greater survival probability and relative growth rates while the bare root and tubeling had decreased survival and growth. *Betula nigra* exhibited increased growth in the Ideal and Saturated cells, while *S. nigra* exhibited increased survival and growth in the Flooded cell. The percentage of all trees that satisfied the minimum 10% increase in height per year in the Ideal, Saturated and Flooded cells was 58.9%, 50.0% and 26.9%, respectively. These results suggest that depending on the particular requirements (survival or growth) of forested wetland compensation sites, the most appropriate woody planting stock depends on site hydrology, species and planting type in combination and that the minimum woody growth rate in Virginia may be difficult to obtain in very wet sites.

Contact Information: H. W. Hudson III, Virginia Institute of Marine Science, College of William & Mary, P.O. Box 1346, Gloucester Point, VA, 23062, USA, Phone: 804-684-7549, Email: hwhudson@vims.edu

TARGETED ECOLOGICAL RESTORATION THROUGH SHALLOW WETLAND MITIGATION BANKING WITH WOOD STORK BENEFITS

Jason A. Lauritsen[1] and *Tim Durham*[2]
[1]National Audubon Society, Naples, FL, USA
[2]Stantec, Naples, FL, USA

Cumulative losses of shallow wetlands in southwest Florida has decreased foraging opportunity early in the breeding season for the endangered wood stork (*Mycteria Americana*), contributing to a delay in nesting and a decline in nesting productivity. Preservation, restoration and creation of productive shallow wetland habitats are vital to wood stork recovery efforts in this historically important breeding area.
The Panther Island mitigation bank expansion site on Corkscrew Swamp Sanctuary has been designed to recoup some of these shallow wetland losses in a manner that increases the foraging value for wood storks and other wading birds early in the breeding season.

Since the time of European development, Southwest Florida has lost over 830 square miles of wetlands. Development patterns have resulted in disproportionate wetland impacts. Shallow wetlands with hydroperiods less than 180days per year have been affected significantly more than deeper wetlands with longer hydroperiods. Wet prairies have been particularly hard hit, with a reduction of over 70% of their historic extent. Within the core foraging area (CFA) of the Corkscrew wood stork colony, wet prairies have declined over 82%. Wet prairies contribute significantly to wood stork foraging opportunities, however due to their shallow wetland profile they are susceptible to hydroperiod alteration, non-native floristic invasions, and continue to be targeted for dredge and fill projects at a greater rate than deeper wetlands.

Efforts to offset wetland impacts typically fail to identify, measure and mitigate the specific and important wetland functions afforded by shallow wetlands. Mitigation banking represents tremendous potential to assist in important ecological restoration and listed species recovery goals while seeking to comply with the “no-net-loss” of wetlands policy. The Panther Island mitigation bank expansion on Corkscrew Swamp Sanctuary has been designed with the implicit goal of restoring shallow herbaceous wetlands on hundreds of acres of heavily drained agricultural fields. The bank lies within a few hundred meters of the largest wood stork breeding colony in the United States. Key elements of the bank include engineered micro-topographic contours designed to concentrate aquatic fauna at intentional wading bird foraging locations from late October through December. Given the scarcity of this type of wetland in southwest Florida, and it’s role in the life cycles of numerous wetland dependent species, this mitigation bank promises to provide important regional benefits.

Contact Information: Jason A. Lauritsen, Corkscrew Swamp Sanctuary, National Audubon Society, 375 Sanctuary Rd. Naples, FL 34120, USA, Phone: 239-229-8170, Fax: 239-348-9122, Email: jlauritsen@audubon.org

USE OF INDICATOR OF REDUCTION IN SOILS (IRIS) TUBES AS A PERFORMANCE MEASURE IN WETLAND RESTORATION

David M. Mahnken
E Sciences, Inc., Orlando, FL, USA

The restoration of hydrologic conditions that support the development of hydric soils and the reestablishment of hydrophytic vegetation in wetland restoration projects is typically measured through the evaluation of seasonal hydropatterns, quantifying the occurrence of hydrophytic vegetation, and direct observations of indicators of hydric soils. The National Technical Committee for Hydric Soils (NTCHS) has approved the use of Indicator of Reduction in Soils (IRIS) tubes as a tool for the identification of anaerobic and reduced conditions in potential hydric soils. Furthermore, the United States Army Engineer Research and Development Center in Vicksburg, Mississippi has provided guidance on using IRIS tubes together with application of the NTCHS Technical Standard in a regulatory setting to assist in identification of anaerobic and reduced conditions. Recently, the United States Army Corps of Engineers has allowed the use of IRIS tubes under the NTCHS Technical Standard as part of a bottomland hardwood forest restoration plan to demonstrate potential reestablishment of hydric soils.

Numerous studies have been conducted to develop the NTCHS Technical Standard that addresses the reduction potential of hydric soils and corresponding removal of iron oxides and oxyhydroxides from the IRIS tube. In this study IRIS tubes were installed at 13 monitoring plots at a bottomland hardwood forest restoration site in north central Louisiana. The purpose of using the IRIS tubes was to compare field observations of hydric soils along with other metrics of restoration success established by an approved wetland restoration plan to the percentage of reduction observed in the IRIS tubes. The project compares the reduction observed from the IRIS tubes with field observations of hydric soil indicators and the reestablishment of hydrophytic vegetation and how these observations support or fail to support the overall wetland reestablishment success criteria approved under the current federal compensatory mitigation rules.

Contact Information: David M. Mahnken, E Sciences Inc., 34 East Pine Street, Orlando, Florida 32801, USA, Phone: 407-481-9006; Fax: 407-481-9627, Email: dmahnken@esciencesinc.com

A DEMONSTRATION OF AN ECOSYSTEM SERVICES VALUATION METHODOLOGY FOR RECLAIMED PHOSPHATE MINED LANDS

Kym Rouse Campbell[1] and ***Joseph Nicolette***[2]
[1]ENVIRON International Corporation, Tampa, FL, USA
[2]ENVIRON International Corporation, Atlanta, GA, USA

Reclaimed phosphate mined lands provide valuable ecosystems services, and traditional approaches to assessing, evaluating, and monitoring these lands often do not consider or quantify these services. Reclaimed wetlands and lakes provide important ecosystem services, such as providing wildlife habitat, sequestering carbon, and providing recreational and commercial fishing opportunities, while reclaimed uplands provide water recharge areas, buffers for aquatic habitats, wildlife habitat and corridors, and connectivity to the overall ecosystem. In this presentation, we demonstrate a methodology for quantifying and valuating ecosystems services for reclaimed phosphate mined lands using two examples. First, we evaluate the ecosystem services of one particular ecosystem associated with reclaimed phosphate mined lands: a reclaimed lake. The Lake Vegetation Index (LVI) was developed by the Florida Department of Environmental Protection (FDEP) to evaluate the ecological health of a lake. Using the LVI, we demonstrate that reclaimed lakes in the Bone Valley Region appear to be as ecologically healthy as natural lakes in the same region. In addition, we demonstrate that the ecosystem services provided by reclaimed lakes appear to equal or exceed those provided by natural lakes. Similar to natural lakes, reclaimed lakes provide wildlife viewing opportunities, as well as recreational and commercial fishing opportunities. However, reclaimed lakes often differ from natural lakes in that: 1) reclaimed lakes typically do not have developed shorelines, while natural lakes are often surrounded by urban, commercial, or industrial development; 2) the watershed of reclaimed lakes typically does not include non-point source pollution resulting from urban runoff, and watersheds of natural lakes often receive runoff from residential, commercial, and industrial development (e.g., metals); and 3) the watersheds of reclaimed lakes typically do not include agricultural runoff (e.g., pesticides, herbicides, organic contaminants), while agricultural runoff often contributes to the watersheds of natural lakes.

Our second example is a landscape-level approach, and aerial photography is used to compare and quantify the ecosystem services of a pre-mined agricultural area (e.g., citrus, cattle) to the services offered by the same area after mining and reclamation, now a mosaic of uplands, wetlands, lakes, and/or streams. Our comparison of the area pre-mining vs. post reclamation indicates that more ecosystem services are offered by the area after mining and reclamation, as compared to the area before mining when its use was solely agricultural. Our presentation quantifies the ecosystem services using economics based ecological and human use metrics and demonstrates, both by looking at a particular ecosystem and from the landscape scale, that reclaimed phosphate mined lands offer valuable ecosystem services. In addition, the ecosystem services of reclaimed phosphate mined lands are similar to or exceed those offered by natural lands. Therefore, the ecosystem services offered by reclaimed phosphate minded lands should be considered during the development of reclamation plans and during the permitting process, and reclamation monitoring plans should include metrics to quantify ecosystem services.

Contact Information: Joseph Nicolette, ENVIRON International Corporation, 1600 Parkwood Circle, Suite 310, Atlanta, GA 30339 USA, Phone: 678-388-1665, Email: jnicolette@environcorp.com

POTENTIAL BENEFITS OF INCORPORATING BIOCHAR, A SOIL AMENDMENT, INTO WETLAND RECLAMATION

Tyler Nicoll
Ground Level, Inc. Bartow, FL, USA

Biochar is a soil amendment made by a process called pyrolysis, the heating of biomass in the absence of oxygen. Currently there is not an established standard for biochar because of the variability of biomass inputs and production processes. Biochar has several applications including agriculture, water filtration, soil remediation, carbon sequestration, greenhouse gas offsets, and ecological restoration. As a newly developing technology, research still needs to be done to narrow down the optimal biochar type and application rate for each intended use. The most up-to-date research was reviewed to determine the potential benefits of incorporating biochar into the wetland reclamation of phosphate mines.

The final step in mine reclamation is plant establishment. Wetlands need to meet permit requirements including herbaceous cover, trees per acre, and tree canopy. Water that is released off of the mine property is subject to certain water quality criteria including turbidity and nutrient load. Greater efficiency in achieving the desired reclamation results will reduce the management time and cost. Biochar can increase plant survival and growth by improving soil degraded due to mining activities. Reclaimed wetlands may be excessively sandy or clayey and low in organic matter. Biochar can adjust the pH, increase microbial populations, increase cation exchange capacity, and increase water and nutrient retention (Lehmann 2009). Because the nutrients in the soil will be adsorbed to the biochar and available for plant use, eutrophication of water bodies can be prevented. Minimal processes are currently utilized to correct the composition and properties of the soil at mine sites.

Field trials are being developed to test biochar applications in wetland and upland reclamation. Biochar will be applied at a calculated application rate that takes into account all the current literature. Biochar can be applied by disking it into the soil or placing into the hole as each tree is planted. Plant growth, survival, and vitality will be compared to plots without biochar. Changes in soil pH and nutrients will also be measured. The full benefit of biochar may take over a year to develop. The current research on the benefits biochar provides the framework to begin testing the integration of biochar into phosphate mine reclamation.

Contact Information: Tyler Nicoll, Ground Level, Inc., 6051 State Road 640 W, Bartow, FL 33830, USA, Phone: (863) 428-2571, Email: tylern@gliearth.com

ENVIRONMENTAL BENEFITS OF STREAM RESTORATION ON PHOSPHATE MINED LANDS

Kristen B. Nowak and *John H. Kiefer*
AMEC-BCI Engineers & Scientists, Inc.

The phosphate mining industry is regulated to reclaim streams and wetlands on mined lands. First, decisions are made regarding which resources should be preserved and which are acceptable to be mined. Stream and wetland evaluations, such as FDEP's Habitat Assessment (HA), Stream Condition Index (SCI), and Uniform Wetland Assessment Method (UMAM), provide data necessary to make informed mine/no-mine decisions. A restoration plan is then created to guide how mined resources will be reclaimed and, in many cases, enhanced compared to pre-mining conditions. Next, the mining industry applies novel construction techniques, such as hydraulic carving, to more quickly put natural stream channels back into the landscape. Lastly, the mining industry monitors these created systems and has found that they can and do function as natural systems, supporting natural biological communities.

Contact Information: Kristen B. Nowak, AMEC-BCI Engineers & Scientists, Inc., 2000 E. Edgewood Dr. Suite 215, Lakeland, FL 33803, USA, Phone: 863-667-2345, Fax: 863-667-2662, Email: kristen.nowak@amec.com

MOSAIC FERTILIZER'S WELLFIELD: HABITAT RESTORATION, CONSERVATION AND GROWING THE FLORIDA SCRUB JAY

***Sandra L. Patrick*[1]**, *Reed Bowman*[2], *David Gordon, Lauren Deaner*[3] and *Grant Lykins*[4]
[1]Mosaic Fertilizer, LLC, Lithia, FL, USA
[2]Archbold Biological Station, Venus, FL, USA
[3]Quest Ecology, Wimauma, FL, USA
[4]Mosaic Fertilizer, LLC, Lithia, FL, USA

Ecological restoration can be defined in terms of recovery. This can mean recovery of the specific vegetation, hydrology, and soils within the ecosystem, but more importantly, the persistent occupation and recovery of the wildlife species that use the ecosystem. The primary goals of Mosaic Fertilizer's (Mosaic) Florida Scrub Jay (*Aphelocoma coerulescens*) Habitat Management Plan is to provide on-site and off-site mitigation for proposed mining impacts, develop suitable Florida scrub jay habitat and implement experimental translocations of at-risk, isolated Florida scrub jays living in non-suitable habitat.

The Florida scrub jay was listed as Threatened by the U. S. Fish and Wildlife Service through the Endangered Species Act in 1987, with a high extinction probability due to habitat loss from land use conversion, habitat fragmentation, and fire exclusion. The successful long-term survival of the highly fragmented Florida scrub jay population in southern Hillsborough and Manatee Counties, formerly known as the M4 metapopulation, depended on habitat restoration, conservation, continued habitat management and translocation. The selected site for this work was the Mosaic Wellfield (Wellfield) located in the geographic center of this population.

Between 1999 and 2001, Mosaic reduced the forested structure at the Wellfield and banded 13 scrub jay families and 1 single jay. With the passage of more than 10 years since project inception, including the translocation of 51 scrub jays, this presentation will illustrate the restoration techniques, translocation methods, and results to date.

Subsequent to the 2011 breeding season, a total of 26 family groups consisting of 84 scrub-jays are being maintained by Mosaic within the Wellfield–Duette Preserve Subpopulation and at the Little Manatee River State Park. As a result of habitat restoration, conservation and translocation of scrub jays at the Wellfield, this project has had the positive effect of reducing the extinction risk of the jays, while contributing to the growth of the population on the Wellfield, as well as adjacent public lands.

Contact Information: Sandra L. Patrick, Mosaic Fertilizer, LLC, 13830 Circa Crossing Drive, Lithia, Florida 33547, USA, Phone: 813-500-6913, Fax: 813-571-6926, Email: sandra.patrick@mosaicco.com

USING RECLAIMED PHOSPHATE LANDS FOR WATER TREATMENT AND AQUIFER RECHARGE

Adam E. Platt[1] and *Stefan N. Katzaras*[2]
[1]CF Industries, Inc., Bowling Green, FL, USA
[2]CF Industries, Inc., Plant City, FL, USA

The CF Industries Inc. (CF) Hardee Phosphate Complex is located in the Bone Valley area of the Central Florida Phosphate District. This facility falls within the Southwest Florida Water Management District's Southern Water Use Caution Area (SWUCA), an area where water resources are or will become critical in the next twenty years. The phosphate industry accounts for 5 percent of groundwater pumping in the area, and has been developing strategies for reducing its overall groundwater withdrawals during mining.

In 2003, CF began evaluating the feasibility of an alternative water resource project on mined and reclaimed lands. The resulting effort led to the development of the Aquifer Recharge and Recovery Project (ARRP), which improves mine water quality through reclaimed wetland treatment systems and sand filtration technology on previously mined land. The ARRP system is designed to store excess mine water in a reservoir, then pump between 2 and 4 million gallons per day through 264 acres of reclaimed wetland cells built on retired sand clay mix areas. Once the water has passed through the reclaimed treatment wetlands, it is pumped onto a 6.75 acre sand filter basin where secondary treatment takes place. The cleaned water is collected in a sump where it is tested for primary and secondary drinking water quality, then discharged back into the Floridian aquifer via an injection well. The ARRP treatment system must complete two years of effluent water quality sampling prior to water being pumped into the aquifer.

The ARRP project has been recognized and supported by several government agencies throughout its development, including Hardee County, the Florida Department of Environmental Protection, and the Southwest Florida Water Management District. The District expressed their support of the ARRP, saying "The project has the potential of providing significant benefits to the SWUCA, an area of stressed groundwater resources, by maintaining or increasing the Floridian aquifer levels. Utilization of excess surface waters and safely injecting those waters into the aquifer is one of several strategies the District is pursuing in providing recovery to the aquifer."

The ARRP project will help reduce impacts on the Floridian aquifer at CF's Hardee Phosphate Complex, and is the largest combined wetland and sand filter water treatment system in Florida.

Contact Information: Adam E. Platt, P. E., CF Industries, Inc. Hardee Phosphate Complex, P.O. Box 1549, Wauchula, FL 33873, USA, Phone: 863-375-4321, Fax: 863-375-2716, Email: aplatt@cfindustries.com
Stefan N. Katzaras, CF Industries, Inc. Plant City Complex, P.O. Drawer L, Plant City, F, 33564, USA, Office: 813-782-1591, Email: skatzaras@cfindustries.com

HYDROLOGY OF CLAY SETTLING AREAS AND SURROUNDING LANDSCAPES IN THE PHOSPHATE MINING DISTRICT, PENINSULAR FLORIDA

Mark Rains, *Kathryn Murphy, Michael Kittridge, Mark Stewart, Ken Trout* and *Mark Ross*
University of South Florida, Tampa, FL, USA

The objective of this study was to use applied and naturally-occurring geochemical tracers to study the hydrology of clay settling areas (CSAs) and the hydrological connectivity between CSAs and surrounding hydrological landscapes. CSAs are byproducts of phosphate mining in peninsular Florida. Following beneficiation, a slurry of 3% of mostly clay-sized solids and 97% water is disposed of in CSAs, which are large, above-grade reservoirs contained by rectangular, earthen berms that are approximately 6-15 m above grade and approximately 120-320 hectares in area. Rapid consolidation and drainage ensues, with the slurry reaching approximately 18-22% solids within a few months. After a few years, a surface crust that is approximately 50-60% solids forms, though the deeper subsurface remains approximately 25% solids for many years thereafter. Depending on economical and environmental factors, as much as 70,000 hectares of CSAs could remain in peninsular Florida when phosphate mining is complete.

The study site is located on the Fort Meade North Mine in Polk County, Florida. The CSA has a well-developed, subangular-blocky, clay-rich surface layer with abundant desiccation cracks and other macropores, and a massive, clay-rich sublayer that is saturated below approximately 1.0-2.5 m. A bromide tracer was applied to study hydrological processes in the upper part of the CSA. Bromide infiltrated rapidly, perched on the massive, clay-rich sublayer, and flowed laterally across the landscape and through depressional wetlands located on the CSA. Infiltration and lateral flow were rapid suggesting that preferential flow through desiccation cracks and other macropores likely dominates flow in the upper part of the CSA. Naturally-occurring solute and stable isotope tracers were used to study the hydrological connectivity between the CSA and the surrounding hydrological landscape. Three-end mass-balance mixing model results indicate that groundwater from the CSA can be found in the surficial aquifer downgradient of the CSA. The precise flowpaths from the CSA to the surrounding hydrological landscape are unclear, though there is evidence of groundwater discharge from the CSA through seeps and springs located on some of the dam walls. Nevertheless, fluxes remain unquantified, so the precise effects of CSAs on the hydrology of the surrounding hydrological landscape also remain unquantified.

Contact Information: Mark Rains, Department of Geology, University of South Florida, 4202 E. Fowler Avenue, SCA528, Tampa, FL 33620, USA, Phone: 813-974-3310; Fax: 813-974-2654, Email: mrains@usf.edu

BANK ON IT: MITIGATION AND THE RESTORATION OF ECOSYSTEM SERVICES TO URBANIZING WATERSHEDS

Ann M. Redmond
Brown and Caldwell, Baton Rouge, LA, USA

Public agencies are struggling to fund and implement effective watershed management programs, particularly in urbanized settings. As a result ecosystem services continue to be lost from these watersheds. One avenue toward restoring and maintaining ecosystem services in urbanizing watersheds is to develop, or encourage the development of, ecosystem banks. These can be implemented as wetland, species, stream, and/or water quality banking projects. Credits generated by these "banks" are used to offset natural resource losses from development activities, including infrastructure development, and should be developed in concert with a watershed approach to restoring watershed health. Projects can either be standalone or part of an umbrella program. They are approved by an interagency team made up of the US Army Corps of Engineers, US Fish and Wildlife Service, US Environmental Protection Agency, and other federal and state agencies, as appropriate depending on the type of project.

Many factors must be considered to successfully use such projects for restoring ecosystem services to watersheds. These range from bank planning (is there a market with room for a new bank? etc.), natural resource assessment (are there watershed restoration plans in place or needed to guide bank site selection? etc.), ecosystem restoration (which sites are well placed in the watershed and technically feasible to restore? etc.), and regulatory factors (what regional regulatory requirements exist and can they be met? etc.). This paper addresses these factors in the context of a watershed approach to site selection and restoration, as well as goal setting that is compatible with nonpoint source, conservation and watershed improvement planning. Pro and cons associated with developing banks, teaming with bankers, or licensing sites to 3rd parties to establish banks will also be addressed.

Contact Information: Ann M. Redmond, Brown and Caldwell, 451 Florida St., Suite 1050, Baton Rouge, LA 70801, USA, Phone: 225-456-2509, Fax: 225-456-2601, Email: aredmond@brwncald.com

AN EXPERIMENTAL APPROACH TO CREATING WET MEADOWS IN THE LOWER PLATTE RIVER CORRIDOR

John A. Shelman
U.S. Army Corps of Engineers, Omaha, Nebraska, USA

The Western Sarpy/Clear Creek project is a Flood Risk Management Project that was conducted under the Corps of Engineers (Corps) General Investigation authority. To mitigate wetland impacts associated with levee construction, the Corps was required to create 40 acres of wetlands. Prior to creating 40 acres of wetlands, a one acre wetland experiment was conducted on-site to test varying seed and mulching applications and to find an elevation range that would provide adequate hydrology. More specifically, the goals of the experiment are as follows: 1) determine if varying the seed application rate has an effect on the establishment of hydrophytic vegetation; 2) determine if seed or wet meadow hay alone is sufficient for establishing hydrophytic vegetation; 3) determine if combining wet meadow hay over seed is useful; 4) determine if shredding hay has any affect; 5) determine if topsoil is suitable for the growth of desirable hydrophytes; 6) find target elevation range based on known wet meadow hydrodynamics; 7) understand the hydrology and hydraulics of the system.

Using ground and surface water data, a four foot elevation range was chosen to capture the seasonal fluctuations of water at the mitigation location. At each one foot elevation range, six treatment and two control plots were randomly placed within the eight blocks available. Six treatment plots included: 1) shredded hay only; 2) seed only applied at the standard seeding rate; 3) shredded hay and seed applied at the standard seeding rate; 4) non-shredded hay only; 5) seed only at double the standard seeding rate and; 6) non-shredded hay and seed applied at double the standard seeding rate. Hay mulch was obtained from a nearby reference wet meadow. Seed and hay source were dominated by native grass and sedge seeds. Metrics calculated from monitoring events included: species abundance, native species richness, percent cover, prevalence index, floristic quality index and Simpson's index of diversity.

Monitoring results indicated that increasing the seed application rate and shredding the hay were unnecessary and would only increase time and money spent constructing the mitigation wetland. Hay application proved to be useful in keeping out annual weeds and invasive plants, such as cattails, while also providing an additional seed source for the wetlands. Germinating plants not in the seed mix were found and matched what was identified in the hay cut from the reference wet meadow. It was determined that the topsoil used in the experiment was acceptable and should be used for the mitigation wetland. Most importantly, a target elevation range (1065.5' to 1067.0' MSL) was identified that would capture seasonal ground and surface water fluctuations. Native species richness and indices reflecting community wetness and floristic quality within the target elevation range were applied to the construction of the mitigation wetland.

Contact Information: John A. Shelman, Environmental Resource Specialist, U.S. Army Corps of Engineers, 1616 Capitol Avenue, Omaha, Nebraska 68102, USA, Phone: 402-995-2708, Fax: 402-995-2758, Email: Johnathan.A.Shelman@usace.army.mil

NATURAL RESOURCES CONSERVATION SERVICE'S ROLE IN THE NATIONAL WETLAND CONDITION ASSESSMENT

L.M. Vasilas[1] and *P.S. King*[2]
[1]USDA Natural Resources Conservation Service, Beltsville, MD, USA
[2]USDA Natural Resources Conservation Service, Georgetown, DE, USA

In 2011, the Environmental Protection Agency (EPA) led an effort to complete field data collection for the National Wetland Condition Assessment (NWCA). The NWCA is the first survey ever designed to assess the ecological integrity of wetland resources at the national scale. The structure and condition of hydric soils are a vitally important component of wetland ecological integrity as they provide the basis for wetlands to sustain unique biological communities and provide unique chemical and biological functions. It is also the wetland factor that is the least understood by most wetland scientists. Early in the research and design process the Natural Resources Conservation Service (NRCS) Soil Survey Division entered into an agreement with the EPA to assist in the development of the soil sampling and lab analysis protocols, training on the use of the protocols, lab analysis of soil samples, and the analysis of the data collected. While the agreement did not include field assistance during the sampling process, many NRCS soil scientist throughout the country also took part in the field sampling to provide more localized training and ensure accuracy of the data collected.

The development of a soil sampling protocol that was based on sound science and also simple enough to be done by wetland scientists who may not have any background in soils and in a time frame that made it manageable to do along with all the other sampling was difficult. The cooperation between the two agencies with NRCS providing the technical expertise in soil science and EPA providing the expertise in the development and implementation of these types of assessments has been vital to the success of this study.

The soils data collected in the NWCA will not only provide a good foundation for assessing condition of hydric soils and wetlands throughout the country, but also will provide the NRCS with hydric soils data that has been lacking in our database to assist in the development of new indicators of hydric soils and refine soil series and soil interpretations to provide more detailed Information on hydric soils in soil surveys. The NRCS National Soil Survey Laboratory is currently working on the analysis of the samples and expects to have all samples analyzed by September of 2012. We expect the soil morphology data to help us better assess the historical condition of each site and the lab analysis data in combination with other data collected such as vegetation, hydrology and land use/land cover data to help better assess the current condition of the site. The NRCS looks forward to assisting EPA in the analysis of this data.

Contact Information: Lenore Matula Vasilas, USDA Natural Resources Conservation Service, Soil Survey Division, 5601 Sunnyside Ave., Mailstop 5471, Beltsville, MD 20705-5000, USA, Phone: 301-504-2188, Fax: 301-504-2230, Email: Lenore.Vasilas@wdc.usda.gov

THE DESIGN FOR THE WETLAND RESTORATION OF A FRESHWATER CRANBERRY BOG IN NEW ENGLAND

Lee Weishar
Woods Hole Group, Falmouth, MA, USA

Restoring a cranberry bog to a productive wetland habitat is a goal shared by many wetland scientists. Historically, cranberry bogs have used large quantities of pesticides and thus, gained an unfavorable reputation. However, in many areas, cranberry bogs provide income to Towns and local cranberry growers are an important part of the local economy of many New England areas. Therefore, when the Town of Mashpee, MA had the opportunity to restore a portion of a cranberry bog they began a feasibility study to determine if it was possible. The cranberry bog is located on the Quashnet River and is situated downstream of a freshwater pond that is site for herring spawning. The restoration design presented several challenges as the bog was under contract for cranberry production, the upwelling groundwater within the bog had been contaminated by a nearby air force base, the hydrology of the site had been extensively altered, it is the site for an active herring run, and the bog is an important native trout spawning area. The contaminated groundwater remediation effort entailed installing a series of wells and a pump and treat water processing system. The treated water was tested and re-released back into the bog. The groundwater contamination has been remediated and the pump and treat system is scheduled to shut down in the next several years, returning the site hydrology to a more natural system. The wetland restoration design had to make provisions for the herring run, trout spawning, and cranberry production, while ensuring that the project would produce a viable wetland. The restoration design segmented the bog into restored wetland and active production areas. The channels with in the bog were redesigned to maximize groundwater upwelling to enhance trout spawning, and prior contamination remediation efforts were remediated. The final design allowed for both uses and incorporated future provisions to restore the entire bog should the Town decide to abandon farming at this site.

Contact Information: Lee Weishar, Senior Scientist, Woods Hole Group, 81 Technology Park Drive, East Falmouth, MA 02536, USA, Phone: 508-495-6221, Fax: 508-540-1001, Email: lweishar@whgrp.com

REPRODUCIBILITY OF A PLANT-BASED INDEX OF BIOLOGICAL INTEGRITY IN WET AND DRY CONDITIONS

***Matthew Wilson**, Suzanne Bayley* and *Rebecca Rooney*
Dept of Biological Sciences, University of Alberta, Edmonton, AB, Canada

Wetlands in the northern edge of Canada's prairies have been impacted by extensive agricultural and urban disturbance. To help the province of Alberta implement a wetland policy that can sustain and preserve the ecological health of wetlands, we created a comprehensive wetland framework that included the development of Indices of Biological Integrity (IBIs) to provide site-intensive estimates of biological condition. IBIs produced from 5 plant and wetland-dependent bird communities were compared to assess semi-permanent and permanent wetlands spanning a gradient of environmental disturbance. The plant-based IBI developed from vegetation in the wet meadow zone had the strongest relationship to the environmental disturbance gradient ($r^2 = 0.68$) and was the most consistent predictor of environmental conditions on an independent set of test sites ($r^2 = 0.72$).

To accurately assess wetland health, IBIs need to be reproducible over time and measure human disturbance while filtering out natural variation. Although plants are widely used as indicators of wetland health, they have been criticized for being unable to distinguish human disturbance from natural variation due to changes in the plant community caused by dynamic cycles in water levels. If IBI scores are sensitive to inter-annual changes in plant community structure, then it is difficult to determine whether a change in a site's biological condition is due to human influence or natural wetland variation.

To test whether the wet meadow zone vegetation IBI could produce consistent scores under dry and wet conditions, we reevaluated a subset of 48 sites (16 reference, 16 agricultural and 16 constructed) in years with below-average precipitation (2008-09) and in subsequent wet years (2010-11). Using non-metric multidimensional scaling (NMS) to depict a site's change in the plant community, we demonstrate that IBI scores are fairly insensitive to inter-annual variation. In fact, only 20% of the total change in species composition at repeated sites was correlated with IBI score. There was also strong agreement between IBI scores calculated in dry and wet conditions (Pearson's $r = 0.84$).

Thus we believe that by monitoring macrophytes within a single vegetation zone (i.e. wet meadow zone), biological condition can be precisely estimated by factoring out some natural variation induced by sampling along the moisture gradient at semi-permanent/permanent wetlands. Providing that water levels are not extreme, we suggest that plant-based IBIs are useful for assessing and monitoring wetland health in the northern prairies.

Contact Information: M. J. Wilson, B217 Biological Sciences Bldg. University of Alberta, Edmonton, AB, T6G 2E9, Canada, Phone: 780-492-4615, Fax: 780-492-9234, Email: mjw4@ualberta.ca

WETLAND ASSESSMENT & REGULATION
- DELINEATION AND ASSESSMENT

MULTI-SCALE MONITORING OF POTENTIAL GROUNDWATER WITHDRAWAL IMPACTS USING DELINEATION METHODOLOGY; LOWER PLATTE RIVER, NEBRASKA (PART 1 OF 2)

***Justin E. Bailey*[1]**, *Michael C. Gilbert*[2], *Sarah J. Soard*[1] and *Kevin P. Tobin*[3]
[1]Burns & McDonnell Engineering Company, Inc., Kansas City, MO, USA
[2]United States Army Corps of Engineers, Omaha, NE, USA
[3]Metropolitan Utilities District, Omaha, NE, USA

The Metropolitan Utilities District (District) in Omaha, Nebraska completed the construction of the Platte West Water Production Facilities Project (Project) in 2008. The Project consists of two new water supply well fields, a new water treatment plant, various water transmission pipelines, and other appurtenant facilities in Saunders and Douglas Counties, Nebraska. Because of the Project's potential to impact wetlands and watercourses both during construction and operation, the District submitted a Section 404 application for approval under the Clean Water Act to the U.S. Army Corps of Engineers, Omaha District (Corps). The Corps issued the Section 404 Individual Permit for the Project in 2003. As part of the terms and conditions included in the Corps Section 404 Permit, wetlands that may be impacted by operation of the Project must be monitored to determine the extent of any impacts to wetlands that may take place as a result of Project operation. The presentation will discuss the extensive monitoring that is required for the Project, which includes wetlands located both in the well fields (that may be directly impacted) and wetlands located in the projected cones of depression (the area expected to experience a 1-foot local groundwater drawdown based on hydrological modeling).

The integrated monitoring design implemented for this Project includes not only monitoring of wetlands within the well fields and cones and depression but also water level elevation monitoring of open water areas, installation of groundwater monitoring wells throughout the cones of depression, monitoring of multiple sources of hydrology data, and the review of natural color and infrared aerial photography. The interrelationships of the multi-scale monitoring program for detecting change within wetlands and thresholds to initiate more intense monitoring or remedial actions will be thoroughly discussed in this presentation.

A further discussion of the vegetative parameters and their analysis is included in Use of the Prevalence Index to Determine Plant Community Trends Related to Groundwater Withdrawal, Lower Platte River, Nebraska (Part 2 of 2), an abstract submitted by Sarah Soard.

Contact Information: Justin E. Bailey, Burns & McDonnell Engineering Company, Inc., 9400 Ward Parkway, Kansas City, MO 64114, USA; Phone: 816.822.4311; Fax: 816.822.4299; Email: jbailey@burnsmcd.com

LEVEL 1, LEVEL 2, AND LEVEL 3 ISOLATED WETLAND ASSESSMENTS IN THE NC AND SC COASTAL PLAIN

Virginia Baker[1], *Dan Tufford*[2], *Robert Truesdale*[3], *John Dorney*[4], *Amy Keyworth*[5], *Ross Vander Vorste*[1], *Breda Munoz*[3], *Frank Obusek*[6], *Ray Milosh*[5], *Rich Bolich*[3], *Rick Savage*[1], *Warren Hankinson*[2], *Chenille Williams*[2], *Kim Matthews*[3] and *Heather Preston*[7]

[1]NC Division of Water Quality, Surface Water Protection Section (DWQ), Raleigh, NC, USA
[2]University of SC, Columbia, SC, USA
[3]RTI International, Raleigh, NC, USA
[4]Atkins North America, Raleigh, NC, USA
[5]NC Division of Water Quality, Aquifer Protection Section (DWQ), Raleigh, NC, USA
[6]NC Center for Geographic Information and Analysis (CGIA), Ashville, NC, USA
[7]SC Department of Health and Environmental Control (DHEC), Columbia, SC, USA

Isolated wetlands (IWs) provide hydrological, water quality, carbon sequestration, and ecosystem benefits that are important for preserving biodiversity and ecosystem stability. These wetlands are more vulnerable than other wetlands because their size is generally small and they lack a surface water connection to downstream navigable waters. Changes in federal jurisdiction (SWANCC vs. ACOE et. al., 2001 and Rapanos and Carabell vs. ACOE, 2006) have made the protection of isolated wetlands the responsibility of the states. In NC, these wetlands have been protected since 2001. However, SC recently gained authority to regulate isolated wetlands in the coastal zone and is currently trying to move forward in the protection of IWs statewide.

Two different EPA funded studies assessed IWs in eight counties on the North Carolina and South Carolina coastal plain between 2008 and 2012. The first project, "The Southeast Isolated Wetland Assessment" (SEIWA) used a three level wetland assessment approach. Level 1 used geographic Information to map the IWs, Level 2 field verified 180 IWs and completed the NC Wetland Assessment Method on all identified IWs, and Level 3 intensively surveyed the biocriteria, pollution adsorption capacity, water quality, and hydrology of two clusters of IWs. The Level 2 field verification indicated the Level 1 mapping was 22% accurate while the rapid assessment found 67% of the sites rated high function, 30% of the sites rated medium function, and 3% of the sites rated low function.

Since only four sites were assessed for the SEIWA Level 2 study, a second IW study, "Hydrologic Connectivity, Water Quality Function, and Biocriteria of Coastal Plain Geographically Isolated Wetlands" is currently being conducted. The results of this study will be combined and/or compared with the results of the SEIWA study. This second study had two foci, hydrology and water quality function and biocriteria. The SEIWA Level 1 map was used to locate 11 sites within the vicinity of the downstream water bodies for the hydrology and water quality focus, while another 11 sites were randomly chosen from the SEIWA Level 2 study for the biocriteria that focused on amphibians, macroinvertebrates, and vegetation.

<u>Contact Information</u>: Virginia Baker, NC DWQ, 2321 Crabtree Blvd. Ste. 250, Raleigh, NC 27604, USA, Phone: 919-715-3415, Fax: 919-807-6893, E-mail: Virginia.baker@ncdenr.gov

NORTH CAROLINA NATIONAL WETLAND CONDITIONAL ASSESSMENT SITE DESCRIPTIONS, RAPID ASSESSMENT RESULTS, AND METHOD EVALUATION

***Virginia Baker*[1], *Rick Savage*[1], *Anthony Scarbraugh*[1], *James Graham*[1], *Tammy Hill*[1] and *Ashley Steele*[2]
[1]NC Division of Water Quality, Raleigh, NC, USA
[2]WK Dickson, Raleigh, NC, USA

The North Carolina Division of Water Quality surveyed 47 sites for the 2011 National Wetland Conditional Assessment (NWCA, EPA 2011) in the coastal plain region of NC. The NWCA was an intensive and robust biological, physical, and chemical one day survey of 900 randomly selected USFWS Status and Trends plots. The NWCA in NC identified 18 estuarine intertidal emergent, two estuarine intertidal scrub shrub, one palustrine emergent, 11 palustrine scrub-shrub, 11 palustrine forested, and four palustrine farmed wetlands. In addition to the intensive survey, three rapid assessments were also completed at each site, USA RAM, which was part of the NWCA, the NC Wetland Assessment Method (NCWAM, NCFAT 2010) and the Ohio Rapid Assessment Method (ORAM, OH EPA 2001). NCWAM is a functional assessment that evaluates hydrology, water quality, and habitat function while ORAM is a conditional assessment that evaluates wetland size, buffers, hydrology, habitat, and plant communities. The NCWAM regional based ecological key was used to classify the 47 sites as 18 Brackish/Salt Marsh, three Estuarine Woody, six Pocosin, eight Hardwood Flat, three Pine Flat, four Bottomland Hardwood Forests, and five Riverine Swamp with 38 sites scoring high, eight sites scoring medium, and one site scoring low. ORAM scores ranged from 37 (out of 90, with 90 indicating highest quality and 0 indicating lowest quality) to 87 with a mean of 65.8 and median of 69. The results for USA RAM are currently being analyzed by the EPA. The NC team also evaluated of the NWCA method in terms of ease of usage and applicability to ecological observations and variables associated with NC wetlands.

<u>Contact Information</u>: Virginia Baker, NC DWQ, 2321 Crabtree Blvd. Ste. 250, Raleigh, NC 27604, USA, Phone: 919-715-3415, Fax: 919-733-6893, E-mail: Virginia.baker@ncdenr.gov

REGIONAL SUPPLEMENTS TO THE CORPS OF ENGINEERS WETLAND DELINEATION MANUAL: 2012 STATUS REPORT

Jacob F. Berkowitz
U.S. Army Corps of Engineers, Engineer Research and Development Center, Vicksburg, MS, USA

The United States contains a wide variety of wetlands and since its implementation in 1987 the Corps of Engineers Wetland Delineation Manual sought to identify and demarcate all wetlands using a single set of guidance procedures. This approach led to persistent problematic wetland delineation situations and inconsistencies in some areas, and it was determined that a single guidance could not adequately characterize the diversity of wetlands found throughout the nation. Based on recommendations from the National Academy of Sciences, the Corps developed regional guidance documents that supplement the procedures outlined in the national Corps of Engineers Wetland Delineation Manual. The process implemented regional supplements for ten regions encompassing the entire nation including: Alaska, Western Mountains and Valleys, Caribbean Islands, Great Plains, Atlantic and Gulf Coastal Plain, Arid West, Midwest, Eastern Mountains and Piedmont, Hawaii and Pacific Islands, and the Northcentral and Northeast. Development of each regional supplement was a collaborative process including the formation of a Regional Working Group of wetland professionals, drafting the regional supplement, review by the National Advisory Team, independent peer-review, field testing, Public Notice for review and comments, publication and implementation of an "interim" supplement for a 1-year trial, and revision and publication of Version 2.0 of the supplement. Each regional supplement contains a description of the region, indicators of hydrophytic vegetation hydric soils, and wetland hydrology, guidance for difficult wetland situations, and data forms. Following publication of the final regional supplement in 2012, the Corps seeks to update the national Corps of Engineers Wetland Delineation Manual and develop procedures for periodic review of national and regional wetland delineation guidance documents to reflect the current state of wetland science.

Contact Information: J. F. Berkowitz, U.S. Army Corps of Engineers, Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS, 39180, USA, Phone: 601-634-5218, Email: Jacob.F.Berkowitz@usace.army.mil

REGIONALIZING THE CORPS OF ENGINEERS WETLAND DELINEATION MANUAL - THE ROLE OF THE NATIONAL TECHNICAL COMMITTEE FOR WETLAND VEGETATION

Paul Minkin and ***Jacob F. Berkowitz***
U.S. Army Corps of Engineers, Engineer Development and Research Center, Vicksburg, MS, USA

The US Army Corps of Engineers continues to update wetland delineation and identification procedures in order to maximize technical competency and reflect the current state of the science. As a result, regional supplements to the Corps of Engineers Wetland Delineation Manual (Corps Manual) have been implemented for ten regions covering the entire nation. The development process included input from over 250 individuals comprising local working groups of wetland professionals, independent peer reviewers from the private sector, and oversight by technical specialists from both agencies and academia. Technical experts play an important role in the development and updating of guidance for wetland delineation procedures and other resource management documents.

The National Technical Committee for Wetland Vegetation (NTCWV) was established in 2006 to evaluate various technical and scientific issues related to vegetation that had been raised during the regionalization and updating of the Corps Manual. The membership consists of representatives from several federal agencies (US Army Corps of Engineers, US Environmental Protection Agency, US Fish and Wildlife Service, USDA-Natural Resources Conservation Service, USDA-Forest Service, and the Bureau of Land Management) and universities.

The NTCWV provides technical botanical support for the regionalization and updating of the Corps Manual. In this capacity, the NTCWV has developed and published literature reviews on the use of bryophytes as indicators of hydric soils and wetland hydrology during wetland delineations, growing season definition and use in wetland delineation, and vegetation sampling for wetland delineation. In addition to providing wetland delineation manual support, the NTCWV also provides botanical support for technical issues related to the National Wetland Plant List.

Contact Information: J. F. Berkowitz, U.S. Army Corps of Engineers, Engineer Development and Research Center, 3909 Halls Ferry Road, Vicksburg, MS, 39180, USA, Phone: 601-634-5218, Email: Jacob.F.Berkowitz@usace.army.mil

MAPPING COASTAL GREAT LAKES WETLANDS AND ADJACENT LAND USE THROUGH HYBRID OPTICAL-INFRARED AND RADAR IMAGE CLASSIFICATION TECHNIQUES

Laura L. Bourgeau-Chavez*, Kirk Scarbrough, Mary Ellen Miller, Elizabeth Banda, Michael Battaglia, Anthony Landon, Richard Powell* and *Colin Brooks*
Michigan Tech Research Institute, Ann Arbor, MI, USA

A mapping effort is underway to produce an international contemporary baseline map of wetland type, extent and adjacent land use in the Great Lakes Basin. Long-term monitoring of Great Lakes coastal wetlands is currently accomplished through the use of science-based indicators (SOLEC or GLEI indicators) to assess conditions. The weakest element of such a management system is the reliance on old, incomplete and static landscape-scale data. This severely impacts the manager's ability to monitor and detect effects from two of the most significant coastal wetland stressors; urban development and invasive plant species. In the United States, the baseline map for wetland delineation is the circa 1970s National Wetlands Inventory (NWI). Although much of the Great Lakes NWI is currently being updated, it lacks Information on lands adjacent to wetlands which represent areas that could be potential wetland stressors. Further, the NWI ends at the U.S. border. While Canadian wetland maps exist, they represent a mosaic of mapping techniques, sources and resolutions. A consistent baseline map is needed for the Great Lakes coasts as well as methods to monitor change in coastal ecosystems.

Due to the complexity of wetland ecosystems it is beneficial to include a fusion of sensors, operating in different frequencies in the mapping process. Synthetic Aperture Radar (SAR) and optical sensors complement each other in the classification and monitoring of wetland ecosystems. Techniques were developed to merge optical/IR and SAR for the mapping of Great Lakes coastal wetlands and adjacent land use in limited areas in 2004 for the Great Lakes Coastal Wetlands Consortium (GLCWC). This GLCWC pilot study demonstrated the improved capabilities of merging multi-sensor SAR (JERS and Radarsat-1, ERS-2) and Landsat data for better wetland condition monitoring. By merging two types of sensor data operating in the visible, infrared, and microwave spectrums in a GIS, we demonstrated not only a robust method, but a prospective complete capability for monitoring wetland type, condition, areal extent, adjacent land cover/land use, invasive species and proximity to other anthropogenic stressors (Bourgeau-Chavez et al. 2004).

The Japanese ALOS PALSAR (L-band 23 cm, 10-20 m resolution) data have been used singularly to successfully map mature monotypic stands of the invasive plant *Phragmites australis* on the U.S. side of the Great Lakes coastal zone (Bourgeau-Chavez *et a*l. 2012). SAR is sensitive to differences in plant biomass and inundation patterns, allowing for the detection and delineation of the tall (up to 5 m), high-density, high-biomass invasive *Phragmites* wetland stands. Similarly, other wetland cover types, such as *Typha spp*. may be distinguished by SAR data through data fusion with Landsat.

A database of circa 2007-11 ALOS PALSAR L-band and Landsat data have been created and processed from spring, summer and fall seasons for mapping the U.S. and Canadian sides of the Great Lakes coastal zone (inland to 10 km). Building on the extensive field and image data base from the *Phragmites* mapping project, the current project includes additional wetland validation and training data collection, as well as air photo interpretation for development of upland and land use training and validation data. Mapping methods are currently being refined through analysis of a series of pilot study areas from sub-boreal and temperate zones, high and low urbanization, as well as high and low agricultural areas to test the hybrid algorithms for mapping. The final maps will be evaluated for accuracy through randomly selected field and air photo interpreted validation data. The results of this project will provide the first ever international Great Lakes coastal land cover/land use map suitable for coastal wetland assessment and management by agencies at the local, tribal, state and Federal levels.

Contact Information: Laura. L. Bourgeau-Chavez, Michigan Tech Research Institute, 3600 Green Ct. Suite 100, Ann Arbor, MI 48105, USA, Phone: 734-913-6873, Fax: 734-913-6880, Email: lchavez@mtu.edu

FLORIDA PARTICIPATION IN THE NATIONAL WETLAND CONDITION ASSESSMENT

***Mary Boyd**, Erica Hernandez, Kelly Chinners Reiss* and *Mark T. Brown*
HT Odum Center for Wetlands, University of Florida, Gainesville, FL, USA

The state of Florida participated in the US Environmental Protection Agency's (US EPA) National Wetland Condition Assessment (NWCA) of 2011 to further the capacity for wetland monitoring and assessment and further wetlands research in the state. In total 195 wetland points were evaluated as part of the US EPA's random sampling design, with 67 wetland points ultimately selected for inclusion in the 2011 field season. Five wetland classes were represented, including estuarine emergent (25%), palustrine emergent (24%), estuarine scrub-shrub (19%), palustrine scrub-shrub (19%), and palustrine forested (12%). Statewide distribution favored the south wetland region (31%), followed by the north wetland region (27%), and central and panhandle wetland regions (21% each).

Desktop site evaluation was used to evaluate wetland points remotely in geographic Information systems (GIS) and a strategy for access was determined. Wetlands were accessible by foot (64%), motorboat (21%), canoe (10%), and airboat (4%). Under the NWCA framework, wetlands were assessed for USA-RAM, buffers, soil, hydrology, water quality, algae, and vegetation. All 67 wetland points in the NWCA study were also evaluated with the Landscape Development Intensity (LDI) index to assess wetland condition in a landscape context. In addition, sub-sets of wetland points were sampled to simultaneously apply a state method for assessing wetland condition, i.e. the Florida Wetland Condition Index, to expand the suite of water chemistry parameters measured, and to assess dissolved oxygen water quality criteria for isolated wetlands. A preliminary interpretation of wetland condition across the Florida landscape will be gleaned from project data.

Contact Information: Mary Boyd, HT Odum Center for Wetlands, 100 Phelps Lab, Museum Road, Gainesville, FL 32611, USA, Phone: (352) 392-2424, Email: mcboyd@ufl.edu

THE CYPRESS SITUATION IN THE SOUTHERN USA, CIRCA 2010

Mark Brown
U.S. Forest Service, Knoxville, TN, USA

One decade into the new millennium, concerns over cypress sustainability emanating from a 1990's boom in cypress used for mulch have abated little. The iconic species typifies southern wetland forests in perceptions and reality. Cypress regeneration involves complicated hydrologic regimes sensitive to disturbances that alter or impede natural processes for reestablishment of forest area once impacted by human or natural factors. This paper analyzes the population, size, extent, and ownership of cypress in the southern United States of America (USA) for indicators regarding the sustainability of this unique resource. Research utilizes the latest Forest Inventory and Analysis (FIA) data available from the United States Department of Agriculture (USDA) Forest Service. In 2010, findings show Cypress forest types cover nearly 3.4 million acres, or 1.6 percent of the 207.6 million acres of timberland in the southern USA. One million of the cypress forest type acres occur in the State of Florida alone. There are a total of 1.125 billion cypress trees across the southern USA, which accounts for 0.8 percent of all tree species present. Sixty-one percent of these cypress trees are small (1.0-4.9 inches in diameter at breast height), 20 percent of the cypress trees are large (9.0+ inches in diameter at breast height), and 19 percent are medium (5.0-8.9 inches in diameter at breast height). The paper further explores differences in distribution of cypress across the southern USA and changes over time regarding key attributes of the resource to assess sustainability.

Contact Information: Mark Brown, U.S. Forest Service, 4700 Old Kingston Pike, Knoxville, TN 37919, USA, Phone: 865-862-2033, Email: mbrown03@fs.fed.us

BASIS FOR DEVELOPING ALTERNATE NUMERIC DISSOLVED OXYGEN CRITERIA FOR FLORIDA'S FRESHWATER WETLANDS

***Robert F. Compton**, Kelly C. Reiss* and *Mark T. Brown*
HT Odum Center for Wetlands, University of Florida, Gainesville, FL, USA

Dissolved oxygen (DO) is essential for the ecological health of aquatic systems and is considered an important component of water quality. DO levels can be influenced by both anthropogenic and natural factors. Under the Clean Water Act, the state of Florida is required to classify and establish water quality criteria for surface waters according to their designated use. The minimum DO level for Florida Class III waters, which include freshwater wetlands, is 5.0 mg/L. Previous wetland studies throughout Florida have found that pristine wetlands can contain naturally low DO levels falling below the 5.0 mg/l standard. Low DO levels can be the result of the combination of naturally high organic loading and warm temperatures, especially in blackwater systems, as opposed to the effect of anthropogenic influences. Additional quantitative data are needed to both support the development of Site Specific Alternative Criteria (62-302.400 F.A.C.) to existing water quality standards and develop protective numeric criteria for wetlands with naturally low DO levels based on ecological condition. As part of the Monitoring Initiative Funds program expanding the scope and state participation of the National Wetland Condition Assessment, multiple reference wetlands throughout Florida were identified and optical dissolved oxygen sensors were used to monitor DO over a 7 day period. Mean diurnal oxygen curves were developed and minimum and maximum DO concentrations along with the timing of peak DO levels were analyzed and compared to the existing water quality criteria within the state of Florida. Out of six wetlands monitored, the mean DO concentration was 1.4 mg/L, which falls below the existing 5.0 mg/L standard.

Contact Information: Robert F. Compton, HT Odum Center for Wetlands, 100 Phelps Lab, Museum Road, Gainesville, FL 32611, USA, Phone: 352-392-2424, Email: bfcompton@gmail.com

INCORPORATING DATA FROM SEVERAL REMOTELY SENSED PLATFORMS TO MAP CURRENT AND POTENTIALLY RESTORABLE WETLANDS

Jennifer Corcoran
University of Minnesota, Saint Paul, MN, USA

Traditional wetland mapping methods are in need of modernization. They typically depend solely on a single date of optical imagery, cloud-free data acquisition, and therefore surface features are often obstructed and inaccurately mapped. Radar sensors are unique in that they are insensitive to atmospheric and low light conditions, and thus can offer more consistent multi-temporal image acquisition. Unique characteristics about surface scattering mechanisms, such as saturated extent of wetlands, can be found by utilizing both the intensity and phase Information from multiple polarizations of a radar signal. In addition, topographic Information reveals the potentiality of water to collect in certain areas, allowing researchers to pair wetland inventory with probability maps to better assist natural resource managers.

The research presented here will show significant developments in wetland mapping by integrating several platforms of remotely sensed data, including: fully polarimetric RADARSAT-2 data and polarimetric decompositions (C-band), dual-pol PALSAR data (L-band), Landsat TM imagery, LiDAR point cloud data with intensity values, and topographic derivatives. It is expected that the surface structure of different land cover types will result in different LiDAR point cloud intensity and backscatter responses in different polarizations, as well as different reflectance values from the bands of Landsat TM imagery. Decision tree classification will be utilized to identify the most significant data sources for discriminating between wetland and upland areas. It is expected that results from this research will deliver a valuable, affordable, and practical wetland probability tool to aid manual photo interpretation, not to replace it.

Contact Information: Jennifer Corcoran, Department of Forest Resources, University of Minnesota, 1530 Cleveland Avenue N, St. Paul, MN 55108, USA, Phone: 952-913-0935, Fax: 612-625-5212, email: murph636@umn.edu

WETLAND CHARACTERISTICS OF GLACIALLY DERIVED BOULDER FIELDS IN THE NORTHEASTERN UNITED STATES

***Lindsey E. Dixon**, Robert W. Lichvar, Katherine Curtis* and *Jennifer Gillrich*
U.S. Army Corps of Engineers Cold Regions and Research Engineering Laboratory, Hanover, NH, USA

Boulder fields are unique landscapes that occur within the Northcentral and Northeast (NC-NE), Western Mountains, Valleys and Coast, and Alaska regions and can develop from glacial activity or periglacial processes. Recent research into boulder fields of the Northeast has provided interesting insights regarding the hydrology in these unique geologic features. These boulder fields were developed from glacial processes and are characterized by topographically concave surfaces, a thick folist layer covering the top of the boulders, FACU to UPL vegetation, mixed upland and hydric soils, and groundwater present through most of the growing season. These distinctive field conditions result in significant discussion regarding whether or not boulder fields are a unique type of wetland.

We evaluated the potential for these boulder fields to be considered wetlands under section 404 of the Clean Water Act by monitoring the hydrology and soils in two boulder fields in Maine during the 2011 growing season. We recorded hydrology data from 19 water table monitoring wells in a variety of micro-topographic positions. The following wetland indicators were tested: primary and secondary hydrology indicators from NC-NE Regional Supplement (RS), presence of ferrous iron using Alpha, alphadipyridyl (AAD) paper strips and AAD liquid, hydric soil indicators as described in the NC-NE RS, iris tube reduction, a separation between the folist layer and the soil surface, and the presence of hydrophytic vegetation determined using the Dominance Ratio and the Prevalence Index.

We tested the proportions of vegetation, soil, and hydrology indicators in plots that met and failed to meet the groundwater hydrology criteria of water within the top 12 inches of the soil surface for 14 or more consecutive days. The data suggest that hydrology and soil indicators described in the NC-NE RS do not always co-occur in northeastern boulder fields. The well data showed that 12 of the 19 plots met the groundwater criteria and 7 plots failed to meet it. 85.7% of the upland plots had at least one hydrology or soil indicator present. Results suggest that boulder fields are wetlands that can be regulated under section 404 of the Clean Water Act. They should be delineated as FACU dominated wetland/nonwetland mosaics.

<u>Contact Information</u>: Lindsey E. Dixon, Remote Sensing and Geographic Information Systems, U.S. Army Corp of Engineers Cold Regions and Research and Engineering Laboratory,72 Lyme Road, Hanover, NH 03755, USA, Phone: 603-646-4736, Fax: 603-646-4750, Email: Lindsey.E.Dixon@usace.army.mil

LEVEL 1 LANDSCAPE SCALE ANALYSIS OF FLORIDA WETLAND CONDITION

***Jenet Dooley**, Kelly Chinners Reiss* and *Mark T. Brown*
HT Odum Ce nter for Wetlands, University of Florida, Gainesville, FL, USA

Landscapes dominated by anthropogenic activity impact neighboring ecosystems, carrying harmful by-products of human activities through atmospheric and water channels. The intensity and propinquity of human altered landscapes have been used as indicators of the integrity of embedded and adjacent ecosystems. The Landscape Development Intensity (LDI) index is a Level 1 Landscape Scale Assessment that uses the non-renewable energy intensity of the surrounding land uses to predict ecological condition of a study area. Level 1 Landscape Scale Assessments use remotely sensing data to analyze large spatial extents with relatively low effort. Geographic Information Systems (GIS) was utilized to perform an LDI analyses to evaluate 67 wetland points to gain a comprehensive understanding of the integrity of Florida's wetlands. These points are a subset of over 900 points included in a national Level 3 Intensive Site Assessment implemented in 2011 by the US Environmental Protection Agency, called the National Wetland Condition Assessment (NWCA). The LDI analysis adds to the Information collected to inform wetland condition as part of the NWCA and eventually will be used to compare Level 1, Level 2 (Rapid Assessment), and Level 3 data. This is the first time that LDI has been used to examine a point compared to a feature with substantial area. As such, four scales are being used to characterize each point: 1) LDI_A: wetland assessment area as established through the NWCA methods; 2) LDI_B: wetland buffer area (140 m radium zone) as established through the NWCA methods; 3) LDI_F: wetland feature as identified by the National Wetland Inventory (NWI) data layer; and 4) LDI_W: watershed containing the wetland point based on the US Geological Surveys Hydrologic Unit Code (HUC). A comparison between the results from the different LDI index spatial scales will be completed and the scale that best correlates to wetland condition will be determined. Growing interest in wetland condition has increased the value of Level 1 Landscape Scale Assessment tools, such as the LDI index, that is accurate, easy to implement and cost effective.

Contact Information: Jenet Dooley, HT Odum Center for Wetlands, 100 Phelps Lab, Museum Road, Gainesville, FL 32611, USA, Phone: 352-392-2424, Email: dooley.jenet@gmail.com

A REVIEW OF ANTHROPOGENIC LANDSCAPE DISTURBANCE EFFECTS ON WETLAND FUNCTION WITH RESPECT TO INTEGRATING LANDSCAPE METRICS INTO ASSESSMENTS OF WETLAND CONDITION

Daniel Dvorett[1], *Craig A. Davis*[1] and *Joseph Bidwell*[2]
[1]Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK, USA
[2]School of Environmental and Life Sciences, University of Newcastle, Callaghan NSW Australia

Rapid assessment methods (RAMs) of wetland condition have been developed for a variety of monitoring applications including tracking mitigation projects and broad trends in wetland health. These methods generally include some combination of biotic, structural, hydrological and landscape measures which are aggregated to provide an overall score of wetland condition. The landscape metrics often include measures of land-use, buffers and wetland connectivity which differ in calculation and spatial scale between methods. This paper provides a review of the literature on how land-use change, buffers, and wetland connectivity impact wetland function. The goal is to identify appropriate landscape measures and effective scales for inclusion in RAMs to strengthen the relationship between generated condition scores and the reality of wetland condition. We reviewed RAMs of condition from eight states (California, Colorado, Delaware, Florida, North Carolina, Montana, Ohio and Rhode Island) to identify all landscape metrics and the spatial scales at which they are applied. RAM guidebooks were reviewed to determine if landscape measures and scale were justified based on what is known from primary literature; most guidebooks do not cite primary research in explaining inclusion of landscape measures. Additionally, an essential component of RAM development is validating RAM scores with more intensive data collection (e.g. indices of biotic integrity and hydrogeomorphic assessments) to ensure condition scores represent actual wetland conditions. Five of the RAMs we reviewed have associated validation data published, which indicated strong relationships between condition scores and more intensive measures of system health. Based on validation, rapid assessment methods appeared to provide relatively accurate measures of wetland condition. However, greater transparency in why metrics are included in RAMs could provide guidance for future methods. Landscape effects may differ between types of wetlands and certain assessment endpoints may be more sensitive to landscape disturbance than others. These are critical considerations when choosing metrics for condition based assessment, which should be inclusive of multiple endpoints. Additional research on landscape scale controls on wetland function and biotic communities will help provide insight into assessments of wetland condition.

<u>Contact Information</u>: Daniel Dvorett, Oklahoma State University, Department of Natural Resource Ecology and Management, 008C Agricultural Hall, Stillwater, OK 74078, USA, E-Mail: dan.dvorett@okstate.edu

A COMPLEX WETLAND DELINEATION INVOLVING A DITCHED WETLAND IN THE TWIN CITIES, MINNESOTA, USA

Steve D. Eggers
U.S. Army Corps of Engineers, St. Paul, MN, USA

Over a 10 year period, landowners, consultants and regulators debated the delineation of an approximately 82 ha wetland area located in the Twin Cities metropolitan area, Minnesota, USA (Site). The Site is part of a larger wetland complex that had been ditched many years ago. A main county ditch traverses the site and a network of lateral ditches was constructed by a private landowner.

The Site is located within the Anoka Sand Plain, which is characterized by a broad, sandy lake plain with ice-block depressions. Peat/muck soils developed within the ice-block depressions. Specific to the Site, the depth of peat/muck ranges from 0 to 13 feet over sand.

Procedures in Section F, "Atypical Situations," of the *Corps of Engineers Wetlands Delineation Manual* (1987) were applied [note: this delineation preceded the applicable regional supplement to the 1987 Manual]. Numerous site visits were conducted over the years at various times during the growing season. It was determined that dominance by hydrophytic vegetation and presence of hydric soils were not at issue. Subject to much debate was the extent to which the ditch system effectively eliminated wetland hydrology. Several methods were applied to estimate the effectiveness of the ditch system. The van Schilfgaarde equation was applied to estimate zones of effectively drained soils paralleling each ditch. Short-term monitoring well data (1 or 2 growing seasons), placed in the context of antecedent precipitation, was collected at different points during the 10-year period. Most useful were monitoring wells placed in transects perpendicular to a ditch as these data documented the actual drawdown effect of the ditch.

An unexpected finding was the degree to which monitoring well data contradicted estimates of drainage produced by the van Schilfgaarde equation. Another finding was that, in general, the deeper the peat/muck, the less effective a ditch was in removing wetland hydrology.

A final delineation was agreed to by the parties involved. It was not based on one factor; rather, multiple indicators were used including monitoring well data, microtopography, vegetation changes, depth of peat/muck, observations made over 10 years of site visits, and best professional judgment.

Contact Information: Steve D. Eggers, Regulatory Branch, U.S. Army Corps of Engineers, 180 5th Street East, St. Paul, MN 55101, USA, Phone: 651-290-5371, Fax: 651-290-5330, E-mail: steve.d.eggers@usace.army

BIOMASS ESTIMATION IN THE EVERGLADES USING SYNTHETIC APERTURE RADAR AND GROUND-BASED LIDAR

Emanuelle A. Feliciano[1], *Shimon Wdowinski*[1] and *Matthew D. Potts*[2]
[1]University of Miami, FL, USA
[2]University of California, Berkeley, CA, USA

Wetland ecosystems, such as the South Florida Everglades have greater carbon storage and sequestration capabilities than tropical forests. Unfortunately, more than 50 percent of the original Florida Everglades has been lost due to industrial development, farming, and urbanization. Carbon/biomass losses due to natural or human intervention can affect global warming. Thus, it is important to monitor biomass fluctuations in large wetland areas. Quantifying carbon and biomass changes is a difficult task given the limited accessibility within wetlands. Therefore many studies rely on remote sensing techniques for successful ecosystem monitoring.

In this study we estimate above-ground biomass (AGB) in the Everglades National Park using space-based Synthetic Aperture Radar (SAR) and ground-based LiDAR a.k.a. Terrestrial Laser Scanning (TLS) observations. We first conducted a calibration study in six vegetation communities: short-, intermediate-, and tall-mangroves, pine, dwarf cypress and hammock. Using precise TLS measurements and forestry surveys, we obtained detailed 3-D estimates of vegetation structure and tree volume. In addition, we acquired tree core samples in order to measure wood density and estimate AGB. The upscaling approach includes spatial analysis of SAR data acquired by three different satellites (ALOS, RADARSAT-2, and TerraSAR-X) at the three different frequencies (L-, C- and X-band). We use three different sensors, because each radar frequency (or wavelength) interacts with different sections of the vegetation. Our data was acquired with dual- or quadruple-polarizations, which provide additional Information on vegetation structure and biomass, because each polarized signal is scattered from different sections of the vegetation by different scattering mechanisms.

Preliminary results indicate that the cross-polarized (HV) L-band (ALOS) is the most sensitive to biomass. Likewise: HV, VH and VV polarized C-band (Radarsat-2) showed sensitivity to biomass, but not to the same degree of the HV L-band data. The sensitivity of the cross-polarized radar signal (HV) is in agreement with vegetation scattering theories, suggesting that the cross-polarized signal represents volume scattering. Furthermore, our results concerning the sensitivity of the HV L-band data to biomass is in agreement with previous biomass studies of tropical forests. One of the main limitations of SAR-based AGB estimates is signal saturation at high AGB values. We found that SAR backscatter saturation begins approximately at 80-100 Mg/ha in both C- and L-bands. Higher biomass sites might be affected by the double-bounce scattering effect, due to a major in-situ tidal influence. For this reason, we plan to explore the use of interferometric coherence for biomass estimations. We also plan to implement the use of airborne LiDAR and airborne SAR data to fill the gap between the ground-based and the space-based measurements.

We provide a comparative analysis of the three SAR sensors to quantify above ground biomass in the different vegetation communities. We are optimistic that the integration of TLS and SAR could be applied to monitor wetland ecosystems around the world. This investigation will help the Reducing Emissions from Deforestation and Forest Degradation (REDD+) project, in which large-scale biomass, carbon stock and vegetation structure monitoring, and mapping are needed.

Contact Information: Emanuelle A. Feliciano, Marine Geology and Geophysics Division, University of Miami, Rosenstiel School of Marine & Atmospheric Science, Miami, FL 33149, USA, Phone: 305-421-4632, Fax: 305-421-4632, Email: efeliciano@rsmas.miami.edu

INTEGRATED GIS MODEL FOR EVALUATING SURFACE WATER WITHDRAWAL IMPACTS ON WETLANDS

Sandra Fox[1], *Palmer Kinser*[1], *Lawrence Keenan*[1], *Fay Baird*[1], *William Wise*[2] and *Clay Montague*[2]

[1] St Johns River Water Management District, Palatka, FL, USA

[2] University of Florida, Gainesville, FL, USA

To assess the potential impacts of potential surface water withdrawals on riverine wetlands, the St. Johns River Water Management District (SJRWMD) adopted and modified a customized GIS tool (“Hydroperiod Tool”) originally developed by the South Florida Water Management District to assess wetland hydrology for the Kissimmee River restoration project. Ponded water depth is calculated across the floodplain using river stage data and wetland terrain elevation data (LiDAR-derived digital elevation model corrected for wetland vegetation). Use of the customized Hydroperiod GIS tool to model the effect of changes in wetland hydrology necessitates a number of simplifying assumptions, including: 1) consideration of only the riverine portion of wetland hydrology (because other sources are expected not to be affected by withdrawals), and 2) modeling of the water surface as a sloping flat pool that extends laterally out across the floodplain with no effect of friction from wetland vegetation. Use of this GIS tool provides the ability to assess temporal and spatial patterns that vary with river stage and produce annual and seasonal statistics, as well as determine ponded depth and duration for specific wetland communities.

SJRWMD added a change analysis function to the tool, which provided the means to assess the environmental effects of a number of surface water withdrawal scenarios. The study area was18,256 hectares of wetlands contiguous with approximately 37 river kilometers in the Upper St Johns River Basin, extending from the Lake Washington weir (the upper reach of hydrologic effects) to the outlet of Lake Poinsett (the proposed withdrawal location). The withdrawal scenarios varied by potential withdrawal amounts, drainage basin land use, and degree of completion of several water management projects. Model hydrologic data input for the tool was provided by the SJRWMD’s Bureau of Engineering using HSPF to simulate 10 years (January 1, 1996 - December 31, 2005). Results from the Hydroperiod tool identified the areal extent of wetlands that would experience fewer days of inundation, as well as the change in ponded depth, for the various scenarios. Additionally, the GIS tool was run for one scenario on a 7,422-hectare area approximately 40 km downstream of the Lake Poinsett area in order to predict withdrawal impacts further downstream.

Contact Information: Sandra Fox, St Johns River Water Management District, 4049 Reid Street, Palatka, FL 32177, USA, Phone: 386-329-4535, Fax: 386-329-4329, Email: sfox@sjrwmd.com

WETLANDS CORRECTION FACTORS FOR LIDAR DIGITAL ELEVATION MODELS

Sandra Fox*[1]*, *Palmer Kinser*[1], *Lawrence Keenan*[1], *Debra Hydorn*[2], *William Wise*[3] and *Clay Montague*[3]

[1] St Johns River Water Management District, Palatka, FL, USA
[2] University of Mary Washington, Fredericksburg, VA, USA
[3] University of Florida, Gainesville, FL, USA

The importance of accurate, spatially comprehensive, high-resolution elevation data for many types of wetland studies cannot be overstated. As LiDAR-derived (Light Detection And Ranging) digital elevation models (DEMs) become increasingly available and affordable, the spatial extent of elevation data for wetland studies has significantly improved. However, the accuracy of LiDAR-derived DEMs in areas of extremely dense vegetation is questionable. Typically, vertical accuracy control points are located in open terrain where the LiDAR pulse consistently reaches the earth's surface; thus in the DEM, wetlands are often classed as "Low Confidence Areas," since dense vegetation may prevent elevation data from meeting the project's overall data accuracy requirements.

For a project predicting the potential impacts of surface water withdrawals on riverine wetlands along the St Johns River (River) for the St Johns River Water Management District (SJRWMD), we needed high quality elevation data and two new LiDAR-derived DEMs had become available. Within each DEM we selected two wetland study areas along the River for which high accuracy survey elevation data were available; one7,422 hectares area and one 18,256 hectares area. Additionally, wetland classification along these transects for these areas was performed at the time of survey. Field survey elevation data from eight transects extending from the River edge to uplands (four transects for each study area; 19 km total length; and 2,200 elevation measurements) were compared to DEM elevations. The DEM elevation data matched the field survey data well in uplands but showed a consistent positive bias in wetland areas in both DEMs. To improve accuracy of the DEM, an approach to develop correction factors for the wetland areas was created using three criteria; 1) minimize the differences between the new (corrected) DEM and the surveyed elevation at each station, 2) eliminate the positive bias so that median error between the new DEM and survey elevations was zero, and 3) be consistent with field knowledge. Final correction factors for the DEMs ranged from zero for woody woodlands to 0.76 m for dense herbaceous communities. These corrections were critical for creating a DEM sufficiently accurate to meet the needs of the water withdrawal assessment.

Contact Information: Sandra Fox, St Johns River Water Management District, 4049 Reid Street, Palatka, FL 32177, USA, Phone: 386-329-4535, Fax: 386-329-4329, Email: sfox@sjrwmd.com

EVALUATION OF WORLDVIEW-2 AND LANDSAT DATA TO DIFFERENTIATE AND MAP FRESHWATER MARSH PLANT COMMUNITIES AT DIFFERENT SPATIAL SCALES FOR TWO EVERGLADES LANDSCAPES

Daniel Gann[1], *Jennifer Richards*[2] and *Andrew Gottlieb*[3]
[1]GIS-RS Center, Florida International University, Miami, FL, USA
[2]Department of Biological Sciences, Florida International University, Miami, FL, USA
[3]Atkins, Jacksonville, FL, USA

Remote sensing methods offer the potential to monitor vegetation across large landscape extents at various spatial resolutions. Application of remote sensing in wetlands, however, has lagged behind its use in other landscapes because of the temporal variability in spectral reflectance that results from varying hydrology. Our objectives were to differentiate and map freshwater marsh communities using multi-spectral remotely sensed imagery of two sensors with different spatial resolutions. We evaluated the effectiveness of WorldView-2 (2m resolution) and Landsat imagery (30m resolution) for plant community mapping utilizing recursive partitioning classification algorithms. We evaluated the separability of plant communities for (1) spectral reflectance characteristics, first-order textural derivatives (local mean and variance) and for single- and dual-date imagery; (2) single tree versus random tree recursive partitioning algorithms; and (3) the hierarchical level of the classification scheme (species versus structure). Accuracy was evaluated in terms of overall and class-specific accuracies and their associated Kappa statistic estimates derived from both contingency matrices of model-based cross-validated results and post-classification stratified random sampling designs.

Our results showed that remote sensing methods were effective in differentiating wetland community classes present in the sampled areas within Water Conservation Area 3 (WCA3) and northern Everglades National Park (ENP). Mapping of community boundaries across the landscape was effective with both data products; graminoid, slough, wet prairie and swamp shrub communities all had high levels of detection accuracy. The most accurate models predicted plant communities from bi-seasonal spectral reflectance + texture variables with texture having a more pronounced effect for the higher resolution WorldView-2 imagery. When we compared the accuracies of classification at the different levels of our community hierarchy, the structure models performed slightly better than the species level models; for the medium resolution imagery a post-classification hierarchical aggregation from species level to structural level delivered significantly better results than classification at the structural level.

The value of a vegetation map to vegetation monitoring is not only determined by its accuracy but also by its spatial precision. The spatial precision of a vegetation map depends on the spatial resolution and minimum mapping unit, which need to reflect the spatial variability of the vegetation classes that are represented in the classification scheme of interest. Our objectives were to determine the effects of spatial resolution, aggregation and generalization methods on the estimates of landscape metrics of composition (relative abundance of plant communities) and their configurations at different spatial resolutions. Aggregation of 2x2 m resolution to increasingly larger mapping units preserved general community boundaries at a much higher precision than grid-based aggregation methods, allowing for more reliable assessment of landscape configuration and detection of expansion and contraction of landscape units.

Contact Information: Daniel Gann, GIS-RS Center, Florida International University, Miami, FL, 33199, USA, Phone: 305-348-1971, Fax: 305-348-6445, Email: gannd@fiu.edu

DEVELOPING A NATIONAL STANDARD FOR CHALLENGES TO THE NATIONAL WETLAND PLANT LIST

J. J Gillrich and *R. W. Lichvar*
U.S. Army Corps of Engineers, Hanover, NH, USA

The National Wetland Plant List (NWPL) contains wetland indicator status ratings that are used during wetland delineations in the USA to determine if vegetation is hydrophytic. Plants are assigned one of five rating categories: obligate wetland (OBL), facultative wetland (FACW), facultative (FAC), facultative upland (FACU) or upland (UPL). Each species' rating is based on the botanical literature and the field experiences of wetland scientists and botanists from across the US. Until recently, no landscape-scale data have been available to confirm or refute these ratings. Although the ratings of most species are generally accepted, plants with ratings of FAC to FACU can be contentious because of their potential impact on jurisdictional determinations. The most recent update of the NWPL allows individuals and/or institutions to challenge a plant species' wetland indicator status using landscape-scale data. This study design was developed in cooperation with the National Panel of the NWPL and the National Technical Committee for Wetland Vegetation.

We tested a challenge study method for collecting plant frequency data and analyzing wetland frequency. Five plant species were randomly sampled throughout a 12-digit HUC in south-central New Hampshire. ARCMap 10.0 randomly generated 100 spatially balanced points inside public land polygons. Sixty 100.0-meter line intercept transects were sampled: 30 in wetlands and 30 in uplands. We compared results produced when wetland frequency was calculated using a traditional frequency formula, a weighted frequency formula, and a Bayesian model that predicts wetland frequency using the data we collected and prior occurrence data.

The three methods agreed when large, equivalent numbers of transects were used to calculate wetland frequency. The formulas disagreed when data were non-normally distributed and/or there were large discrepancies in the number of wetland and upland transects used in the calculations. For challenges to the NWPL, the preferred data collection method is 30 upland and 30 wetland transects. Sampling wetlands and uplands in proportion to their occurrence in the landscape is not recommended because these proportions are difficult to determine accurately in a 12-digit HUC. The weighted frequency formula may be used, provided that a minimum of 10 transects of one type are collected and the data are normally distributed. These are general methods that should ensure that proposed additions or changes to the NWPL are evaluated using data collected at an appropriate scale and are analyzed using scientific methods. Sampling methods may need to be adjusted for species whose occurrence in wetlands is seasonal or varies with disturbance or watershed type.

Contact Information: J. J Gillrich, U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, 72 Lyme Road, Hanover, NH, 03755, USA, Phone: 603-646-4607, Fax: 603-646-4750, email: jennifer.j.gillrich@usace.army.mil

LANDSCAPE-SCALE WETLAND FUNCTIONAL ASSESSMENT ON ALASKA'S NORTH SLOPE

Zachary Halstead, *Anne Leggett, Tobin Lilly, Malcolm Salway, George Hoden* and *Douglas Jewell*
HDR Alaska, Inc., Anchorage, AK USA

For a proposed natural gas project on the North Slope of Alaska, the wetland assessment team employed a landscape-level approach to describe wetland functions. The project area, including 64,000 acres with over 100 miles of pipeline and road corridor alternatives, is over 95% wetland. Methods for assessing wetland functions are evolving in Alaska, with none yet fully proving itself in undeveloped areas. Challenges also included: (1) lack of site-specific data beyond aerial photography, vegetation mapping, and a digital elevation model; and (2) a project area of extensive, flat wetland that could not meaningfully be divided into Assessment Areas. To meet assessment needs, the team refined a Geographic Information System (GIS)-based method it previously developed and used on other projects. This approach identifies where on the landscape each function occurs, rather than first defining Assessment Areas then identifying the functions that occur within each.

Input Information included the following. The team had mapped the full study area using an Information-rich vegetation classification system. This system reflects vegetation structure, microtopography, landscape position, substrate type, salinity, vegetation/water interspersion, and moisture regime. They mapped streams and approximate floodplains using field observations, aerial photo interpretation, and topographic data. For polar bears, GIS layers of suitable denning habitat existed, as well as known den sites and designated Critical Habitat. The U.S. Fish and Wildlife Service had prioritized wildlife habitat types on the North Slope; the team translated these to equivalents in the project's vegetation classification system and hand-mapped some types. Fish presence GIS layers also existed.

The team selected wetland functions they considered meaningful in the project area, and defined each. For functions that are ubiquitous, they either did not assess the function, or defined it to identify areas with particularly high effectiveness. Finally, the team developed simple word models to predict where each function occurs at a high level, and translated those models into data queries in GIS. They ran iterations of each model to achieve results consistent with their predictions based on best professional judgment. Federal resource agency staff contributed to method development through three work sessions in which functions were selected and defined and the conceptual models refined and approved.

Advantages of using GIS data layers and logical models are: (1) the method is highly transparent and easy to understand; (2) models are applied uniformly over the landscape, thus minimizing inconsistencies of individuals' judgment; (3) models can easily be changed and re-run over expansive areas as better Information becomes available; and (4) no assessment areas need be defined. This landscape approach is proving effective for large-scale projects, and is highly adaptable to the baseline Information available for each project site.

Contact Information: Zachary Halstead, HDR Alaska, Inc., 2525 C Street, Suite 305, Anchorage, AK 99503, USA, Phone: 907-644-2000, Fax: 907-644-2022, Email: Zachary.halstead@hdrinc.com

THE NORTH DAKOTA INTENSIFICATION OF THE NWCA: AN ENDEAVOR IN COLLABORATION

***Christina L. M. Hargiss**[1], Edward S. DeKeyser[1], Jack E. Norland[1], Thomas DeSutter[1], Lindsey Meyers[1]* and *Michael J. Ell[2]*

[1]North Dakota State University, Fargo, ND, USA
[2]North Dakota Department of Health, Bismarck, ND, USA

The National Wetland Condition Assessment (NWCA) in North Dakota (ND) was conducted on 11 wetlands, with 2 revisits, during the summer of 2011. An additional 42 wetlands were tested as part of the intensification of the NWCA for ND during the same time frame. Data taken at the intensification sites included data from the NWCA as well region specific data including the Index of Plant Community Integrity (IPCI), the ND Rapid Assessment (NDRAM), and the Hydrogeomorphic Model (HGM). Additional data including soil mercury, landscape, and multi-elemental fingerprinting samples; and vegetation landscape clipping samples were taken for specific graduate projects. To complete this large undertaking many individuals representing a number of agencies took part in the project; agencies include: EPA's Office of Water; EPA's Western Ecology Division (EPA-WED); EPA Region 8; Natural Resources Conservation Service (NRCS); North Dakota Department of Health, Division of Water Quality (NDDoH); North Dakota Department of Agriculture (NDDA); and four departments/programs from North Dakota State University (NDSU). Data from the IPCI, NDRAM, and HGM have been compiled and will be compared to the NWCA data to obtain an overall assessment of wetland condition in ND.

Contact Information: Christina L. M. Hargiss, School of Natural Resource Sciences, North Dakota State University, NDSU Dept. 7650, P.O. Box 6050, Fargo, ND 58108, USA; Phone: 701-231-8451; Fax: 701-231-7861; Email: Christina.Hargiss@ndsu.edu

LOCAL WETLAND INVENTORIES AND ORWAP: APPLICATIONS FOR ASSESSING, PROTECTING, AND MITIGATING WETLANDS

Sarah Hartung[1] and *Paul Adamus*[2]
[1]Environmental Science Associates, Inc., Portland, OR, USA
[2]Adamus Resource Assessment, Inc., Corvallis, OR, USA

State of Oregon planning goals require cities and counties to field verify, assess, and map all wetlands larger than 0.5 acre through a process known as a local wetland inventory (LWI). The primary purpose of LWIs is to identify wetland areas prior to site development and permitting, especially those that may warrant extra protection at the local level. Wetland regulatory agencies in Oregon have adopted a new wetland assessment tool – the Oregon Rapid Wetland Assessment Protocol (ORWAP) – in order to more accurately assess wetland functions and values. Environmental Science Associates and Adamus Resource Assessment applied ORWAP to the largest LWI approved in Oregon to date, the South Deschutes County LWI. The study area has a high incidence of ground water contamination from widespread use of older septic systems in highly permeable soils, and the county is interested in protecting existing wetlands that potentially purify ground or surface water in situations where contamination sources have not been pinpointed or are difficult to remediate.

With local staff support, Environmental Science Associates and Adamus Resource Assessment conducted the South Deschutes County LWI from March 2010 through July 2011. The LWI was adopted into the county's comprehensive plan in the fall of 2011. The study area covers 18,937 acres of public and private land and includes three major river systems. During field investigations, we identified 114 wetlands and 71 "probable" wetlands which are smaller than 0.5 acre. We assessed the functions and values of the 114 wetlands using ORWAP, which ranks wetlands according to relative levels of 16 ecosystem services they potentially provide, including water quality improvement. Because groundwater contamination is a major concern in the county, ORWAP's score for the nitrate removal function was used as the principal determinant for selecting wetlands to protect locally as important water quality resources. A total of 35 sites (30 percent of the assessed wetlands) scored high for nitrate removal and were added into county land use planning rules as "priority water quality resources."

ORWAP has since been used to rank wetlands in other LWI's in Oregon. A modified version, termed WESP (Wetland Ecosystem Services Protocol), is available for functions-based ranking of wetlands in temperate regions outside of Oregon and builds upon 30 years of developing wetland rapid assessment methods throughout North America. Resource agencies in Alaska and Alberta are currently supporting calibration and application of WESP in those regions. In this presentation, we also compare ORWAP to Florida's Uniform Mitigation Assessment Method (UMAM) in the context of assessing wetland functions to determine compensatory mitigation.

<u>Contact Information</u>: Sarah Hartung, Environmental Science Associates, Inc., 522 SW Fifth Ave., Ste 820, Portland, OR 97204, USA, Phone: 971-295-5004, Fax: 503-226-8017, Email: shartung@esassoc.com

CROSSWALK OF THE FLORIDA WETLAND CONDITION INDEX WITHIN THE NATIONAL WETLAND CONDITION ASSESSMENT

***Erica Hernandez**, Carrie Boyd, Kelly Chinners Reiss* and *Mark T. Brown*
HT Odum Center for Wetlands, University of Florida, Gainesville, FL, USA

The Florida Wetland Condition Index for Vegetation (FWCI-V), an index of biological integrity, was conducted at 18 freshwater wetlands in 2011 in conjunction with the US Environmental Protection Agency's (US EPA) Nation Wetland Condition Assessment (NWCA). Sites were selected to meet FWCI-V wetland criteria for palustrine emergent and palustrine forested wetlands. Wetlands were stratified across a gradient of anthropogenic influence, embedded in landscapes dominated by silvicultural (n=8), agricultural (n=2), urban (n=2), and reference (n=6) land use categories. Macrophyte community composition was measured using NWCA design (i.e. nested quadrats within a 40 m radius plot) and FWCI-V design (i.e. 40 m long belted transects). Data from the NWCA Level 3 Intensive Site Assessment will be evaluated using FWCI indices in a cross-walk of the two methodologies. Species area curves will be developed to compare and contrast the data collection methods and to understand differences in community structure and richness. We expect the assessment of wetland health between the two methodologies to be correlated. Preliminary results from these studies will be presented.

Contact Information: Erica Hernandez, HT Odum Center for Wetlands, 100 Phelps Lab, Museum Road, Gainesville, FL 32611, USA, Phone: 352-392-2424, Email: echernan77@gmail.com

REFERENCE SITE SELECTION FOR THE NATIONAL WETLAND CONDITION ASSESSMENT: INTEGRATING BEST PROFESSIONAL JUDGEMENT AND OBJECTIVE SELECTION CRITERIA

Janet A Nestlerode[1], Gregg Serenbetz[2], Michael E. Scozzafava[2] and ***Mary Kentula***[3]

[1]US EPA National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, Florida, USA

[2]US EPA Office of Wetlands, Oceans, and Watersheds, Wetlands Division, Washington, DC, USA

[3] US Environmental Protection Agency, Corvallis, Oregon, USA

The National Wetlands Condition Assessment (NWCA), one of a series of environmental assessments being conducted by states, tribes, the U.S. Environmental Protection Agency, and other partners, surveyed over 900 wetland sites across the lower 48 states during Summer 2011. The NWCA is designed to assess ecological integrity at regional and national scales and identify and rank the stressors most commonly associated with poor conditions. As deviation from the reference condition may be used as a measure of the effect of stressors on the assessment area, the selection and evaluation of reference sites that represent the best attainable (or least disturbed) watershed condition, habitat structure, water quality and biological parameters are critical components of the NWCA assessment. Over 1100 handpicked candidate reference sites across six select coastal and inland wetland types were obtained from state, university, and other federal monitoring programs. These candidate reference sites were critically evaluated with a set of explicit criteria, using a combination of ground reconnaissance, aerial photography interpretation, and soil and vegetation maps, to yield 110 sites that will be used for comparison to probabilistically-based sampling sites during data analysis.

<u>Contact Information</u>: Mary Kentula, US Environmental Protection Agency, 200 SW 35th Street, Corvallis, OR 97333, USA, Phone: 541-754-4478, Email: kentula.mary@epa.gov

ADAPTIVE TECHNIQUES FOR LARGE-SCALE WETLAND DELINEATION

Dale F. Knapp
Stantec Consulting Services Inc., Topsham, Maine, USA

The opportunity to complete full natural resource assessments on 10,000 or more acres is an exciting but daunting task. Because we are not simply looking at a broad ecological characterization, each resource within that area must be individually mapped and catalogued. Permitting requirements at the state and federal level require accurate resource boundary determinations so wetland and other resource impacts can be avoided, minimized or quantified. Large-scale projects involving the installation of infrastructure in remote locations demand evolving techniques and technologies to maximize efficiency, simplicity, and accuracy of resource boundary determinations. During the course of many of these types of projects in the Northeastern U.S., we have developed practical methods that allow biologists to cover more ground in a reduced amount of time while collecting accurate data. These methods keep projects moving forward within the established timeframe, while also protecting and identifying wetlands early in the design process so avoidance and minimization can be built into the design. The result is a smaller project impact and a smoother regulatory review process.

This presentation will discuss pre-survey techniques that increase efficiency and accuracy such as creating unique identifiers for each field-identified resource. Naming protocols and Global Positioning System data dictionaries can be specifically tailored to a particular project to avoid lost data during the transition from field collection to the mapping database. Utilization of custom mapping grids of varying widths can help orient biologists on the landscape, maximize efficiency, and reduce the size of crews needed. Large-scale delineations often take teams into areas of rugged terrain where cell phone coverage may be sparse. This presentation will also discuss protocols to keep crews safe and productive, as well as calculating the typical number of acres a field crew can cover daily based on terrain and similar project experience. As data are gathered and crews return to the office, biologists are faced with large amounts of field notes, photographs, and maps. This presentation will address the most important component of data management during field delineations: quality control that ensures that resource and mapping data included in the state and federal permit applications are accurate and uniform. The combination of these pre-survey, in-the-field, and post-survey techniques inform project team members and state and federal regulators of the best way to responsibly manage our valuable natural resources. This presentation will provide field-tested, effective techniques to biologists with interest in large-scale resource delineation and resource assessment.

Contact Information: Dale Knapp, Stantec Consulting, 30 Park Drive, Topsham, ME 04086, USA, Phone: 207-729-1199, Fax: 207-729-2715, Email: dale.knapp@stantec.com

MONITORING WETLAND CHANGES USING MULTITEMPORAL LANDSAT CHANGE DETECTION, WEB MAPPING SERVICES, AND CROWD SOURCING

J. Dykstra, *D. Meeks, D. Cunningham, A. Estrada* and ***G. Koeln***
MDA Information Systems, Inc., Geospatial Division, 820 West Diamond Ave., Suite 300, Gaithersburg, Maryland, USA

Despite various federal, state, and local wetland protection laws, both permitted and non-permitted wetland losses continue. Many change detection techniques using pairs of Landsat data can detect changes in wetlands. However, most of these techniques also have high commission errors preventing automation of the process without image analysts reviewing and removing the commission errors. MDA's Correlated Land Change (CLC) process, which uses many Landsat scenes in a multitemporal change detection approach, was designed to eliminate commission errors. The CLC process begins with a multitemporal stack of coregistered Landsat multispectral scenes. Using MDA's patented CCA (Cross Correlation Analysis) change procedure, a change measure is calculated, on a pixel-by-pixel basis, between all possible 2-image-pair permutations within the multitemporal image stack. The CLC process then applies multitemporal templates to discern patterns of man-made change within this vast collection of pair-wise change analyses. This process has been shown to eliminate most commission errors created by clouds, seasonal changes in natural vegetation, and changes created under standard agricultural practices. Plans are to create a publicly available web mapping service that will allow the user to display the US Fish and Wildlife Service's National Wetland Inventory data, the CLC product identifying areas and dates of change, and will provide a user interface enabling users to describe the changes that have occurred to the wetland. It is anticipated that this crowd sourcing technique, by adding comments and photos of the change directly into the web mapping service, will prove to be another deterrent to wetland losses. The web mapping service will be demonstrated and will include crowd-sourced photos and comments posted describing the wetland changes in the Orlando, FL area.

Contact Information: Gregory Koeln, MDA Information Systems, Inc. , 820 W. Diamond Ave., Suite 300, Gaithersburg, MD 20878, USA, Phone: 240-833-8200, Email: Greg.Koeln@mdaus.com

LIDAR INTENSITY AND ELEVATION DATA TO INFER FORESTED WETLAND EXTENT AND FUNCTION

Megan W. Lang[1], *Robert A. Oesterling*[2], *Greg W. McCarty*[3], *Daniel E. Fenstermacher*[4] and *Owen T. McDonough*[5]

[1]U.S. Department of Agriculture Forest Service, Beltsville, MD, USA
[2]University of Maryland Department of Geography, College Park, MD, USA
[3]U.S. Department of Agriculture Agricultural Research Service, Beltsville, MD, USA
[4]University of Maryland Department of Geography, College Park, MD, USA
[5]University of Maryland Center for Environmental Science, Solomons, MD, USA

The improved conservation and management of wetlands to maximize ecosystem service delivery requires accurate knowledge of wetland extent and function. Unfortunately, even the most accurate U.S. wetland maps contain relatively high levels of error in areas that are difficult to map, such as forests, and the relationship between map categories and wetland functions is not well developed. Light Detection and Ranging (LiDAR) intensity and elevation data have the potential to not only improve the accuracy of wetland maps but also the ability to infer wetland function through the mapping of key wetland functional drivers, such as hydroperiod. Although LiDAR intensity and elevation can be collected from the same sensor simultaneously, they have distinct capabilities for wetland monitoring that should be recognized in order to take full advantage of both datasets. We investigated the accuracy of inundation maps produced using LiDAR intensity data collected during average and drought conditions and the predictive strength of wetness maps created using digital elevation models (DEMs) and multiple topographic metrics, including primary (e.g., relief) and secondary (e.g., topographic wetness indices) metrics, in the Coastal Plain of Maryland. LiDAR intensity based maps of inundation representing the beginning of the growing season during years of different weather conditions (i.e., average and drought) were found to have a high level of accuracy based on in situ data. The LiDAR intensity based maps of wetness were used to gauge the predictive strength of LiDAR based topographic indices produced using varying approaches, including multiple flow routing algorithms (i.e., D8, D∞, and FD8). The distinct advantages and disadvantages of these approaches are detailed and their predictive strength is compared to existing wetland maps based on aerial photography. Results indicate that LiDAR intensity and elevation based maps have the potential to improve the accuracy and automation of wetland mapping. LiDAR intensity based maps of inundation produced using data collected during years of contrasting weather patterns help to illustrate changes to wetland boundaries and distributions that may occur with climate change, and the potential impact of these changes on wetland biogeochemistry and the provision of ecosystem services.

Contact Information: Megan W. Lang, USDA Agricultural Research Service, Beltsville Agricultural Research Center, Hydrology and Remote Sensing Laboratory, 10300 Baltimore Avenue, Bldg. 007 Rm. 104 BARC-West, Beltsville, MD 20705 USA, Phone: 301-504-5138, Fax: 301-504-8931, Email: mwlang@fs.fed.us

INTEGRATED ANALYSIS OF INTERFEROMETRIC SAR, SATELLITE ALTIMETRY AND HYDRAULIC MODELING TO QUANTIFY LOUISIANA WETLAND DYNAMICS

Hyongki Lee[1], *Jin-woo Kim*[2], *Zhong Lu*[3], *Hahn Chul Jung*[4], *C.K. Shum*[2] and Doug *Alsdorf*[2]

[1]Department of Civil and Environmental Engineering, University of Houston, Houston, TX
[2]School of Earth Sciences, Ohio State University, Columbus, OH
[3]US Geological Survey, Vancouver, WA
[4]Hydrological Sciences, NASA GSFC, Greenbelt, MD

Wetland loss in Louisiana has been accelerating due primarily to anthropogenic and nature processes, and is being advocated as a problem with national importance. Accurate measurement or modeling of wetland-wide water level changes, its varying extent, its storage and discharge changes resulting in part from sediment loads, erosion and subsidence are fundamental to assessment of hurricane-induced flood hazards and wetland ecology. Here, we use innovative method to integrate interferometric SAR (InSAR) and satellite radar altimetry for measuring absolute or geocentric water level changes and applied the methodology to remote areas of swamp forest in coastal Louisiana. Coherence analysis of InSAR pairs suggested that the HH polarization is preferred for this type of observation, and polarimetric analysis can help to identify double-bounce backscattering areas in the wetland. Envisat radar altimeter-measured 18-Hz (along-track sampling of 417 m) water level data processed with regional *stackfile* method have been used to provide vertical references for water bodies separated by levees. The high-resolution (~40 m) relative water changes measured from ALOS PALSAR L-band and Radarsat-1 C-band InSAR are then integrated with Envisat radar altimetry to obtain absolute water level. The resulting water level time series were validated with in situ gauge observations within the swamp forest. Furthermore, we compare our water elevation changes with 2D flood modeling from LISFLOOD hydrodynamic model. Our study demonstrates that this new technique allows retrospective reconstruction and concurrent monitoring of water conditions and flow dynamics in wetlands, especially those lacking gauge networks.

Contact Information: Hyongki Lee, Department of Civil and Environmental Engineering, University of Houston, N107 Engineering Building #1, Houston TX 77204-4003, Office: 713-743-4685, Fax: 713-743-0186, Email: hlee@uh.edu

BRINGING SCIENCE AND TECHNOLOGY TO THE NATIONAL WETLAND PLANT LIST

R.W. Lichvar and *J.J. Gillrich*
U.S. Army Corps of Engineers, Hanover, NH, USA

The National Wetland Plant List (NWPL) is an interagency product administered by the U.S. Army Corps of Engineers. The other Federal agencies involved in updating and assisting in the design of the NWPL include the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (FWS), and the Natural Resources Conservation Service (NRCS). Since 2006, the NWPL has been undergoing extensive updating and review. Prior updates to the list by the FWS in 1988 and 1996 were extensive but limited due to the lack of computer technology. The externally scientific-peer-reviewed update of the NWPL uses two approaches that had not been part of previous updates. First, all aspects of update are done through regional panels, external professional botanists, and the public by use of an interactive web site. Recently the web site was used to coordinate the involvement of over 400 people actively participating in the update. All parties involved made their input online, and their actions can be viewed by wetland regions or by species. This allows any user to see how each species received its wetland rating based on the type of data or input and who supplied that input. Second, the current NWPL update is designed to increase the quality of the wetland ratings by using a broadened, dynamic system. This is accomplished in several ways: 1) at any time anyone in the professional public and academic community can make comments and input that will be evaluated annually, 2) challenges to wetland ratings are now possible through a process that guides the challenger as they develop acceptable and usable landscape-level frequency data, 3) statistical challenge studies will be peer-reviewed by the National Technical Committee for Wetland Vegetation for species tested at the 12-digit HUC level, 4) large existing regional and national datasets will be analyzed and computer algorithms will be used to assess wetland ratings at various spatial scales, and 5) updating will be done annually. The annual updating will include nomenclature and taxonomy, newly proposed species, changes as needed based on the results from challenge studies or dataset analysis, re-evaluations of wetland ratings based on GIS and floristic provinces analysis, considerations of any new subregions, and several continuous quality control steps. If changes to wetland ratings are warranted, they will be made during the annual update.

Contact Information: R.W. Lichvar, U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, 72 Lyme Road, Hanover, NH, 03755, USA, Phone: 603-646-4657, Fax: 603-646-4750, Email: robert.w.lichvar@usace.army.mil

PREDICTING WETLAND FUNCTIONS AT THE LANDSCAPE LEVEL FOR COASTAL GEORGIA

***Jan Mackinnon*[1]**, *Ralph Tiner*[2] and *John Hefner*[3]

[1]Georgia Department of Natural Resources, Brunswick, GA, USA
[2]U.S. Fish and Wildlife Service, Hadley, MA, USA
[3]Atkins North America, Inc., Raleigh, NC, USA

The Coastal Resources Division of the Georgia Department of Natural Resources with assistance from Atkins North America, Inc., in cooperation with the U.S. Fish and Wildlife Service, conducted a remotely sensed landscape level study to predict the relative capability of the wetlands in six coastal Georgia counties to provide eleven important ecological services or functions. The functions evaluated included surface water detention, coastal storm surge detention, stream flow maintenance, nutrient transformation, carbon sequestration, retention of sediment and other particulates, bank and shoreline stabilization, and four habitat functions. The process involved interpreting digital aerial photography and assigning abiotic attributes to each of approximately 52,000 wetland polygons included in the recently updated National Wetlands inventory database for the 3 million acre study area. These attributes described the wetlands' 1) position on the landscape, 2) physical shape, 3) water flow path and 4) water body type for estuaries, rivers, lakes, and ponds. The wetlands data were compiled into a NWI+ database. A workshop was conducted to obtain the observations regarding functional capabilities from local Georgia wetland experts. Then with guidance from the Fish and Wildlife Service and based on the state of the current understanding regarding wetland functions as described in the literature, wetlands were sorted based on their anticipated capability to perform the various functions. Outputs from the project include maps, tables, and digital spatial database showing the locations of all wetlands and their predicted high, moderate or low capability to support each of the eleven functions. This NWI+ wetland functional assessment study was the first of its kind in the Southeast Region and the largest in geographic extent attempted to date. The Information generated from the study provides a preliminary wetland functional assessment useful for regional and watershed planning purposes.

<u>Contact Information</u>: Jan M. Mackinnon, Georgia Department of Natural Resources, One Conservation Way, Brunswick, GA 31520, USA, Phone: 912-262-3053, Fax: 912-262-3131, Email: jan_mackinnon@dnr.state.ga.us

IMPROVING SUCCESS RATES FOR COMPENSATORY WETLAND MITIGATION USING QUANTIFIABLE ECOLOGICAL PERFORMANCE STANDARDS DEVELOPED FROM LEVEL 3 NATIONAL WETLAND CONDITION ASSESSMENT DATA

Mick Micacchion

Midwest Biodiversity Institute, Columbus, OH, USA

Field crews sampled 1258 natural wetlands across the nation in 2011 as part of the National Wetland Condition Assessment (NWCA). The NWCA was designed to determine the ecological integrity of wetlands at regional and national scales, build state and tribal capacity for monitoring and analyses, promote a robust, statistically valid set of wetland data and develop baseline Information to evaluate progress. NWCA goals include advancing the science of wetlands monitoring and assessment, reporting on the condition of the Nation's wetlands, and helping states and tribes implement wetland monitoring and assessment programs.

In the Lake Erie watershed of Ohio 60 compensatory wetland mitigation projects, 30 mitigation bank and 30 permittee-responsible mitigation sites were also monitored in 2011 using the NWCA monitoring protocols for the Great Lakes Basin Evaluation of Compensatory Sites (GLBECS) project. To provide immediate results on wetland ecological condition and an assessment of success or failure of the mitigation projects the NWCA vegetation data collected was used to calculate Vegetation Index of Biotic Integrity (VIBI) scores (Mack 2004), a Level 3 wetland assessment tool. Achieving VIBI scores reflective of at least a "good" level of ecological condition was set as the quantifiable success criteria as this is a universal performance standard used in Ohio for all wetland mitigation projects and equates to wetlands that are of sufficient ecological integrity to adequately compensate for losses and demonstrate high environmental resilience.

Overall, 30% of mitigation bank and 13% of permittee-responsible sites in the GLBECS study were considered successful. The 30% success rate is a large improvement from an earlier evaluation of Ohio mitigation banks (Mack and Micacchion 2006) that found only a 9.7% success rate using the same criteria. Reasons for the improvements are tied to the inclusion of credit release schedules dependent on the attainment of quantifiable ecological performance standards in all recent Ohio wetland mitigation bank instruments. These provisions that place the risk for non-performance on the bankers provide strong incentive for making informed decisions on bank establishment considerations that will maximize success. The high failure rate (87%) for permittee-responsible sites could be best addressed by incorporating a mechanism similar to a credit release schedule into permit conditions that retains a financial interest from the permittee until success criteria based on quantifiable ecological goals are met for those projects. The GLBECS study results highlight the great potential for future development of Level 3 wetland ecological integrity assessment tools, like the VIBI, using the NWCA data to establish, not only ambient wetland assessment tools, but similar measurable wetland ecological performance standards for compensatory mitigation wetlands that can be used over a broad geographic context.

Contact Information: Mick Micacchion, Midwest Biodiversity Institute, 5530 Olentangy River Road, Columbus, OH 43235, USA, Phone: 614-457-6000, Fax: 614-457-6005, Email: mmicacchion@mwbinst.com

REGIONALIZING THE CORPS OF ENGINEERS WETLAND DELINEATION MANUAL - THE ROLE OF THE NATIONAL TECHNICAL COMMITTEE FOR WETLAND VEGETATION

Paul Minkin and *Jacob F. Berkowitz*
U.S. Army Corps of Engineers, Engineer Development and Research Center, Vicksburg, MS, 39180, USA

The US Army Corps of Engineers continues to update wetland delineation and identification procedures in order to maximize technical competency and reflect the current state of the science. As a result, regional supplements to the Corps of Engineers Wetland Delineation Manual (Corps Manual) have been implemented for ten regions covering the entire nation. The development process included input from over 250 individuals comprising local working groups of wetland professionals, independent peer reviewers from the private sector, and oversight by technical specialists from both agencies and academia. Technical experts play an important role in the development and updating of guidance for wetland delineation procedures and other resource management documents.

The National Technical Committee for Wetland Vegetation (NTCWV) was established in 2006 to evaluate various technical and scientific issues related to vegetation that had been raised during the regionalization and updating of the Corps Manual. The membership consists of representatives from several federal agencies (US Army Corps of Engineers, US Environmental Protection Agency, US Fish and Wildlife Service, USDA-Natural Resources Conservation Service, USDA-Forest Service, and the Bureau of Land Management) and universities.

The NTCWV provides technical botanical support for the regionalization and updating of the Corps Manual. In this capacity, the NTCWV has developed and published literature reviews on the use of bryophytes as indicators of hydric soils and wetland hydrology during wetland delineations, growing season definition and use in wetland delineation, and vegetation sampling for wetland delineation. In addition to providing wetland delineation manual support, the NTCWV also provides botanical support for technical issues related to the National Wetland Plant List.

Contact Information: J.F. Berkowitz, U.S. Army Corps of Engineers, Engineer Development and Research Center, 3909 Halls Ferry Road, Vicksburg, MS, 39180, USA, Phone: 601-634-5218, Email: Jacob.F.Berkowitz@usace.army.mil

HGM POSTER

Chris Noble
USACE, Vicksburg, MS USA

This poster presents maps and Information related to the current status of Hydrogeomorphic (HGM) assessments across the country.

Contact Information: Chris Noble, US Army Corps of Engineers, ERDC, Environmental Laboratory, Vicksburg, MS 39180 USA, Phone: 601-634-3482, Fax: 601-634-3205, email: Chris.V.Noble@us.army.mil

COMPARATIVE ANALYSIS OF COASTAL WETLAND HEALTH IN THE DELAWARE ESTUARY ASSESSED USING RAPID METHODS

Angela T. Padeletti*[1]*, *Danielle Kreeger*[1], *Kelly Somers*[1], *Andrew* Howard[2] and *Alison Rogerson*[2]

[1]Partnership for the Delaware Estuary, Wilmington, DE, USA

[2]Delaware Department of Natural Resources and Environmental Control, Dover, DE, USA

Tidal wetlands are a hallmark feature of the Delaware Estuary, yet we know little about their health. Data for wetland acreage in the estuary are limited, specifically some data is over thirty-five years old in some parts of the watershed. The Partnership for the Delaware Estuary launched the Mid-Atlantic Coastal Wetlands Assessment to fill in these data gaps using various rapid assessment methods and intensive site monitoring throughout representative areas of the estuary. The Mid-Atlantic Tidal Rapid Assessment Methodology, originally developed by the Delaware Department of Natural Resources and Environmental Control, was used to examine wetland stressors and health in three such tributary watersheds; Maurice, NJ, Christina, DE, and Pennsylvania tidal wetlands. These watersheds span a broad stressor gradient, extending from urban, low salinity areas (Philadelphia, Wilmington) to rural, agricultural areas with salt marshes and a long history of salt hay farming. Thirty randomly selected sites were visited at each of the three watersheds. Hydrology, habitat, and landscape condition were evaluated with on-the-ground and landscape GIS analyses to identify likely stressor-response relationships and yielding an overall wetland health score for site. Urban wetlands were higher in diversity than might be expected, but they appeared significantly impaired by smothering from floatable debris (trash) as well as their landward migration potential was severely restricted. Moreover, approximately 60 Pennsylvania sites designated as coastal wetlands in the National Wetlands Inventory needed to be visited to find 30 sites that were still wetlands, suggesting that significant losses of wetlands (to development) occurred since the data was acquired, despite state and federal protection. Taken together, these results indicate that the nationally rare freshwater tidal wetlands of the upper Delaware Estuary continue to be threatened by direct destruction as well as indirect stressors. In contrast, coastal wetlands in rural watersheds appear to be impaired by diverse local stressors. Watershed-specific report cards on health are being developed to inform and engage the public, and attribute-specific data are being summarized for coastal managers so they can strategically address specific sources of wetland impairment during these lean budget times.

Contact Information: Angela T Padeletti, Partnership for the Delaware Estuary , 110 South Poplar St, Wilmington, DE 19810, USA, Phone: 302-655-4990; Fax: 302-655-4991, Email: apadeletti@delawareestuary.org

FUNCTIONAL ASSESSMENT OF ALPINE WETLAND HABITATS AT A PUMPED STORAGE HYDROELECTRIC FACILITY IN THE ROCKY MOUNTAINS OF COLORADO.

Erin L Page
HDR Engineering, Bellingham, WA, USA

Public Service Company of Colorado (PSCo), an Xcel Energy company, owns and operates under a license issued by the Federal Energy Regulatory Commission (FERC) the Cabin Creek Pumped Storage Hydroelectric Project (FERC No. 2351) located on South Clear Creek and its tributary, Cabin Creek, in Clear Creek County, Colorado. The Project is a pumped storage facility that is located entirely within the Arapaho National Forest, occupying a total of 268 acres of National Forest System (NFS) lands. The Project is comprised of Upper and Lower Reservoirs formed by rock-filled dams; a power tunnel 4,150 feet long from the Upper Reservoir to a powerhouse located at the upstream end of the Lower Reservoir with an authorized installed capacity of 300 megawatts (MW) in two reversible pump-turbine units; generator step-up transformers adjacent to the powerhouse; and appurtenant facilities. All major Project features have been in place since 1967.

A functional assessment and wetland habitats study was conducted to address concerns related to potential Project effects on wetlands within the Project area. In consultation with the United States Forest Service (USFS) and other state and federal agencies, the Functional Assessment of Colorado Wetlands (FACWet) method was used to conduct an assessment of current conditions in the regulatory process to re-license the Project.

The main study goals were to: (a) document the distribution and condition of wetlands within the FERC Project boundary; (b) assess the functional condition of ecologically significant wetlands using FACWet; (c) describe general characteristics of hydrological and biological composition of habitats and (d) review historical photographs in order to identify any potential locations for wetland restoration or enhancement.

As a result, several wetland habitats of differing classification were described. Three of these wetland habitats were assessed using the FACWet method. Each of the FACWet wetlands scored average or above, and exhibited unique habitat qualities. One of the sites studied is breeding habitat for the boreal toad (*Anaxyrus boreas boreas*), a species that is listed as Endangered by the state of Colorado and designated by the Rocky Mountain Region of the USFS as a sensitive species.

Contact Information: Erin Page , HDR Engineering , 1111 North Forest St., Bellingham, WA 98225, USA, Phone:360-671-1150, Email: erin.page@hdrinc.com

COMMUNITY ECOLOGY OF URBAN PONDCYPRESS DOMES AND REFERENCE EQUIVALENTS

Kelly Chinners Reiss[1]

HT Odum Center for Wetlands, University of Florida, Gainesville, FL, USA

This study aims to understand the effects of landscape development from anthropogenic activities on the biotic community structure of urban wetlands focusing on isolated pondcypress domes found throughout the southeastern coastal plain. Biological, physical, and chemical parameters were sampled in 78 palustrine forested wetlands less than 2 ha in size, categorized by generalized *a priori* land use categories as reference (n=37) and urban (n=41) and located throughout Florida. Macrophyte sampling was conducted along four belted transects established along the cardinal directions; composite diatom, macroinvertebrate, water, and soil samples were collected for laboratory analysis.

Reference wetlands had significantly different dissolved oxygen, color, turbidity, water pH, specific conductance, and water column total phosphorus (TP), than urban wetlands (Fisher's LSD pair wise comparison, α=0.05). No significant differences were found in the soil parameters measured. Biotic community measures of richness, evenness, and diversity were not significantly different between urban and reference. The Multi-Response Permutation Procedure (MRPP), used to test the similarity of community composition for each assemblage among the four Florida wetland regions, suggested regional differences in biotic community composition (α = 0.05). Latitude and longitude were included as environmental variables in non-metric multidimensional scaling (NMS) ordination to relate changes in community composition with environmental gradients. Variability in diatom community composition was associated with a measure of human development intensity (i.e. the Landscape Development Intensity (LDI) index) and six water parameters including dissolved oxygen, turbidity, pH, specific conductance, total Kheldahl nitrogen (TKN) and TP. Variability in macrophyte community composition was similairly associated with LDI, latitude and longitude and five water and soil parameters including dissolved oxygen, water column pH, water column TP, soil moisture, and soil TP. The macroinvertebrate community had the fewest significant environmental variables including LDI, latitude, and water column pH. The cumulative r-squared values for the diatom (74.6%), macrophyte (77.4%), and macroinvertebrate (68.9%) communities were favorable for community data.

This research contributes to our understanding of changes in the community composition of isolated forested wetlands (based on the diatom, macrophyte, and macroinvertebrate assemblages) in relation to land use categories. While this dataset has elucidated chemical, physical, and biological difference among wetlands, the specific mechanisms of change remain unclear, as even within reference wetlands there was considerable variation in community structure. What is clear is that urban pondcypress domes foster different biotic communities from reference equivalents.

Contact Information: Kelly Chinners Reiss, HT Odum Center for Wetlands, 100 Phelps Lab, Museum Road, Gainesville, FL 32611 USA, Phone: (352) 392-2424, Email: kcr@ufl.edu

FLORIDA'S USE OF SUPPLEMENTAL NWCA FUNDS TO INFORM WATER QUALITY STANDARDS DEVELOPMENT

Nia Wellendorf[1], *Ken* Weaver[1] and ***Kelly Reiss***[2]

[1] Florida Department of Environmental Protection, Tallahassee, FL, USA

[2] HT Odum Center for Wetlands, University of Florida, Gainesville, FL, USA

The Florida Department of Environmental Protection (FDEP) obtained supplemental funding through the Environmental Protection Agency (EPA) National Wetland Condition Assessment (NWCA) to collect additional water quality data to inform revision of state water quality standards for wetlands. The FDEP currently has numeric water quality standards that apply to wetlands, but available data suggest that wetlands may not attain these water quality standards due to natural conditions, especially low dissolved oxygen (DO). The FDEP has developed alternative DO criteria for the Everglades, but alternative criteria development is costly and time consuming. A statewide DO standard designed to protect wetland health would improve the state's process for impaired waters determination. Additionally, FDEP anticipates development of numeric nutrient criteria for wetlands within the next decade, and there are insufficient data for such criteria development. The NWCA was a good opportunity for FDEP to acquire additional wetland data to support water quality standard development goals.

The EPA NWCA sampling included water quality analyses for total nitrogen, ammonia, nitrate+nitrite, total phosphorus, and chlorophyll *a,* but those are insufficient analytes for FDEP to fully describe and explain potential low DO concentrations. Two types of supplemental water quality data were collected: 1) Additional water quality samples were collected at NWCA sites for analysis of color, turbidity, and total Kjeldahl nitrogen (TKN); and 2) Continuously recording DO sondes were deployed at a variety of minimally impacted freshwater wetland sites. The additional water quality analytes help FDEP to determine the cause of anticipated low DO concentrations because natural inputs of organic matter in wetlands, indicated by color and TKN, contribute to oxygen demand. DO sonde data will provide a full profile of DO concentrations experienced by aquatic life within the wetlands. Due to drought conditions and seasonal variability, only 34 of the 69 site visits included water quality sampling. Nineteen sampled sites were estuarine, and 15 were palustrine. Preliminary data analysis will be presented. Turbidity levels were twice as high, on average, in estuarine sites (7.7 NTU) as in palustrine sites (3.3 NTU), whereas color and TKN levels were at least twice as high in palustrine systems (180 PCU, 1.6 mg/L) as in estuarine (45 PCU, 0.8 mg/L). Instantaneous measurements of DO and pH were higher on average in estuarine (4.0 mg/L, 7.5 SU) than palustrine sites (3.1 mg/L, 6.3 SU). Instantaneous DO concentrations were below the state standard of 5 mg/L at 13 of 15 sampled palustrine sites. DO concentrations decreased as color and TKN increased at freshwater sites, suggesting that the low DO levels may be caused by natural inputs of organic matter rather than anthropogenic enrichment.

Contact Information: Nijole (Nia) Wellendorf, Florida Department of Environmental Protection, Standards and Assessment Section, 2600 Blairstone Rd. MS 6511, Tallahassee, FL 32399, Phone: (850) 245-8190, Fax: (850) 412-0663, E-mail: Nijole.Wellendorf@dep.state.fl.us.

INITIAL REGULATORY APPLICATIONS OF THE FLORIDA WETLAND CONDITION INDEX FOR VEGETATION (FWCI-V)

Ashley O'Neal[1], *Nia* Wellendorf[1] and ***Kelly Reiss***[2]
[1] Florida Department of Environmental Protection, Tallahassee, FL, USA
[2] HT Odum Center for Wetlands, University of Florida, Gainesville, FL, USA

The Florida Wetland Condition Index for Vegetation (FWCI-V) was developed to be a rapid screening tool for ecological condition by determining how closely a freshwater wetland's flora resembles that of a similar wetland in an undisturbed condition. Specific methods apply to isolated herbaceous, isolated forested, and strand and floodplain wetlands. The method is currently being used in an exploratory manner in additional wetland community types. Additional data are necessary for validating the tool in regions that were not included in the original development, and for including additional freshwater wetland types, such as bayheads and wet prairies. The Florida Department of Environmental Protection (FDEP) is currently using the FWCI-V on a test basis in a variety of regulatory applications. The FWCI-V is being used as part of Fifth Year Biological Assessments to evaluate the effects of point source discharges on receiving wetlands, and in a Before/After Control Impact study to evaluate the effectiveness of enhancement wetlands in mitigating nutrient levels and restoring sheetflow to downstream wetlands (and fully protecting downstream wetlands). We report on initial data collected in regulatory applications of the FWCI-V, how the data have been interpreted, and what additional data need to be collected. An additional independent dataset developed in conjunction with the EPA National Wetland Condition Assessment will further validate this biological assessment tool, and help FDEP to establish thresholds of biological condition in the future.

Contact Information: Ashley O'Neal, Florida Department of Environmental Protection, Standards and Assessment Section, 2600 Blairstone Rd. MS 6511, Tallahassee, FL 32399, USA, Phone: (850) 245-8070, Fax: (850) 412-0663, E-mail: Ashley.O'Neal@dep.state.fl.us.

LESSONS LEARNED FROM THE 2011 NATIONAL WETLAND CONDITION ASSESSMENT

Dennis McCauley[1], ***Jamie Saxton***[1], *Chris Turner*[1] and *Michael Scozzafava*[2]
[1]Great Lakes Environmental Center, Inc., Traverse City, Michigan USA,
[2]US EPA Office of Water, Washington, DC

In 2011, EPA initiated a survey and assessment of randomly selected wetlands throughout the conterminous U.S. to address the need for improved water quality monitoring at a national scale and to protect, sustain, and restore the health of critical natural habitats and ecosystems, including wetlands. The National Wetland Condition Assessment (NWCA) is one in a series of probability-based National Aquatic Resource Surveys (NARS) conducted by EPA to provide the public with a comprehensive assessment of the condition of the Nation's waters. This survey established a national baseline and will be used to track statistically-valid trends in wetland condition. The survey identified key stressors to these systems and explored the relative importance of each in restoring or maintaining river and stream health. Randomized design, and standardized field and laboratory protocols, allowed EPA to analyze data that are nationally consistent and regionally relevant. Probability-based surveys offer a scientifically-valid way to fulfill statutory requirements, complement traditional monitoring programs, and support management decisions.

Results from the NWCA summarizes the first-ever assessment of wetlands across the contiguous United States using consistent protocols and scientifically-defensible probability-based approach. The NWCA was completed after careful consideration of pre-survey planning, field training, field sampling, sampling logistics, laboratory analysis, data analysis and reporting. Approximately 55 state and regional, contractor and tribal crews were deployed and supported across the country; sampling and sample analysis was tracked from initiation; laboratory analysis was completed at EPA, state, regional and contract laboratories; and the data analysis and reporting was completed by EPA lead workgroups, states and contractors. Approximately 1,300 wetlands were sampled all across the country including several state enhancement and other special studies. The complexity and difficulty of each step offered unique challenges and opportunities and provided lessons learned for the following NWCA assessments and for other upcoming National Aquatic Resources Assessments. The lessons learned are discussed in this presentation.

Contact Information: Dennis McCauley, Great Lakes Environmental Center, Inc., 739 Hastings St. Traverse City, Michigan, USA, Phone: 231-941-2230, Fax: 231-941-2240; Email: dmccauley@glec.com.

HIGH-RESOLUTION WETLAND WATER LEVEL MONITORING TOWARDS EVERGLADES RESTORATION INTEGRATING SYNTHETIC APERTURE RADAR INTERFEROMETRY AND SATELLITE RADAR ALTIMETRY

C.K. Shum[1], *Hyongki Lee*[2], *John W. Jones*[3], *Jinwoo Kim*[1] and *Zhong Lu*[4]
[1]Division of Geodetic Science, School of Earth Sciences, Ohio State University, OH, USA
[2]Department of Civil & Environmental Engineering, Univ. Houston, TX, USA
[3]US U.S. Geological Survey, Reston, VA, USA
[4]US Geological Survey, Vancouver, WA, USA

Habitat conditions in the large and complex greater Everglades, Florida ecosystem are dependent on interactions among climate, hydrology, disturbance, nutrient enrichment, sediment accumulation and exotic species invasion. In this pilot study, we focused on the compilation, fusion, and analysis of archival C-band and L-band two-pass satellite synthetic aperture radar interferometry (InSAR) and radar altimeter (RA) data 2007–2008, to measure and map absolute surface water level changes at high resolution (~weekly and ~40 m at InSAR and up to ~350 m along-track at RA observational locations) across the pilot study area that is a focus of restoration science experiments in the Everglades. Radar altimetry can also measure coastal sea level change and when combined with gage data are sensitive to vertical land motion or subsidence, thus providing a mechanism to refine the vertical datum of the Everglades wetland. Here, we used ALOS L-band PALSAR ScanSAR, C-band Radarsat-1 and Envisat ASAR InSAR measurements, for land cover and water classifications, and integrated these data with Envisat 18-Hz radar altimeter-observed water level change, early 2007 to late 2008 study period. Due primarily to ALOS' burst alignment failure, L-band ScanSAR-ScanSAR interferometry was not available during the study time period over the region of interest, and only a single C-band ScanSAR-ScanSAR interferometry pair is feasible. Thus, L-band ScanSAR mode data are only used for land cover and water classifications in this demonstration study. The satellite data fusion (C-band InSAR with Envisat altimetry) provided a demonstration of a high-resolution (~40 m) absolute water level change map over our study region in the Everglades. Satellite measured water level changes have been validated using the gauge records available from the Everglades Depth Estimation Network (EDEN), and show good agreement.

<u>Contact Informaiton</u>: C.K. Shum, Division of Geodetic Sciences, School of Earth Sciences, Ohio State University, 125 South Oval Mall, Columbus, OH 43210, USA. Phone: 614-292-7118. Fax: 614-292-7688. Email: ckshum@osu.edu

USE OF THE PREVALENCE INDEX TO DETERMINE PLANT COMMUNITY TRENDS RELATED TO GROUNDWATER WITHDRAWAL, LOWER PLATTE RIVER, NEBRASKA (PART 2 OF 2)

Sarah J. Soard[1], *Michael C. Gilbert*[2], *Justin E. Bailey*[1] and *Kevin P. Tobin*[3]
[1]Burns & McDonnell Engineering Company, Inc., Kansas City, Missouri
[2]United States Army Corps of Engineers, Omaha, Nebraska
[3]Metropolitan Utilities District, Omaha, Nebraska

As discussed in Part 1 of this presentation (Multi-Scale Monitoring of Potential Groundwater Withdrawal Impacts Using Delineation Methodology; Lower Platte River, Nebraska (Part 1 of 2) by Justin Bailey, the terms and conditions included in the Corps' Section 404 Permit to the Metropolitan Utilities District (District) stated that the wetlands located in the Platte River floodplain well fields must be monitored to determine the extent of any impacts resulting from Project operation. Burns & McDonnell and the Corps developed a site-scale monitoring plan that requires a systematic, multi-temporal approach to sample wetlands that may be impacted. Based on the wetland delineation for the Project, monitoring sites were selected to represent the range of wetland types (forested, scrub-shrub and emergent), proximity to pumping locations, and potential sensitivity to change. Monitoring has been conducted twice annually from 2005 through 2011 to evaluate the conditions of the wetlands before groundwater withdrawal (2005-2008) and during operation (2008 through present).

Pre- and post-operation Prevalence Index calculations serve as the principal vegetation metric for detection of change. Pre-operation sampling was conducted to determine the natural range of variability in community wetness to compare with data from the operational phase. Piezometers were installed in each monitored wetland to support interpretations of Prevalence Index data. Other vegetation metrics were analyzed to determine impacts in conjunction with the Prevalence Index. This consisted of the floristic quality index, species richness and species diversity. Prevalence Index data from selected sites are presented to illustrate variation in community wetness over time and in response to local groundwater withdrawal. The statistical analyses used to determine significance of change and thresholds to increase sampling intensity or remedial mitigation are presented. Observations and recommendations on use of the Prevalence Index for monitoring and mitigation applications are also discussed.

Contact Information: Sarah J. Soard, Burns & McDonnell Engineering Company, Inc., 9400 Ward Parkway, Kansas City, MO 64114, USA, Phone: 816.822.4330, Fax: 816.822.4299, Email: ssoard@burnsmcd.com

COMPARISON OF WETLAND FUNCTIONAL ASSESSMENTS IN TEXAS AND LOUISIANA

***Matthew G. Stahman*[1]**, *Jody N. Schaap*[1], *Kevin D. Janni*[2] and *Daniel R. Bollich*[3]
[1]SWCA Environmental Consultants, Houston, TX, USA
[2]SWCA Environmental Consultants, Arlington, TX, USA
[3]Delta Land Services, Port Allen, LA, USA

Functional assessments are a critical part of wetland mitigation bank establishment and U.S. Army Corps of Engineers Clean Water Act (Section 404) permittee wetland impact mitigation plans. Functional assessments provide quantitative analysis of various wetland functions such as wildlife habitat, flood flow alteration, water quality, and sediment trapping. Functional assessments include the Hydrogeomorphic Method (HGM), Texas Rapid Assessment Method (TXRAM), Charleston Method, and various other regional methods used throughout the country. These methods vary in complexity and level of implementation effort from rapid desktop analyses to more involved field evaluations.

Functional assessments provide a way to compare different quality wetlands to one another by quantifying the number of "functional units" provided by each wetland. By deriving functional units for an impact site, one can determine the number of functional units (i.e. credits) needed from a mitigation bank for a permitted impact based on that bank's functional score. The number of credits assigned a mitigation bank depends on how much "functional lift" a mitigation bank is able to accomplish once fully established and restored. The lower the pre-bank function and the higher the post-bank function, the more credits become available for sale or use. Generally, the mitigation banker does best to increase the post-project value of each function to the highest possible level by restoring site hydrology, implementing planting regimes and employing construction strategies that increase those functions as quickly as possible.

Knowing how a given functional assessment works is critical to both the permittee and the mitigation banker. In this presentation, we compare and contrast four different functional assessments currently used by the U.S. Army Corps of Engineers Galveston, Fort Worth, Vicksburg and New Orleans Districts in Texas and Louisiana (HGM, TXRAM, Charleston Method and Modified Charleston Method). We also discuss differences in functional scores, credits generated and project costs associated with the use of these different functional assessments on a single example project. In general, our results suggest that less complex functional assessments result in more mitigation acres per wetland impact acre than more complex functional assessments.

<u>Contact Information</u>: Matthew Stahman, SWCA Environmental Consultants, 7255 Langtry, Suite 100, Houston, TX 77040, USA, Phone: 713-934-9900, Fax: 713-934-9906, Email: mstahman@swca.com

EXAMINATION OF STATEWIDE WETLAND ASSESSMENT METHODS FOR NORTH DAKOTA

Matthew P. Stasica*, Edward S DeKeyser, Christina L.M Hargiss* and *Lindsey M. Meyers*
School of Natural Resource Sciences, North Dakota State University, Fargo, ND, USA

The development of methods assessing the condition and functional capacity of North Dakota's wetlands has been limited to the depressional wetlands of the Northern and North Western Glaciated Plains (prairie grassland) ecoregions. The effort to expand assessment methods to other wetland classes and ecoregions throughout the state of North Dakota is the primary goal of this research. During the growing season of 2011, 53 wetlands ranging from lacustrine depressional, palustrine depressional and forested class wetlands were sampled. Additionally, 40 ecoregion specific "reference" wetlands sampled during the growing seasons of 2009 and 2010 were also considered. Vegetation was sampled utilizing a quadrat method. Soil profile attributes were gathered and hydrologic and landscape variables were also examined. Collected data was evaluated using multi-metric biologic integrity indices, functional capacity indices, and a rapid assessment. Multi-variate analysis, regression analysis, and cross-comparison were used to validate the output of each assessment method with independent reference standard wetland data. The variability in the results for each assessment method differed amongst wetland type and region. The more rigorous field assessments for multi-metric indices and functional capacity indices indicate a possible need for new development of ecoregion and class specific methods for North Dakota. However, the rapid assessment method could be beneficial as a tool for evaluation of wetlands in multiple environmental and regional contexts. Using this procedure of examination can help guide and inform future efforts to create, modify, and establish a framework for a statewide assessment protocol of various wetland classes throughout North Dakota. In addition, developing an assessment with statewide application can simplify efforts to monitor, manage, and mitigate the variety of wetlands distributed across the state of North Dakota.

Contact Information: Matthew P. Stasica, School of Natural Resource Sciences, North Dakota State University, Dept. 7680, Walster Hall, Fargo, ND 58108, USA, Phone: 701.231.7868, Fax: 701.231.7861, Email: matt.stasica@my.ndsu.edu

LANDSCAPE-LEVEL FUNCTIONAL ASSESSMENT USING ENHANCED WETLAND GEOSPATIAL DATA

Ralph Tiner
U.S. Fish & Wildlife Service, Hadley, MA, USA

While much government attention has focused on creating methods for site-specific analysis of wetland functions for evaluating the impacts of proposed development and for predicting the condition of wetlands through probabilistic sampling, the U.S. Fish and Wildlife Service has been developing techniques to use its National Wetlands Inventory (NWI) data to predict wetland functions for watersheds. The expansion and availability of geospatial data in digital form and advances in geographic Information system technology over the last 20 years have made it possible to integrate various datasets to: 1) improve wetland mapping, 2) expand wetland classification beyond the current national standard and 3) use the expanded database to predict wetland functions.

To use NWI data for landscape-level analysis, one could either expand the classification of individual wetlands or use other geospatial databases and analytical procedures to group wetlands into categories suitable for predicting wetland functions. The latter could be done on a project-by-project basis, while the former would provide a more comprehensive wetland database that could be used for functional assessment as well as for other purposes. Given that the NWI is being updated, it made sense to develop more descriptors to expand the NWI database. Four sets of new attributes were created to describe landscape position (relation of a wetland to a waterbody if present), landform (physical shape of the wetland), water flow path (the directional flow of water associated with the wetland), and waterbody type (different types of estuaries, rivers, lakes, and ponds) – “LLWW descriptors.” The Wetlands Subcommittee of the Federal Geographic Data Committee recognized the “value-added” of the LLWW descriptors and recommended that they be included in wetland mapping to increase the functionality of wetland inventory databases.

Correlations between the parameters in the expanded NWI+ database and a number of wetland functions have been developed in working with wetland scientists mostly from the eastern United States. To date, eleven functions can be predicted by this expert-designed assessment method: 1) surface water detention, 2) streamflow maintenance, 3) nutrient transformation, 4) sediment and particulate retention, 5) carbon sequestration, 6) shoreline stabilization, 7) coastal storm surge detention, 8) provision of fish and shellfish habitat, 9) provision of waterfowl and waterbird habitat, 10) provision of habitat for other wildlife, and 11) provision of habitat for unique, rare, or highly diverse plant communities. Additional functions can be added or aggregated by users.

NWI+ databases have been created for many areas across the country on a user-funded basis. Several states are creating these databases from existing NWI data or in their efforts to update NWI data. Examples of the applications of NWI+ databases will be shown to illustrate how landscape-level functional assessments can be readily generated by enhancing existing geospatial wetland data.

<u>Contact Information</u>: Ralph Tiner, Northeast Region, U.S. Fish and Wildlife Service, 300 Westgate Center Drive, Hadley, MA 01035, USA, Phone: 413-253-8620, Fax: 413-253-8482, Email: ralph_tiner@fws.gov

RUGGED MOBILE WETLAND DATA COLLECTION SOLUTIONS FOR ASSESSMENT AND MONITORING

Brandon Tolle[1] and *Rick Gosalvez*[2]
[1]Navigation Electronics, Lafayette, LA, USA
[2]Trimble Navigation

This session will review tools and best practices of remote wetland data collection that comply with the COE Wetlands Delineation Manual.

With the advancement of wetland science, the U.S. Army Corps of Engineers (USACE) has released a new set of Regional Supplements to the 1987 Corps of Engineers (COE) Wetlands Delineation Manual. These manuals were created in order to accurately identify and describe the three required wetland parameters which can vary significantly from region to region. As stated by the COE, producing "Regional Supplement[s] is part of a nationwide effort to address regional wetland characteristics and improve the accuracy and efficiency of wetland-delineation procedures. Regional differences in climate, geology, soils, hydrology, plant and animal communities, and other factors are important to the identification and functioning of wetlands. These differences cannot be considered adequately in a single national manual."

As part of the procedure for developing the new supplements, the United States and Territories were sorted by the COE into 10 Regions (Map of Regional Supplements). The 10 Regions are based upon differences and unique characteristics amongst the United States Department of Agriculture (USDA) Land Resource Regions (LRRs) and Major Land Resource Areas (MLRAs) (Conterminous U.S Map & AK, HI, the Caribbean, and the Pacific Basin Map). However, conventional processing of Routine Wetland Determination forms as prescribed in the new Regional Supplements to the U.S. Army 1987 Corps of Engineers Wetlands Delineation Manual is disjointed, time consuming, and inefficient. Primarily, this is true when wetland ecosystem restoration practices do not leverage integrated technology solutions for timely, accurate, and convenient monitoring and assessment of resources.

To streamline data collection and processing methods, Timmons Group and Trimble have created a rugged, simple, and reliable solution to enable mobile wetland data collection. WetCollect™ is a hosted software solution designed to expedite the data collection and processing of COE Wetland Determination Forms. Instances exhibit cost effective and reliable implementations of the technology, which have resulted in compliant and accurate wetland ecosystem monitoring and assessments.

Contact Information: Brandon Tolle, Navigation Electronics, PO Box 13545, Lafayette, LA 70506, USA, Phone: 850-228-2070, Email: brandon@neigps.com

APPLICATION OF GIS AND STATISTICAL TOOLS FOR THE IDENTIFICATION AND ASSESSMENT OF ISOLATED WETLANDS ON THE SOUTHEAST COASTAL PLAIN

***Robert S. Truesdale*[1]**, *Frank Obusek*[2], *Breda Munoz*[1], *John Dorney*[3], *Dan Tufford*[4], *Virginia Baker*[5] and *Kim Matthews*[1]

[1]RTI International, Research Triangle Park, NC, USA
[2]GeoIterations LLC, Asheville, NC, USA
[3]Adkins North America, Raleigh, NC, USA
[4]University of South Carolina, Columbia, SC, USA
[5]Department of Environment and Natural Resources, Raleigh, NC, USA

Previous studies and regulatory experience suggest that on the southeast coastal plain, isolated wetlands (IWs) are small, numerous and hard to protect from agricultural and other development pressures; however there has been no comprehensive inventory of the IW resource in North and South Carolina to confirm these assumptions. The Southeast Isolated Wetlands Assessment (SEIWA) used a statistical framework and Level 1, Level 2, and Level 3 wetlands assessment methods to identify and characterize geographically isolated wetlands (IWs) in the coastal Carolinas. This paper describes how the statistical framework and Level 1, GIS-based methods were developed and applied to enumerate IWs in the eight-county study area, how Level 2 methods were used to characterize the resource in terms of dimensions, type, condition, and carbon capacity, and how the statistical framework was used to extend the Level 2 results to the entire IW resource in the study area.

Although this project did find that Level 1 methods alone were not highly accurate in identifying IWs (the method was better at identifying wetlands than in determining their isolation), the statistical framework in sampling the dataset for the Level 2 field work enabled SEIWA to characterize the IW to a known level of accuracy at a regional or state scale. We found that Level 1 methods are an important tool to find and conduct a preliminary characterization of a large number of wetland features that may be isolated and, with field verification applied in a statistically designed study to confirm accuracy, can be used to develop estimates, with known accuracy, of IW extent and characteristics for a study area. Verification was especially critical to identify the small ditches and drainage swales that connected many of the candidate IWs in the study but were too small to be picked up by LiDAR used in Level 1. The general conclusions of the Level 2 portion of SEIWA are that IWs in our study area are numerous (estimate of 22,000 IWs in the four SC counties and 30,000 in the four NC counties), relatively small (mean size of 0.68 acres), and account for a small percentage of overall wetland area (about 1.9% of the total wetland area). Overall most IWs in the study area were forested ecosystems of three general types (forested flats [50%], forested ponds [33%], and small pocosins [16%]) that occur in relatively small depressions on the uplifted marine terraces that form this portion of the southeastern coastal plain. The IWs in the SEIWA study area are estimated to contain about 5 million metric tons (Mg) of carbon in their wetland soils, with an average soil carbon content of over 190 tons per acre.

Contact Information: Robert S. Truesdale, Water and Ecosystem Services, RTI International, 3040 Cornwallis Road, Research Triangle Park, NC 27709,USA, Phone: 919-541-6152, Fax: 919-541-7155,
Email: rst@rti.org.

SUITABILITY OF THE NEW GENERATION OF SAR SATELLITES TO THE WETLAND INSAR APPLICATION

Shimon Wdowinski[1], *Sang-Hoon Hong*[2] and *Brian Brisco*[3]
[1]University of Miami, Miami, FL, USA
[2]Korea Aerospace Research Institute, Daejeon, Republic of Korea
[3]Canada Centre for Remote Sensing, Ottawa, Canada

Wetland InSAR (Interferometric Synthetic Aperture Radar) is a relatively new application of the InSAR technique that detects water level changes in aquatic environments with emergent vegetation. The method works, because the radar pulse is backscattered twice ("double-bounce"), once from the water surface and the other from the vegetation. Initial studies relied on L-band SAR data (24 cm wavelength) to detect water-level variation in the floodplains and wetlands. More recent studies have shown that the method works also with C-band (5.6 cm) and X-band (3.1 cm) data. It is a surprising result, because C- and X-band radar signal interacts mainly with vegetation canopies due short wavelength of the signal. Interferometric coherence analysis indicates that all data types can produce high quality results (high coherence) with short acquisition intervals (1-105 days).

A new generation of SAR satellites with amazing pixel resolution of 1-5 meters and multi-polarizations capabilities provide very high SAR data quality enabling the detection smaller scale flow structures in wetlands. The new satellites include the German X-band TerraSAR-X/TanDEM-X satellites, the Italian X-band COSMO-SkyMed satellite constellation (four satellites), and the Canadian C-band RADARSAT-2 satellites, which can operate in full quad-polarization acquisition mode. Although the Japanese L-band ALOS satellite operated in coarser resolution (4-20 m), its dual- and quad-polarization data also reveal important details of wetland flow structures.

We tested the suitability of the new SAR satellite data for the wetland InSAR application by acquiring data over the Everglades wetlands in south Florida. The Everglades can be viewed as a large-scale laboratory, because it is a large-scale very diverse wetland system that is monitored by a very dense network of stage (water level) gauges. Interferometric processing of the data revealed very high quality products showing many details of both small- and large-scale flow structures. One of the most surprising results was the detection of water level change fringes in the cross-polarization interferograms, suggesting that the cross-polarization signal bounced off the water surface and is not only a volume scattering product, as previously assumed. Based on this new insight, we revised the vegetation scattering theories by adding a new double bounce component from cross-polarization that was previously ignored.

Contact Information: Shimon Wdowinski, Division of Marine Geology and Geophysics, Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149-1098, USA, Phone: 305-421-4730, Fax: 305-421-4632, Email: shimonw@rsmas.miami.edu

MULTI-ELEMENT FINGERPRINTING OF WETLAND SOILS YIELDS INSIGHT INTO WETLAND QUALITY AND FUNCTIONING

A.H. Yellick[1], *D.L. Jacob*[1], *E.S. DeKeyser*[2], *C.L.M. Hargiss*[2], *C. Yan*[3] and *M.L. Otte*[1]
[1]Wet Ecosystem Research Group, Biological Sciences, North Dakota State University, Fargo, ND
[2]Natural Resources Sciences, North Dakota State University, Fargo, ND
[3]Computer Sciences, North Dakota State University, Fargo, ND

The element composition of a wetland soil is governed by its hydrological status, parent material, land use, and vegetative communities. Wetland hydrology is dynamic and can act to enrich or deplete the concentrations of water soluble elements. The parent material can be composed of differing amounts of clay and sand, with the main constituent of each being aluminum, iron, potassium and silicon. Land use such as agriculture can enrich elements such as zinc, sulfur, cadmium, and phosphorous through the continued use of phosphate fertilizer. Finally, plants can enrich iron, manganese, and zinc near their root zones due to their effect on soil redox chemistry and these effects vary from species to species. The outcome of these processes can be defined by ICP-MS, which analyzes the concentrations of more than 60 elements to produce a multi-element fingerprint. These fingerprints are relatively inexpensive to produce ($21-28/ sample) and can be valuable in the study of wetland biogeochemistry and in assessment of wetland quality and functioning.

This poster describes how we used multi-element fingerprinting to study the relationship between the quality of 20 wetland plant communities as defined by the Index of Plant Community Integrity (IPCI) and wetland soil element chemistry in temporary wetlands within the Prairie Pothole Region of North Dakota. The IPCI assess vegetative communities using various diversity metrics to classify a wetland as displaying very poor, poor, fair, good, and very good index scores. We used the results to develop a tool which utilizes the relationships between the concentrations of 10 elements to classify IPCI measurements.

<u>Contact Information</u>: A.H Yellick, Wet Ecosystem Research Group, North Dakota State University, Fargo, ND 58108, USA, e-mail: alex.yellick@my.ndsu.edu

WETLAND ASSESSMENT & REGULATION - RISK ASSESSMENT

WETLAND AND STREAM RESTORATION TECHNIQUES FOLLOWING EMERGENCY RESPONSE ACTIONS TO THE LINE 6B OIL SPILL IN MARSHALL, MICHIGAN

Stu Kogge and *Brian Majka*
Cardno JFNew, Marshall, Michigan, USA

On July 26, 2010 a crude oil leak was discovered on Line 6B in Marshall, Michigan. Line 6B is a 30-inch diameter pipeline that transports oil from Sarnia, Ontario, Canada to Griffith, Indiana, USA. More than 800,000 gallons of crude oil broke through the underground pipe which surfaced and moved through a wetland complex into Talmadge Creek. Recent rains had put the creek at flood stage and caused it to overtop its banks, thus oil entering the creek also moved into the adjacent floodplain and wetland areas. The creek then flowed 2.2 miles to its confluence with the Kalamazoo River. Emergency response actions were immediately implemented and upon completion of preliminary remediation efforts, restoration of wetland resources commenced in accordance with United States Environmental Protection Agency (USEPA) and Michigan Department of Environmental Quality (MDEQ) consent orders and directives.

Within a day of being Contacted by Enbridge Energy, Limited Partnership (Enbridge), Cardno JFNew conducted ecological assessments of existing biota and resources of the wetlands and floodplain areas affected along Talmadge Creek. Draft restoration plans were immediately prepared and approved for over 2 linear miles of stream and wetland impact. Plans were finalized, federal and state agency approvals were obtained, restoration materials were shipped cross country, and wetland restoration efforts commenced along the creek within days. Utilization of experienced staff with a firm understanding of local geology, soils, plant communities, groundwater, material suppliers, and agency concerns were all critically important in getting plans approved and restoration work started in a matter of days.

Cardno JFNew utilized several standard as well as a few unique restoration techniques to address the high volume of groundwater moving through these wetlands to the creek. Subsurface rock chutes, layering of various textured soils, and use of various erosion and sedimentation control materials were all used to control groundwater and maintain prior wetland hydrologic regimes. Remediation efforts required the removal of soils up to 3 feet in depth, and which also resulted in the removal of a seed bank that contained non-native and invasive species. Restoration efforts to date have been very effective and coupled with planned additional plantings, monitoring and maintenance activities will result in an increase in native plant diversity and a reduction in non-native and invasive species. This presentation will provide an overview of the incident, the dedication of Enbridge, their consultants, and the regulatory agencies to remediate and restore wetland and stream resources affected by emergency response actions to an oil spill.

Contact Information: Stu Kogge, Cardno JFNew, P.O. Box 100, Holt, MI, 48842,USA, Phone: 517-898-9018, Email: stu.kogge@cardno.com; Brian Majka, Cardno JFNew, 11181 Marwill Avenue, West Olive, MI 49460, USA, Phone: 574-229-2667, Email: brian.majka@cardno.com

DETERMINATION OF THE EFFECTS OF CONTAMINANT MIXTURES ON AQUATIC MACROPHYTES

***Ramona D. Smith*[1]**, *P. Chris Wilson*[1] and *Samira Daroub*[2]

[1]Soil and Water Science Department, University of Florida/IFAS-Indian River Research and Education Center, Fort Pierce, FL, USA

[2]Soil and Water Science Department, University of Florida/IFAS-Everglades Research and Education Center, Belle Glade, FL, USA

Because of the sensitive nature of ecosystems in Florida as well as the economic reliance of the state on agriculture, much research has been done to quantify and estimate the effects of agricultural chemicals, including pesticides, in these environments (SFWMD, 2000; Shahane, 2007; FDEP, 2005; Harman-Fetcho et al., 2005; Downing et al., 2004; Doering & Chamberlain, 1998; and many others). Often, field studies which quantify pesticides found in targeted ecosystems are then compared to toxicity indices (Downing et al., 2004; Harman-Fetcho et al, 2005; and others). Although it is recognized that organisms in the ecosystem would not realistically be exposed to a single toxicant at a time, many studies look at suites of chemicals identified and quantified from field studies and then base the toxicity of these chemicals on the dose-response curves of organisms exposed to a single toxicant at a time (Munn & Gilliom, 2001; Banks et al., 2003). Because there exists the possibility of potentiation, additivity, synergism, or antagonism when organisms are exposed to mixtures of xenobiotics like pesticides, it may be desirable to compare field concentrations to toxicity data based on combinations of pesticides to which species may be exposed. To do this effectively, integrated multilevel studies are considered necessary to interpret these effects because chemical contamination may act at such a variety of levels (Porter et al., 1993). In previous related field work, surface water along the river portion of the Caloosahatchee River was sampled over a one-year period and analyzed for locally relevant pesticides and pesticide degradation products. Both metolachlor and atrazine, class III herbicides, were observed in all samples with concentrations ranging from 0.0029 ppb to 0.27 ppb and 0.028 ppb to 2.9 ppb, respectively. In the current study, duckweed (*Lemna minor)* was the test subject used to identify chronic effects of atrazine and metolachlor, individually and in combination, on frond count, root length, fresh weight, and photosynthesis based on toxicity testing procedures recommended by the US EPA. Individual EC50 values based on frond count were determined to be 0.232 ppm for atrazine (1 toxic unit, TU) and 0.132 ppm for metolachlor (1 TU). Based on this data from the individual toxicity tests, it was expected that the test concentration of 0.5 TU atrazine + 0.5 TU metolachlor in the mixture study should show a 1 TU effect, or 50% mortality. In actuality, 1 TU of effect is observed at a lower concentration, closer to the 0.25 TU + 0.25 TU test mixture, indicating a synergistic effect of the two herbicides. Because these two compounds are so frequently found in our field samples, more research is required to identify extremely low dose chronic effects and the possibility of recovery from exposure to such mixtures.

Contact Information: Ramona Smith, Soil and Water Science Department, University of Florida/IFAS-IRREC, 2199 South Rock Road, Fort Pierce, FL 34945, USA, Phone: 321-951-4002 (H) 321-223-5041 (C), Email: ramona@ufl.edu

GREAT BARRIER REEF CATCHMENT: WETLANDS RISK ASSESSMENT

***Maria Vandergragt**, Cheree Fenton* and *Adam Forknall*
Department of Environment and Resource Management, Environment and Resource Sciences, Water Quality and Aquatic Ecosystem Health, Brisbane, Qld, Australia

The catchments of the Great Barrier Reef make up an area of approximately 424 000 km^2 with approximately 283 000 ha of mapped natural lacustrine and palustrine wetlands of 1ha or larger. Wetlands in these catchments have many important values and provide a variety of significant ecosystem services. They can play an important role in nutrient cycling and sediment trapping. They contribute to maintaining local climate. They also support a diversity of plants and animals and promote ecological processes such as the breeding and recruitment of marine and freshwater fish species. Human activities such as land clearing, the intensification of agriculture and urban development has resulted in increased sediment, nutrients and pesticides flowing into the GBR lagoon which forms part of a declared World Heritage Area. Human activities are also placing pressure on the freshwater wetlands in the Great Barrier Reef catchment.

The Reef Plan 2009-2013 targets state that "*there will have been no net loss or degradation of natural wetlands*." To ensure that this target is met, Queensland monitors the change in wetland extent through updates of the wetland mapping. While Information on the extent and loss of wetlands is available, there is only very limited Information available on condition of wetlands in GBR catchments. A comprehensive understanding of risk is crucial for prioritising management and establishing a monitoring program for wetlands in Great Barrier Reef catchments.

The Queensland Wetland Program has undertaken an assessment of risk to these wetlands. This project applied a comprehensive risk and condition assessment framework recently developed by the Queensland Department of Environment and Resource Management (DERM) under the Queensland Wetlands Program, and which explicitly links risk and condition through conceptual models. In this project "risk" is the product of pressures which could affect wetlands and the likelihood of degradation or loss of a wetland as a consequence of pressures.

The Queensland wetland mapping and a one second digital elevation model were used as a basis for delineating wetland watersheds. The spatial relationships between the watershed and selected pressures indicators were determined to derive risk scores incorporating the vulnerability of different wetland types. Risk was assessed at the individual wetland, sub-catchment, regional and GBR wide scales. Indirect pressures include catchment disturbance, impacts on the fringing zone of the wetland, hydrological disturbances and loss of connectivity of the wetland to the overall landscape. Direct pressures include those associated with impacts on wetland soils and water quality, wetland biota and the physical form of the wetland. The outcomes of the assessment presented in a colour coded and numeric report cards designed to be easily understood and interpreted by users from a variety of backgrounds.

This is the first comprehensive assessment of risk to wetlands in the GBR catchments and in Australia.

<u>Contact Information</u>: Maria Vandergragt, Department of Environment and Resource Management Ecosciences Precinct, 41 Boggo Road, Dutton Park, Brisbane, QLD 4102, Australia, Phone: 61731705553, Email: maria.vandergragt@derm.qld.gov.au

WATER QUALITY ISSUES IN RAMSAR WETLANDS

J. T. A. Verhoeven
Ecology and Biodiversity, Department of Biology, Utrecht University, The Netherlands

Wetlands generally provide the service of water quality enhancement. Although many natural wetlands do remove nutrients from through-flowing water and the value of this function could be important in economic discussions, extreme caution should be exerted in enlarging this service by increasing the nutrient loading rates. Wetlands rich in plant species are often characterized by nutrient-limited plant growth. Only in cases where wetlands are naturally nutrient-rich, such as tall reed beds or Papyrus swamps, moderate increase of the nutrient loading rates may be considered.

If local problems exist with eutrophic water entering a natural wetland with a low loading threshold, it may be advised to construct a wetland at the location of the inputs, with the aim to reduce the nutrient loading to the wetland itself. Ramsar guidance may be developed to support managers to test the feasibility of such options and to determine the vulnerability of natural wetlands.

Water quality issues have generally not been taken into account in discussions on quantitative water resources management, such as Environmental Flows in River Basin Management. It will be important to develop guidance for managers and policy makers involved in Environmental Flow-related issues, to help them assess the risks that the water to be discharged for environmental purposes will have negative effects on wetland biodiversity and functioning just because of its quality.

Contact Information: Jos Verhoeven, Utrecht University, Padualaan 8 Utrecht 3584 CH, Netherlands, Phone: 31302536851, Email: j.t.a.verhoeven@uu.nl

WETLAND ECOSYSTEMS PROCESSES & FUNCTIONS - COASTAL WETLANDS (MANGROVES MARSHES SAVS)

MARINE SUBSIDIES DELIVERED BY BIRDS TO MANGROVE FORESTS

M .F Adame*, J. Caamal, J.N. Gamboa* and *J.A. Herrera-Silveira*
Centro de Investigación y Estudios Avanzados (CINVESTAV-IPN) Mérida, Yucatán, México

Seaward transport of terrigenous nutrients through rivers and runoff affect the biodiversity and productivity of coastal wetlands. A less studied process, the landward transport of marine nutrients, could also have important effects in some coastal areas. In this study we investigated nutrient subsidies delivered by marine birds to islands covered by mangrove forests. The islands are located within an oligotrophic coastal lagoon with large groundwater inputs and no river influence. We selected six islands that represent a range of bird occurrence: two islands with permanent bird colonies (*Phalacocorax auritus*), two islands with temporal bird colonies (*P auritus* and *Pelicanus occidentalis*) and two islands with none. Forest structure, pH and interstitial salinity were measured at each island. Sediment and mangrove leaves (fresh and dry) were collected during three seasons throughout a year. Sediment and leaves were analyzed for phosphorus (P), carbon and nitrogen. The results show that P concentration in the sediment and leaves were significantly higher in areas with permanent bird colonies (0.21-0.86% in sediment and 0.12-0.22% in leaves) compared to islands with temporal (0.03-0.12% and 0.08-0.20%) or no bird colonies (0.01-0.07% and 0.08-0.18%). Additionally, some species of mangroves in islands with permanent bird colonies had lower nutrient reabsorption than the rest of the islands, suggesting nutrient relief by P additions. Phosphorus concentrations were highest in the winter, the nesting season. These results suggest that marine birds can significantly subsidy mangrove forests and probably adjacent underwater vegetation by delivering nutrients derived from marine sources. This study provides a unique example where marine outweigh terrestrial subsidies into a coastal wetland.

<u>Contact Information</u>: Maria Fernanda Adame, Centro de Investigación y Estudios Avanzados (CINVESTAV-IPN) Unidad Mérida, Antigua Carretera a Progreso km.6, Mérida Yucatán, México, C.P. 97310 Phone: 999-942-94-00, ext 2565, Fax: 999-981 2923, Email: mfadame@mda.cinvestav.mx

THE ROLE OF CRAB BURROWS AS PREFERENTIAL CONDUITS FOR TIDAL WATER IN LOW HYDRAULIC CONDUCTIVITY MANGROVE PEAT IN EVERGLADES NATIONAL PARK, FLORIDA, USA

Gordon H. Anderson, *Karen M. Balentin* and *Thomas J. Smith III*
U.S. Geological Survey, Southeast Ecological Science Center, Gainesville, FL USA

Mangroves are adapted for harsh marine conditions by excluding salt from root water uptake. However, lower salinity is less metabolically stressful to mangroves. Everglades mangrove root peat has low hydraulic conductivity (0.23 m/d ± s.e. 0.09) and higher average porewater salinity than adjacent estuaries. Crab burrows provide preferential conduits during diurnal tidal flooding, reducing porewater salinity near mangrove fine rootlets.

At a mid-reach riverine mangrove site adjacent to the Harney River in Everglades National Park, average river salinity (10.4 PSU) was ~ 4 PSU lower than riverbank peat porewater salinity(14.4 PSU) based on periodic measurements from 2000-2007. Harney River bank burrow density averaged 63 per m^2 with corresponding void space volume (using burrow casts) which ranged 3-6% of total volume in the upper 25cm of the soil profile. Water salinity monitoring of crab burrows will be continued to evaluate daily tidal exchange flow volumes. Alternative non-destructive methods will be explored to better characterize the crab burrow shape, number of burrow entries and proximity to fine mangrove rootlets.

The health and sustainability of Everglades coastal mangroves and the role which crab burrows serve as a mechanism to enhance mangrove survival is an important ecological question and a potential indicator for evaluating performance of the Everglades restoration.

Contact Information: Gordon H. Anderson, Southeast Ecological Science Center, Everglades Field Station, 40001 S.R. 9336, Homestead, FL 33034, USA, Phone: 305-242-7891, Fax: 305-242-7836, Email: gordon_anderson@usgs.gov

PARTITIONING ROOT ZONE AND DEEP SEDIMENT DYNAMICS USING PAIRED SURFACE ELEVATION TABLES IN EVERGLADES NATIONAL PARK, FLORIDA, USA

Karen M. Balentine and *Thomas J. Smith III*
U.S. Geological Survey, Southeast Ecological Science Center, Gainesville, FL USA

Surface elevation tables (SETs) are used worldwide to measure soil elevation change in coastal wetland environments. SETs provide reliable long term sediment change measurements. Elevation change is a combination of many processes that occur within the entire soil profile. Shallow root zone and deep sediment profile change dynamics can be determined by using a paired shallow and deep SET design. Twenty four paired shallow and deep rod SETs were installed along the southwest coast of Everglades National Park. Each SET pair was placed near a preexisting automated groundwater gage recorder to incorporate water level change with sediment dynamics. Elevation change was measured quarterly along a downstream-upstream transects on the Shark and Lostmans River estuaries for five years (2006-2011). Preliminary results suggest that elevation change is driven by changes in groundwater. Changes in soil elevation for the deep-SET follow changes in groundwater more closely than changes in shallow-SET. An additional factor, for downstream, river mouth, sites appears to be the annual rise and fall in water levels in the Gulf of Mexico, as surface elevation tracks this pattern.
Long term monitoring of wetland elevation change is important to evaluate the health and vulnerability of coastal wetlands. One of the objectives of the Comprehensive Everglades Restoration Plan (CERP) is to enhance upstream timing, flow and delivery of water into the coastal estuaries. Impacts to the Everglades coastal wetlands from upstream CERP modifications and downstream coastal changes (sea level rise, storms) can be determined by monitoring coastal and ecotone sediment elevation change.

Contact Information: Karen M. Balentine, U.S. Geological Science Center, Everglades Field Station, 40001 SR 9336, Homestead, FL 33034,USA, Phone: 305-242-7874, Fax: 305-242-7836, Email: kbalentine@usgs.gov

ORGANIC CARBON BURIAL RATES IN SOUTHWESTERN EVERGLADES MANGROVE SEDIMENTS

Joshua L. Breithaupt[1], *Joseph M. Smoak*[1], *Thomas J. Smith*[2] and *Christian J. Sanders*[3]
[1]University of South Florida, Environmental Science, St. Petersburg, FL, USA
[2]U.S Geological Survey, Southeast Ecological Science Center, St. Petersburg, FL, USA
[3]Universidade Federal de Fluminense (UFF), Departamento de Geoquímica, Niterói-RJ, Brazil

Although their areal coverage is less than two percent of the overall marine surface area, mangroves are of increasing interest in the global carbon cycle because of the high rates of organic carbon (OC) production and burial in their sediments. The production, pathways and fates of OC in mangrove systems have been discussed in a wide body of literature, including several carbon budget syntheses that have specifically addressed the burial rate and the fraction it represents of the ecosystem's production. However, most of the studies on which these estimates are based rely on mass balance models using biomass surveys, litterfall, export and herbivorous consumption rates rather than direct measurement of production and OC burial. To test the usefulness of these estimates at the local level, we used direct measurements of both local-scale production and OC burial. The century-scale burial rate of OC was determined with radiometric dating (i.e. ^{210}Pb) from 50-cm long sediment cores in a mangrove forest near the mouth of the Shark River in Everglades National Park. Mean annual production rates were obtained from published results of atmosphere-forest CO_2 fluxes taken by a local eddy covariance flux tower.

Demonstrating the importance of local over regional controls, our resulting burial rates are roughly twice those measured at mangrove sites just 35 km to the northwest, and slightly greater than measurements retrieved 65 km to the southeast in the Florida Keys. Additionally, this study is just one of four globally to offer a comparison of local burial rates with local production rates in mangrove settings. Here the methods include direct measurement of both parameters on a small spatial scale, and provide informative considerations for comparison with mass balance approaches to the global mangrove carbon budget.

Contact Information: Joshua L. Breithaupt, University of South Florida, 140 7th Avenue South, St. Petersburg, FL, 33701, USA, Phone: 941-330-6428, Email: jlbreith@mail.usf.edu

EARLY RESULTS AND GUIDANCE FROM A COASTAL HABITAT RESTORATION PROJECT TWENTY YEARS AFTER THE 1991GULF WAR OIL SPILL

***Christopher D. Cormack*[1]**, *Jason A. Hale*[1], *Owen Langman*[1], *Thomas G. Minter*[1], *Jeremy J. Gabriel*[1], *Michael J. Risk*[2], *Linos Cotsapas*[1,2] and *Jacqueline Michel*[3]

[1]Pandion Technology, Ltd., Limassol, Cyprus
[2]Durham, Ontario, CA, USA
[3]Research Planning, Inc., Columbia, SC, USA

At the conclusion of the 1991 Gulf War, an estimated 10 million barrels of crude oil were released into the Arabian Gulf, eventually stranding along approximately 800 km of the Saudi Arabian coastline. Oil contaminated intertidal substrates through pore spaces (primary porosity) as well as through burrows made by benthic infauna (secondary porosity). As of 2003, there were 774 hectares of heavily impacted marsh and 574 hectares of moderately impacted marsh. Natural recovery has been slowest for upper salt marsh habitats. Indications of long-term ecological degradation include: limited re-colonization by benthic fauna beyond low marsh tidal elevation; lack of new perennial halophyte germination; widespread distribution of thick laminated algal mat; persistently flooded upper marsh areas and highly variable but persistent oil contamination.

Three remediation methods designed to enhance natural recovery are being tested and implemented alone and in combination in salt marsh habitats: excavation of new and existing tidal channels; reduction of physical barriers by tilling and/or removal of thick algal mat substrate; and transplanting of perennial halophytes, including mangroves (*Avicennia marina*) and chenopods (*Halocnemum strobilaceum* and *Arthrocnemum macrostachyum*). All treatments were replicated and have been monitored prior to and after remediation activities.

Excavation of new tidal channels extended the habitat of lower intertidal benthic fauna horizontally into upper marsh habitats; snails, burrowing crabs, and some polychaetes colonized this new habitat within weeks. Refreshment of existing channels via re-profiling had similar results. Both treatments improved drainage of the upper marsh.

Reduction of physical barriers to burrowing was best accomplished by tilling, with or without removal of thick algal mat substrate. Removal of the algal mat layer alone had little positive effects.

The short-term ecological impact of transplanting mangroves included increased burrowing by crabs (especially *Nasima dotilliforme*) in sapling substrate, and export of leaf material to nearby tidal channel and marsh surface habitats. Survival of mangroves was highest when transplanted along existing channels; survival of transplanted chenopods was limited. Improvements in transplanting technique for chenopods will be required to gauge their utility as salt marsh restoration tools.

Contact Information: Christopher D. Cormack, Pandion Technology, Ltd., P.O.Box 4719 Al Khobar 31952 Kingdom of Saudi Arabia, Phone: (+966) 56-002-5790, Email: ccormack@pandiontech.com

WHY ARE MANGROVES EXPANDING INTO SALTMARSHES IN EASTERN AUSTRALIA?

Leila Eslami- Andargoli and ***Pat ER Dale***
Environmental Futures Centre, Griffith School of Environment, Griffith University, Nathan, Queensland, Australia

Mangrove expansion into saltmarsh has been noted over several decades in eastern Australia. There have been several biophysical factors suggested in the literature. This paper reports an integrated approach that has focussed on patterns of rainfall, as a physical factor, and of land use, as an anthropogenic factor. Finding and then using break points in the pattern of rainfall, it has analysed mangrove expansion and related this to rainfall. As well, it has analysed land cover changes on a sub-catchment basis for the same time periods. The research used remotely sensed data between 1972 and 2004, with the rainfall break point identified for 1990 (relatively wet before, dry after). It analysed land use patterns using the same time periods and related these to mangrove expansion. The results showed that rainfall was a major factor explaining mangrove expansion, and, although land cover changes also contributed, the relationship with land cover differed between the wetter and drier rainfall periods.

Contact Information: P.Dale, Griffith School of Environment, Griffith University, Nathan, Queensland, Australia 4111. Phone: +61 7375 7136, Email: L p.dale@griffith.edu.au

EARLY GROWTH PERFORMANCES OF THE SWAMP-FOREST TREE PTEROCARPUS OFFICINALIS REGARDING SOIL AND LIGHT CONDITIONS

M. Dulormne, *D. Imbert*[1], *F. Bompy, V. Virapin*[1], *V. Lapido* and *N. Texier*
EA 926 DYNECAR, Université des Antilles et de la Guyane, Pointe-à-Pitre, Guadeloupe (F.W.I.), France

Pterocarpus officinalis (Fabaceae) is the dominant tree species of the swamp forest patches that still remain behind mangrove areas in the Antilles. Such coastal freshwater wetlands are especially at risk due to sea-level rise on the one hand and ongoing landward anthropogenic pressures on the other. In order to implement conservation projects, unifactorial ex situ experiments have been conducted to investigate saplings' requirements/tolerance toward flooding, salinity, soil type, light conditions and bacterial symbiosis.
Plant morphology (leaf number, stem height, collar diameter), dry matter repartition (roots, stem, leaves), and physiologic parameters (net photosynthesis, water stomatal conductance, chlorophyll content) have been measured on 12- to 18-months old saplings.

As compared to watered soils, flooded soils did not significantly affect growth and physiology of P. officinalis. Saplings grown under flood conditions developed adventive root system and extensive aerenchyma close to stem collar. Net photosynthesis was significantly reduced when salinity exceeded 10 g L-1. Light attenuation of 50% and over also reduced seedling development. Growth performances of saplings grown on swamp forest clayey soil did not differ from those of saplings grown on forest peat. Saplings inoculated with N2 fixing Bradyrhizobium had higher biomass production due to increased physiologic capacity (net photosynthesis and chlorophyll content).

In conclusion, inoculated P. officinalis saplings seem able to grow successfully in full sunlight on any kind of wet or evenly flooded soils, provided that ground salinity do not exceed 10 g L-1. However, possible detrimental effects associated to full sunlight (increased wind velocity, ground heating) may occur and should be investigated.

Contact Information: Maguy Dulormne, EA 926 DYNECAR, Université des Antilles et de la Guyane, UFR Sciences Exactes et Naturelles, BP 592, 97159 Pointe-à-Pitre cedex, Guadeloupe (F.W.I.), France, Phone: +590-590-483-056, Email: maguy.dulormne@univ-ag.fr

DEVELOPING REALIZED NICHE SPACE PROBABILITY DISTRIBUTION FUNCTIONS FOR THE EVERGLADES LANDSCAPE VEGETATION SUCCESSION MODEL

Steve Friedman and *Leonard Pearlstine*
Everglades National Park; National Park Service, Homestead, FL, USA

The Everglades Landscape Vegetation Succession Model (ELVeS) Version 1.1 was parameterized using a composite remotely sensed vegetation map developed by combining aerial photographic maps and satellite imagery. Source data for each of these components were derived from data representing 4 different acquisition dates between 1993 and 2004. High resolution color infrared aerial photography was used for each of the Everglades Water Conservation Areas. Everglades National Park was not included in the area covered by aerial photography so a classified Thematic Mapper image from 1993 was used for this geographic area. Four hydrologic metrics (Mean Annual Water Depth in the Wet periods, 17 Day Water Depth Minimum and Maximum and the Standard Deviation of Annual Water Depth) derived from the Everglades Depth Estimation Network data archive were used to develop probability functions describing the distribution patterns of freshwater marsh communities. The vegetation map accuracy strongly influences the accuracy of the derived relationships for modeling.

Vegetation succession processes in part are based on time sensitive relationships between the dynamic hydrologic drivers which were not adequately addressed in this first version of the model. Differences between the acquisition dates for the vegetation map and the Everglades Depth Estimation Network (EDEN) hydrologic metrics were not considered. Temporal differences between these data sources incorporate un-quantified errors describing vegetation communities and hydrological drivers.

Improvements to the vegetation probability function parameters were undertaken to enhance the performance of ELVeS. Field vegetation survey data were analyzed to strengthen the relationships developed earlier with the mapped vegetation data. The 2005 EPA Everglades ecosystem assessment (R-EMAP Status Report), 2010-2011 aerial photo ground control survey (South Florida Caribbean Network Inventory and Monitoring Office) , the 2003-2005 Cape Sable Seaside Sparrow vegetation surveys (Mike Ross, Florida International University) and 1990-2010 Taylor Slough surveys (Everglades National Park) were examined to quantify the freshwater marsh vegetation community distribution patterns. Hydrologic metrics described above representing the same year as the vegetation survey and 1 year, 2 years, 3 years and 5 years before the vegetation survey were examined to quantify how hydrologic lag effects influenced vegetation distribution patterns.

This sensitivity analysis of the temporal effects of inter-annual hydrological conditions was undertaken to improve the overall fit of hydrologic metrics and hence the performance of the ELVeS. Maps illustrating vegetation probability distributions using the new probability functions and the original functions were contrasted to identify where change in the vegetation patterns occur.

Contact Information: Steve Friedman, Everglades National Park, South Florida Natural Resources Center, National Park Service, 950 N. Krome Ave., Homestead, FL 33030, USA, Phone: 305-242-4282, Fax: 305-224-4147, Email: steve_friedman@nps.gov

A SEAGRASS HABITAT SUITABILITY INDEX SPATIAL MODEL

Althea S. Hotaling[1]*, Thomas K. Frazer*[2]*, Robert Swett*[2] and *L. Rex Ellis*[3]*,*
[1]University of Florida School of Natural Resources and Environment, Gainesville, FL, USA
[2]University of Florida Fisheries and Aquatic Sciences, Gainesville, FL, USA
[3]University of Florida Soil and Water Science, Gainesville, FL, USA

Photosynthetically active radiation, salinity, water temperature, and depth data collected from 50 points in Estero Bay were used to create a spatial map of the bay identifying areas ideal for seagrass restoration. Geostatistical Kriging was used to interpolate habitat conditions throughout the Bay. Light measurements were taken throughout the bay every 3 weeks to establish what areas have light of sufficient intensity throughout the year to support seagrass. Salinity and water temperature will also be recorded at light sampling points to locate areas with salinity regimes that can support at least one seagrass species throughout the year. Many sites with more than 25% surface irradiance do not currently have seagrass. This approach to identifying areas ideal for seagrass restoration can be applied many other areas in need of seagrass restoration and also to other ecosystems.

Contact Information: Althea Hotaling, University of Florida, Bldg. 803 McCarty Dr., Gainesville, FL 32611, USA, Phone: 352-392-6237, Email: theah@ufl.edu

THE EMERGY ANALYSIS ON WETLAND ECOSYSTEM OF CHIKU, TAIWAN

Shu-Mei Huang, *Ming-Chee Wu*, *Mon-Shieh Yang* and *Howar Lee*
National Cheng Kung University, Tainan, Taiwan, ROC

ChikCoastal Wetland is the largest wetland in Taiwan, it is a complex ecosystem containing estuaries, littorals and wetlands; which has rich biodiversity and high productivity, along with high ecological and economical values. According to the results of recent research, the Chiku Wetlands are facing problems such as shoreline retreat, lagoon shrinkage, and flora extinction.

Scope of this study is to quantitatively evaluate the economics of this ecological system as well as its emergy and material flux by using the Emergy Analysis Theory of Odum (1987); in addition with the realization of the environmental stresses of the region. The emergy assessment process for wetland ecological benefits are including four steps such as: (1) construction of a conceptual model for the emergy analytical system; (2) draft out the emergy analysis table with the calculated emergy values; (3) estimation of emergy indices; (4) expatiation of wetland ecological benefits in accordance of the analytical tables of emergy indices system and the emergy schemes.

According to the graphical analysis for emergy of this eco-economical wetland system and its table of emergy indices, the results show that the average solar emergy input to the Chiku Wetlands is only about 7×10^{20} sej (the solar energy joule), but with the output a little bit greater than 1×10^{22} sej; even though with the terrestrial vegetation has nearly a one third of reduction during the monitoring period. It is that the increase of watery area been converted into the habitats of the aquatic organisms has lead to the increasing output of the overall emergy of this wetland system.

On the other hand, as the wetland becomes the habitat for the protected species, the *Platalea minor Temminck*, a famous waterfowl of the world, it gives the wetland to exhibit a higher value of waterfowl solar emergy. It therefore explains the importance of waterfowl protection act in the Chiku Wetland. The net Emergy Yield Ratio of the area is about 5.25, which is regarded as comparatively high; namely, the greater the emergy yield ratio value is, the higher the eco-economic benefits are given by the wetland, as well as the higher economic contribution to the society.

The Environmental Load Ratio is about 2.98, which is also regarded as a comparatively high value. A main reason for this higher value is due to the great deal of development and investment to the aquaculture farming; the artificial wetlands, that results in high loading capacity for this regional environment. Emergy Exchange Ratio is about 0.14; which nevertheless indicates that the local market price does not show the true values for the products of the wetland resources. Taking the emergy into consideration, the product of wetlands results in a greater loss in the economic system of the society. The Emergy Sustainable Indices of Chiku Wetlands is about 1.76, the sustainability of the wetland system is weaker with the smaller value.

Contact Information: Shu-Mei Huang, Department of Earth Sciences, National Cheng Kung University, Tainan City, Taiwan, ROC, Phone: +886-934076579, Fax: +886-6-2740285, Email: tsowei0225@gmail.com

EVALUATING RADAR SENSORS FOR RETRIEVING MANGROVE BIOPHYSICAL PARAMETERS OF BOTH PRISTINE AND DEGRADED FORESTS

***John M. Kovacs*[1]**, *Xixi Lu*[2], *Xianfeng Jiao*[1], *Chunhua Zhang*[3] and *Francisco F. de Santiago*[4]
[1]Nipissing University, North Bay, ON, Canada
[2]National University of Singapore, Singapore
[3]East Tennessee State University, Johnson City, TN, USA
[4]University of Western Ontario, London, ON, Canada

Over the last few decades the monitoring and mapping of mangrove forests from space has been dominated by optical sensors. However, many of these coastal wetlands are located in tropical regions where quasi permanent cloud cover limits the use of these space-borne tools. Unhindered by cloud cover or time of day, a variety of multi-polarimetric Earth observing Synthetic Aperture Radar (SAR) based satellites sensors have recently been launched. In this investigation we examine the potential use of two of these sensors, the C-band Radarsat-2 and the L-band ALOS PALSAR, for extracting mangrove biophysical parameters of both pristine and degraded mangrove forests.

Data from sixty one transects were collected from a severely degraded mangrove forest of the Mexican Pacific and then examined in relation to backscatter from both SAR sensors. The field data were collected from a range of conditions, from extremely healthy to severely degraded (i.e. dominated by dead trees), of this black mangrove (*Avicennia germinans*) dominated system. When the severely degraded stands (n = 16) are excluded from the analysis, strong relationships were found between the radar backscatter values and various forest parameters including leaf area index, basal area and stem density. The strongest relationships were found in the co-polarized HH data for both C and L band data at the highest spatial resolution, with the later sensor exhibiting the best results.

Both sensors were also examined in the case of a healthy pristine mangrove system located in Guinea, West Africa. Data from sixty transects were collected from this black and red mangrove (*Rhizophora* species) dominated system that included homogeneous areas of both healthy dwarf and healthy tall mangroves. For the black mangrove, the strongest relationships were found when examining the L-band co-polarized HH backscatter. In contrast, the L-band cross-polarized HV data was found to be the best indicator of the red mangrove biophysical parameters. In regards to the C-band Radarsat-2 data, poor results for both the black and red mangrove were observed but, unlike the L-band, only one acquisition date was examined.

Contact Information: John M. Kovacs, Department of Geography, Nipissing University, 100 College Drive, North Bay, ON, P1B 8L7, Canada, Phone: 705-474-3450, Fax: 705-474-1947, Email: johnmk@nipissingu.ca

ECOHYDROLOGIC CHARACTERIZATION AS AN ESSENTIAL TOOL FOR SUCCESSFUL MANGROVE FOREST MANAGEMENT AND RESTORATION

Roy R. Lewis III
Coastal Resources Group, Inc., Salt Springs, Florida, USA

Three mangrove forest management and restoration projects in Southwest Florida, USA, are described. These are Clam Bay (CB), and Fruit Farm Creek (FFC) near Naples, and Giant's Camp (GC) on Tampa Bay. All three sites contain areas of dead, stressed and healthy mangroves that have been the subject of research on both qualitative and quantitative ecohydrologic characterization prior to restoration. The completed project, CB, received only qualitative characterization of the dead mangrove area hydrology, while adjacent open water areas received quantitative characterization. While successful in restoring mangroves through hydrologic restoration only (no mangrove planting), the site does require annual maintenance of created and restored tidal channels. Based upon the lack of maintenance-free restoration at CB, the other two sites (FFC and GC) have received quantitative ecohydrologic monitoring using an autonomous tidal level monitoring network prior to restoration design. The results of this sampling were incorporated into the ecological engineering design at these latter two sites. Both are currently under construction. It is suggested that ecohydrologic characterization of apparently healthy mangrove forests where reconnaissance level characterization indicates possible hydrologic modifications and stress indicators are present, is essential for cost-effective management and prevention of future death of mangrove requiring expensive restoration projects and loss of ecological services over extended periods.

Contact Information: Roy R. Lewis III, President, Coastal Resources Group, Inc., PO Box 5430, Salt Springs, Florida 32134, USA, Phone: 352-546-4842, Fax 352-542-5224, Email: lesrrl3@aol.com or lesrrl3@gmail.com

ESTIMATION OF LAND-SURFACE ELEVATION USING AERIAL PHOTOS AND PARAMETER ESTIMATION TECHNIQUES FOR HINDCAST MODELING OF EVERGLADES HYDROLOGY

Melinda Lohmann[1], *Eric D. Swain*[1], *Ann Foster*[2], *Thomas J Smith*[2], *Don L. DeAngelis*[3] and *Jiang Jiang*[4]

[1]U.S. Geological Survey- Florida Water Science Center, Davie, FL, USA
[2]U.S. Geological Survey- Southeast Ecological Science Center, St. Petersburg, FL, USA
[3]U.S. Geological Survey- Southeast Ecological Science Center, Coral Gables, FL, USA
[4]University of Miami, Department of Biology, Coral Gables, FL, USA

Topography plays a major role in the flow patterns, hydroperiods, and distribution of salinity in the Everglades. The distribution of flora in the Everglades has changed, often in response to major storm events, indicating that the topography may have also changed. To evaluate the effects of major storm events on Everglades hydrology, the USGS is developing a numerical model (BISECT) for hindcasting and forecasting hydrologic response to hurricane events. A representation of the topography of the historical time period is needed to depict the hydrologic flow patterns. Aerial photos along the Harney River will be used to define the distribution and density of existing vegetation at selected times and an automated parameter estimation model will be used to estimate elevations by matching water levels and salinities, which correspond to the defined vegetation regime.

A preliminary study is being conducted in a subset of the BISECT model domain, the Harney River Basin, where aerial photos are available, and the smaller model extent allows the parameter estimation simulations to run in a reasonable time frame. Aerial photographs taken along the Harney River in the years 1940 and 2004 are being used to define the distribution of existing vegetation. The 2004 aerial photos are being used to calibrate the model and the 1940 aerial photos are being used to estimate the elevation changes. The 1940 aerial photographs have been scanned from paper copies and georeferenced, and the 2004 aerial photographs have been downloaded from the Florida DEP LABINS site (data.labins.org). Six classification categories, marsh, mangrove, water, other trees, barren and unknown, have been used to represent the major cover types. The observed distribution characteristics are then assigned to each BISECT model grid cell as a percentage of each land-cover type, flora density and distribution for 1940 and 2004. Using this Information for the subset of the BISECT model along Harney River, a parameter estimation simulation is being used to estimate the changes in land surface elevation. The parameter estimation simulation uses a formula that calculates the relationship between vegetation growth rate and hydrology, as a function of salinity, water depth, and plant density, to estimate potential elevation changes that produce the observed hydrologic flow patterns of the time period.

These predicted results will be extrapolated over the larger BISECT model domain, which extends over the entire Everglades, to hindcast historical hurricane events and their impact upon the Everglades landscape.

<u>Contact Information</u>: Melinda Lohmann, USGS Florida Water Science Center, 7500 SW 36th Street, Davie, FL 33314, USA, Phone: 954-377-5955, Email: mlohmann@usgs.gov

NITROGEN LIMITATION IN DWARF *AVICENNIA MARINA* MANGROVES

Gonasageran Naidoo and *Yougasphree Naidoo*
School of Life Sciences, University of KwaZulu -Natal, Durban, South Africa

The effects of N and P enrichment on growth and physiological responses of dwarf *Avicennia marina* mangroves in a hypersaline (58±8 psu) field site in Richards Bay, South Africa were investigated. It was hypothesized that at high salinities mangroves allocate more resources to roots than shoots, and that nutrient enrichment with N and P will shift resource allocation to shoots and enhance growth and productivity.

In unvegetated areas of the dwarf zone, one-year old *A. marina* seedlings were planted in long cylindrical pots and enriched bimonthly with N, P, N+P, or remained unfertilized (control-C), and growth and morphology of plants monitored for two years. Photosynthetic gas exchange was measured with a portable gas exchange system (LiCor 6400), chlorophyll fluorescence with a field portable, pulse amplitude, modulated fluorometer (PAM – 2100) and leaf chlorophyll content with a hand-held chlorophyll content meter, CCM-200 (Opti Sciences). Inorganic ions were determined by atomic absorption, P by the molybdenum blue procedure and N by the automated Dumas dry combustion method using a CNS analyzer.

Enrichment with N and N+P shifted resource allocation to shoots from 38% to 55%, and increased dry biomass accumulation by over 500%, compared to the control treatment. In the N and N+P treatments, plant height, number of leaves, leaf chlorophyll content and photosynthesis increased by 50%, 330%, 30% and 30%, respectively, compared to the C and P treatments. Enrichment with N and N+P increased N concentrations in roots by 60% (from 1.0±0.1 to 1.6±0.2 of dry mass) and in shoots by 100% (from 1.3±0.1 to 2.7±02% of dry mass). Plants enriched with P alone were similar to those of the control. This study demonstrated that dwarf *A. marina* in Richards Bay is N limited, and that N enrichment shifts resource allocation from roots to shoots and increases growth and productivity.

Contact Information: Gonasageran Naidoo, School of Life Sciences, University of KwaZulu- Natal, P/B X 54001, Durban, 4000, South Africa, E-mail:naidoogn@ukzn.ac.za

TROPHIC DYNAMICS IN MANGROVE ECOSYSTEMS IN PORT EVERGLADES

Amy C. Hirons and ***Kelly Parks***
Nova Southeastern University, Dania Beach, FL, USA

Mangrove forests, or mangals, are low energy, tropical-subtropical habitats at the interface of land and sea and can be found all over the world. These habitats are known for being extremely productive communities that have a complex food web that is based on the detritus derived from dead vegetation and associated microorganisms as well as entrained marine and terrestrial material. This food web supports a wide diversity of food to a diversity of infaunal, epifaunal, and juvenile species. Besides supporting a food web of permanent inhabitants, mangroves may also contribute to the food webs of offshore communities, such as seagrass beds, through the migration of predatory and herbivorous fish. Port Everglades has always featured mangroves lining the sides of the intercoastal waterway as well as the individual channels, but it is also an extremely active site for commercial and recreational use and has undergone significant physical changes. Three different mangrove communities in Port Everglades were examined and through field collection, flora and fauna species were taken from each of the three mangrove sites These samples were then analyzed using stable isotope analysis to establish patterns of energy flow from mangrove vegetation to apex predators, identify possible influences from the port activities, and discover transference of energy to other communities.

Individual samples were collected from four mangrove species, four algal families, three terrestrial plant families, four crustacean families, eight gastropod families, and ten osteichthyes families. The stable isotope analysis revealed that gastropod species had a similar average $\delta^{13}C$ signature (-22.52) to that of the algae species (-22.93). The stable isotope analysis also revealed that the detrital material had a more enriched carbon signature (-25.64) than the distinguishable live mangrove vegetation (-28.29), revealing that the detrital material provides a useful linkage between the mangrove vegetation and the consumers. The ranges of the $\delta^{15}N$ signatures of vertebrate and invertebrate consumers (6.50-11.25) compared to the wide range of signatures of producers (1.5-5.16) shows a strong trophic system. This data has so far revealed that the mangroves provide not only an energy source, but also substrata for growing primary producers and sessile consumers as well as a collection site for decaying material.

Contact Information: Kelly Parks, Nova Southeastern University, 3625 College Ave, RHGA Box 1908, Fort Lauderdale, FL 33314, USA, Phone: 781-608-2791, Email: kp592@nova.edu

MODELING COASTAL VEGETATION COMMUNITY SUCCESSION USING THE EVERGLADES LANDSCAPE VEGETATION SUCCESSION MODEL

Leonard Pearlstine[1], *Steve Friedman*[1], *Stephanie Romañach*[2], *Tom Doyle*[3], *Jimi Sadle*[1], *Sonali Saha*[6], *Tom Smith*[2], *Don DeAngelis*[2,7], *Michael Turtora*[2], *Leon Sternberg*[7], *Kristie Wendelberger*[8], *Ronnie Best*[4] and *Eric Swain*[5]

[1]Everglades National Park; National Park Service, Homestead, FL, USA
[2]Southeast Ecological Science Center; U.S. Geological Survey, Gainesville, FL USA
[3]National Wetlands Research Center, U.S. Geological Survey, Layfayette, LA USA
[4]Greater Everglades Priority Ecosystems Science; U.S. Geological Survey, Davie, FL USA
[5]Florida Integrated Science Center; U.S. Geological Survey, Ft Lauderdale, FL USA
[6]The Institute for Regional Conservation, Miami, FL USA
[7]Department of Biology; University of Miami, Miami, FL USA
[8]Southeast Environmental Research Center; Florida International University, Miami, FL USA

Mangrove and buttonwood communities line the western and southern coast of the Everglades. Mangrove communities serve critical roles from the base to the highest trophic levels in the coastal system and provide habitat for 217 species of fish, 18 to 24 species of amphibians and reptiles, 180 species of birds, and 21 species of mammals. Everglades National Park and The Institute for Regional Conservation have identified 27 rare and often critically imperiled plant species associated with mangrove and buttonwood habitat that are vulnerable to sea level rise. With rising sea level, extensive mangrove and buttonwood forest as well as natural marl berms that protect the inland Everglades from saltwater intrusion are expected to be affected. Protecting and managing for change in these critical habitats along the Everglades coasts requires spatially-explicit understanding how these areas may respond to alterations in freshwater inflows, salinities and water depths resulting from Everglades restoration, sea level rise and climate change.

The Everglades Landscape Vegetation Succession model (ELVeS) is designed to simulate succession following changes to ecological state conditions. The model uses empirically-based probabilistic functions of vegetation community niche space and temporal lags to evaluate expected community response within the model's domain. Its use is intended to inform management and policy decisions by enhancing understanding of projected vegetation response patterns to changes in landscape hydrology, soil biogeochemisty, climate and other environmental conditions and by providing dynamic habitat changes as an input to other ecological models. The model has previously been parameterized for the Everglades fresh water spatial domain, including the southern Florida Water Conservation Areas and Everglades National Park. A multi-agency working group convened in January of 2012 to develop approaches and parameters to expand ELVeS to coastal communities. The results of that modeling, including application of the model to sea level rise scenarios, are presented.

Contact Information: Leonard Pearlstine, Everglades National Park, South Florida Natural Resources Center, National Park Service, 950 N. Krome Ave., Homestead, FL 33030, USA, Phone: 305-242-4228, Fax: 305-224-4147, Email: leonard_pearlstine@nps.gov

CONSIDERING NITROGEN AND BLACK MANGROVE (*AVICENNIA GERMINANS*) IN CONTEXT: LESSONS LEARNED

Christine N. Pickens[1], *Karen L. McKee*[2] and *Mark W. Hester*[1]
[1]Department of Biology, University of Louisiana at Lafayette, Lafayette, LA, USA
[2]U.S. Geological Survey, National Wetlands Research Center, Lafayette, LA, USA

Numerous studies have investigated interactions between black mangrove, *Avicennia germinans*, and nitrogen supply, though reported results have varied. Here, we examine the results of three multi-factorial studies that involved direct or indirect manipulation of nitrogen and discuss how the context of each study affected the results. The objectives of these studies included developing techniques for enhancing black mangrove restoration success, elucidating the effects of climate change on black mangrove, and determining the role of interspecific interactions at the range limit of black mangrove. We evaluated measurements from these studies, such as photochemistry, biomass, tissue nitrogen, root morphology, and porewater nitrogen. We consistently found that nitrogen stimulated short-term growth response indicators and biomass production of *Avicennia germinans* seedlings; however, not always in a consistent manner. These differences were likely due to amount and frequency of nitrogen addition, growth conditions (e.g., hydrology, sediment types, greenhouse vs. field locations), and interspecific interactions that were specific to each study. With growing concerns regarding coastal eutrophication, global climate change, and shifts in plant community composition and species diversity, we will present the lessons learned from these studies and how they apply to future challenges facing black mangrove restoration and management.

Contact Information: Christine Pickens, Department of Biology, University of Louisiana at Lafayette, PO Box 42451, Lafayette, LA 70504, USA, Phone:337-482-5235, Fax:337-482-5834, Email: christine.pickens@gmail.com

ESTABLISHMENT OF LONG TERM SOIL SURFACE ELEVATION MONITORING SITES IN BISCAYNE NATIONAL PARK

Kevin R. T. Whelan[1] and ***Michelle C. Prats***[2]
[1]National Park Service, Palmetto Bay, FL, USA
[2]Florida International University, Miami, FL, USA

The goal of this project is to establish a long term soil surface elevation monitoring program in Biscayne National Park. Wetland soil elevation is a key factor in species colonization and survival. Soil elevation affects hydroperiod, tidal inundation period and frequency, and soil oxidation-reduction state. In turn, hydrology affects soil processes such as sedimentation, erosion, and the shrink and swell of soil materials. Our program aims to monitor rates of soil accretion and erosion, and determine if soil processes are keeping pace with sea level rise (which has been measured at 1.6 mm/yr).

Surface and belowground soil processes play a role in determining overall soil elevation. By using the surface elevation table (SET) in conjunction with feldspar marker horizons we are able to measure the entire soil profile plus surface accretion and erosion. SET site selection is dependent on peat depth, limited access by the public, uniformity of vegetative cover, and overall representation of a typical mangrove forest. Using the above site criteria, two SET sites have been established in Biscayne National Park.

The SET sites in Biscayne National Park are complimentary to the SET monitoring project currently established in the Everglades National Park by the US Geological Survey, with the goal to understand impacts for Everglades Restoration. The Everglades sites are located from upstream freshwater marshes to downstream riverine mangrove forests and are co-located with the Florida Coastal Everglades Long-term Ecological Research (FCE-LTER) project. These sites have provided extensive insight into ecosystem processes (both above and below ground) and how these effect soil surface elevation. By collaborating findings from Biscayne National Park and Everglades National Park, we can make inferences about the ecological processes shaping the geomorphology of the costal mangrove ecosystem in South Florida on a large spatial scale.

Contact Information: Michelle C. Prats, Florida International University, 18001 Old Cutler Road, Suite 419, Palmetto Bay, FL 33157, USA, Phone:305-252-0347, Fax:305-253-0463, Email: MS.shell@Gmail.com

EFFECTS OF INTERIOR POND CREATION ON SEDIMENTATION, HYDROLOGY, AND ELEVATION CHANGES OF SALT MARSHES

Tracy Elsey-Quirk*[1]*, *S. Adamowicz*[2]*, M. Brannin*[1] and *D.J. Velinsky*[1]
[1]Patrick Center for Environmental Research, Academy of Natural Sciences of Drexel University, Philadelphia, PA, USA
[2]U.S. Fish & Wildlife Service, Wells, ME, USA

Salt marsh structure and function, including carbon and nutrient burial and accretion processes, is a balance of sediment deposition and retention and plant production and decomposition. Open Marsh Water Management (OMWM) has been adopted in several Atlantic coastal states to control mosquitoes by excavating pools and connecting ditches (radials) in interior salt marsh areas. While pools are natural salt marsh features, OMWM can increase the density of pools across the marsh and create pools in areas where natural pools may not have formed. In addition, pools and radials may be established in areas that have been previously grid ditched. Grid ditching has reduced the occurrence of natural pools, but the effects of creating pools and radials at a high density in areas previously grid ditched is unknown.

The establishment of pools and radial ditches may alter sedimentation and flooding dynamics and therefore plant processes. To examine whether creating pools affects sedimentation, flooding, and accretion rates in salt marshes we measured elevation, area of open water, water depth and salinity, surface elevation, and soil and porewater chemistry in marshes that have been subject to OMWM and nearby control marshes. Study locations were in the Parker River National Wildlife Refuge in Massachusetts (MA) and the Forsythe National Wildlife Refuge in New Jersey (NJ). These areas varied in geomorphology, tidal range, OMWM technique, and other factors. Preliminary data revealed that the benchmark surface elevation tables (SETs) in the MA control site were an average of 11 cm lower in elevation than the SETs in the MA OMWM site. Initial continuous water level and salinity data suggest that water level and salinity is greater in the MA OMWM site. The MA OMWM site had greater short-term sedimentation rates, a greater accretion rate, and a higher soil organic matter content. The area of open water is over 2.5 times greater in the NJ treatment site than in the NJ control site. Elevations were similar between treatment and control sites and surface elevation change was variable. While the change did not significantly differ from zero for either site, the slope of the line of surface elevation change was significantly different between the two sites. Our data suggest that one implication of creating interior open water in previously grid ditches salt marshes is altered hydrology and sedimentation that may result in differences in the trajectory of response to relative sea level rise.

Contact Information: T. Quirk, Patrick Center for Environmental Research Center, Academy of Natural Sciences of Drexel University, Philadelphia, PA 19103, USA, Phone:215-299-1109, Email: quirk@ansp.org

SEASONAL HYDROLOGY DRIVES PREDATOR AND PREY CO-OCCURRENCE ALONG A MARSH-MANGROVE ECOTONE: IMPLICATIONS ACROSS ECOLOGICAL SCALES

Jennifer S. Rehage

Earth & Environment Department, Southeast Environmental Research Center, Florida International University, Miami, FL

The species composition of ecological communities reflects interactions among organisms as well as between organisms and their abiotic landscapes. At small spatiotemporal scales, abiotic conditions influence patterns of species movement and habitat use. At larger scales, they affect patterns of species abundance and distribution. Further, abiotic conditions influence the strength and outcome of species interactions, with consequences across multiple ecological scales. The structuring effect of abiotic conditions may be particularly important along ecotonal gradients. In southern Florida, mangrove-lined creeks link freshwater marshes to estuarine habitats.

I examined the spatiotemporal dynamics of fish communities along the upper Shark River in Everglades National Park. Ten sites were sampled repeatedly across seasons (2004-2011) with electrofishing to examine the response of mangrove and marsh fishes (predators and prey) to hydrological drivers (marsh water levels and salinity). Fish abundance varied markedly seasonally, and was negatively related to marsh water levels. Marsh fishes moved into the estuary in the dry season, locally increasing prey and predator abundance, but limited to the upper area, perhaps by salinity. Marine/estuarine predators move up the estuary matching prey increases, but appear limited by oxygen levels.

These results indicate that ecotonal creeks may serve as important dry-season refugia for freshwater taxa, and that pulses of freshwater taxa into tidal creeks may trophically link estuarine and marsh habitats. Furthermore, the nature and strength of these linkages appear to be affected by how species and functional groups (i.e., estuarine or marsh, predator or prey) respond spatially and temporally to abiotic conditions. Increases in freshwater inflows related to restoration efforts may affect this linkage by prolonging the pooling of freshwater in upland marshes and changing abiotic conditions at the ecotone.

Contact Information: Jennifer S. Rehage, Department of Earth and Environment, Florida International University, Miami, FL 33199, USA, Phone:305-348-3804, Fax:305-348-6137, Email: rehagej@fiu.edu

SEAGRASSES IN VARIABLE ENVIRONMENTS: THE IMPORTANCE OF LIFE HISTORY IN CONTROLLING *RUPPIA MARITIMA* AT THE EVERGLADES-FLORIDA BAY ECOTONE

***Theresa Strazisar*[1]**, *Marguerite S. Koch*[1], *Elizabeth Dutra*[1] and *Christopher J. Madden*[20]
[1]Aquatic Plant Ecology Laboratory, Biological Sciences Department, Florida Atlantic University, Boca Raton, Florida, USA
[2]South Florida Water Management District, Everglades Division, West Palm Beach, Florida, USA

Ruppia maritima (widgeon grass) is a critical submerged aquatic vegetation (SAV) species for wildlife in variable environments worldwide. This species creates benthic habitat for fish, waterfowl, wading bird prey, marine mammals and elasmobranchs at the productive, but variable salinity environment, of the Everglades-Florida Bay ecotone. This species is critical among estuaries of the ecotone and sustaining this habitat is an important objective for Everglades' restoration. In variable environments like ecotones, plant population persistence is attributed to the ability to physiologically adjust, successfully recruit from a seed bank and transition though various life history stages. Competition can also be important where variability is lowest. Competitive interactions between *R. maritima* and other SAVs are greatest along the ecotone where salinity is stable, while it is less important where salinity is most variable. Despite the importance of recruitment and life history transitions that drive this species' overall distribution in Florida Bay, these processes are poorly understood. We are examining factors underlying *R. maritima* dynamics at this ecotone. To this end, we are paramaterizing a stage-based life history model using seed bank surveys, seed germination and seedling and adult survival experiments both in the presence and absence of competitors along the ecotone. We are synthesizing these results with long-term SAV and abiotic monitoring data to elucidate the mechanisms underlying the distribution and abundance of this species.

In laboratory mesocosms, variable salinities (0-45 psu; R2=0.98) promoted *R. maritima* seed germination once salinities returned to <5 psu. Seedlings also survived a broad range of stable salinities (0-50 psu). However, in a subsequent field study, seedling and vegetative adult survival were successive life history "bottlenecks" reduced by increases in salinity variability along three ecotone study sites toward Florida Bay. Seedling survival was 4-6x greater at the upper site (80%, p<0.05) than the lower sites. This transition was primarily limited by two patterns at these sites: a >2-fold increase in salinity maxima and the 4-6-fold increase in amplitude of fluctuations within intermediate (13-40 d) and long (70-90 d) salinity cycles identified by harmonic analysis. Vegetative adult survival was reduced from the upper (93%) to the lower site (22%) by the 10-fold greater frequency of short-term salinity fluctuations (from 24-244), particularly >10 psu. These results indicate seedlings and adults cannot osmotically adjust to high rates of salinity change and repeated fluctuations experienced at the lower ecotone.

The high salinity variability at the ecotone and its effects on seedlings and adults indicates the population is highly dependent on recruitment. However, the *R. maritima* seed bank is small, with only 2% seed viability, while ≤30% of seeds initiated germination, but embryos failed to develop. Low seed bank viability indicates *that R. maritima* sustainability in the lower Everglades estuaries along the ecotone is dependent on water management optimization to enhance survival of seedlings and vegetative adults to increase sexual reproduction and seed production. This research is providing the foundation for defining this optimization envelope that can be used to reach restoration goals and more clearly define minimum flow requirements for Florida Bay.

Contact Information: Theresa Strazisar, Department of Biological Sciences, Florida Atlantic University, 777 Glades Road, Boca Raton, FL 33431, Phone 561-297-0585 or 4221, E-mail: tstraz@gmail.com

DENITRIFICATION RATES IN COASTAL LOUISIANA BAYOU SEDIMENT AND MARSH SOIL: ROLE OF MACROPHYTES AND CONSEQUENCES FOR DIVERSION MANAGEMENT

***Christine M. VanZomeren*[1]**, *John R. White* and *Ronald D. DeLaune*[2]
[1]University of Florida, Gainesville, FL, USA
[2]Louisiana State University, Baton Rouge, LA, USA

The Caernarvon Diversion directs Mississippi River water into coastal marshes in the Breton Sound Estuary. Elevated nitrogen levels in the Mississippi River water result in nutrient loading to these coastal marsh systems. However, discharge rate in the Breton Sound Estuary varies throughout the year and from year to year based on fisheries and wildlife concerns related to salinity changes. Fresh and brackish marshes only receive the high nitrate river water when the discharge rate is sufficiently high enough to move diverted water from canals (bayous) up onto the marshes. When the discharge rate is low, Mississippi River water remains in canals and exogenous nitrate bypasses potential removal through denitrification and uptake within the marshes and instead is directed into coastal waters. The goal of this study was to determine the net nitrate removal rates under two different discharge scenarios; low and high discharge. Bayou sediments represent the low flow conditions when the water is constrained within the canals and the marsh soil represents the high flow diversion events when the water floods over the marshes. We hypothesize that a decrease in nitrate concentration will occur faster in the marsh soil than in bayou sediment due to higher carbon content and microbial biomass. To test this hypothesis, cores containing bayou sediment and marsh soil with roots removed were exposed to a water column containing 2 mg NO_3-N L^{-1}. Water column nitrate and ammonium concentration were monitored over 9 days. Net nitrate loss in bayou sediment cores was 1 mg NO_3-N L^{-1} while the net nitrate loss was less at 0.78 NO_3-N L^{-1} in the marsh soil likely due to higher N mineralization from the soil organic N pool and subsequent nitrification in the water column. There was also a significant difference in net N loss between planted and unplanted marsh soil demonstrating the macrophyte's critical role in uptake of nitrate from the water column combined with higher denitrification associated with denitrifier microbial communities within the rhizosphere. The presence of macrophytes is critical in maintaining water quality in these systems as the majority of ammonium produced in the soil is intercepted and assimilated into macrophyte biomass in the marsh. This conclusion is supported by previous experiments where removal of 2 mg NO_3^- L^{-1} occurred within 12 hrs with no concomitant increase in ammonium concentration in the presence of macrophytes. The operation of the diversions should be maintained on the high flow end of the spectrum to assure that nitrate is delivered up onto the vegetated marsh instead of flowing through the bayou canals and delivering nitrate out into the coastal ocean.

Contact Information: Christine M. VanZomeren, Soil and Water Science Department, University of Florida, Gainesville, FL 32611, USA, Phone: 352-392-1803, Fax: 352-392-3399, Email: cvanzomeren@ufl.edu

MANGROVE CONVERSION AND AQUACULTURE DEVELOPMENT IN WAVE-DOMINATED ESTUARY IN NORTHEASTERN BRAZIL FROM LANDSAT IMAGES

***R. Suzan Waleska Pequeno*[1]** and *Pedro Walfir M. Souza Filho*[1]
[1]Universidade Federal do Pará, Belém, PA, Brasil

The mangrove forest in Brazil currently has an estimated area of 25.000 km² is just over 150.000 km² in the present world (Spalding et al 2010). Over the last decades, the extent of mangroves area has been decreasing due to agriculture or aquaculture development, as well as for urban expansion. In Brazil, especially in the Northeast Region, this practice is increasing and replacing most of the mangroves in the estuaries of these semi-arid areas for cultivation. In this context, remote sensing data provide the main Information for evaluation and quantification of mangrove cover change through time series analysis. This study aims to quantify the conversion of mangrove ecosystem in areas of marine farming from 1985 to 2008 period along the Coreaú estuary in the State of Ceará, Northeastern Brazil.

Initially, Landsat 5 and 7 images of years 1985, 1987, 1991, 1992, 1993, 1994, 2000, 2001, 2003, 2004, 2005, 2006, 2007 and 2008 were orthorectified. Later, an object-oriented classification was done in the software Definiens Ecognition from two criteria: color and shape. The segmentation algorithm used for this study was multiresolution segmentation with scale 10, 0.1 smoothing and 0.5 compressions. The weight of importance assigned to each image was 10 for band 4, 5 for band 5 and 1 for the bands 3, 2 and 1. From the multiresolution classification were defined two classes: mangrove, body of water and aquaculture pond. For each classes were distributed in the image samples that ranged from 50 to 20 to set the values of the interval class, and contribute to the accuracy determination. After obtaining the shapefiles, these data were worked in ArcGis 10 to calculate the total area of mangroves, and the area of cultivation.

In 1985 mangroves occupied an area of 37.66 km², while in 2008 mangrove area was 34.03 km². Accretionary processes are responsible for an increase of 4.67 km^2, while erosion processes are responsible for the loss of 4.42 km^2. However, an area of 3.58 km^2 of mangrove was converted to aquaculture ponds from 1985 to 2008. Hence, based on natural processes is possible to conclude that mangrove areas area stable or they are experimenting a small expansion (0,25 km^2). Nevertheless, when include mangrove deforestation this corresponds to a loss of 9.5 % of mangroves areas. This percentage is low in comparison with deforestation observed in Indonesia, but one alert is given about mangrove degradation in the Northeastern of Brazil. Therefore, we conclude that from digital image processing techniques of satellite data is possible to identify and quantify natural and anthropogenic changes in estuarine mangroves to select areas for conservation, restoration and rehabilitation.

<u>Contact Information</u>: R. Suzan Waleska Pequeno, Universidade Federal do Pará, Belém, PA, Brasil, Phone: +55 91 32018009, Fax: +55 91 32017478, Email: suzan@ufpa.br

HEAVY METALS IN *PHRAGMITES AUSTRALIS* AND SOIL IN TIDAL WETLAND OF THE YELLOW RIVER DELTA

Junjing Wang and *Junhong Bai*

School of Environment, Beijing Normal University, State Key Joint Laboratory of Environmental Simulation and Pollution Control, Beijing, China

Little Information is available on heavy metals distribution in wetland plants and soil and their relationships in tidal salt marshes. Heavy metals, i.e., copper (Cu), lead (Pb), zinc(Zn), cadmium(Cd), and chromium(Cr) were measured in different tissues of *Phragmites australis* and marsh soil of the Yellow River Delta, China to investigate their distribution characteristics and the effects of wetland plant uptake on heavy metal concentrations in soil. Results showed that the concentrations of heavy metals in soil decreased from surface soils to the 10-20 soil layers, while they increased slightly with increasing depths along soil profiles below 20cm. Concentrations of Cr and Cd in different tissues of *Phragmites australis* followed the order root ＞ leaf＞ stem, moreover, the root tissue had significantly higher Cr than as stem and leaf did. However, Pb concentrations were in the order of root＞ stem ＞ leaf, which showed different capabilities of assimilating heavy metals in different plant tissues. Heavy metals dominantly accumulated in the root tissue. Correlation analysis showed that there were significant correlations among Cd and Pb, suggesting that they might originate from the common source. The accumulation ratio values of heavy metals were calculated, it was revealed that the root tissue accumulated high concentrations of heavy metals especially the Cd, Cr and Pb.

Contact Information: Junjing Wang, School of Environment, Beijing Normal University, State Key Joint Laboratory of Environmental Simulation and Pollution Control, No. 19 Xinjiekouwai Street, Beijing 100875, China, Phone: + 86 10 58802029, Fax: + 86 10 58802029, Email: junjing719@163.com

EFFECTS OF PBDES ON ENZYMATIC AND NON-ENZYMATIC ANTIOXIDANTS IN SEEDLINGS OF *KANDELIA OBOVATA*

*Nora Fung Yee TAM** and ***Ying WANG***
Department of Biology and Chemistry, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong, China

Polybrominated diphenyl ethers (PBDEs), common brominated flame retardants (BFRs), are emerging global environmental pollutants. The contamination of PBDEs in environments may induce oxidative stress to organisms through the over-production of reactive oxygen species (ROS). Mangroves, naturally grow along tropical and sub-tropical coastal regions, are often subject to wastewater discharges and solid waste dumping due to their close proximity to urban development and anthropogenic activities. Consequently, they are also exposed to PBDE contamination. Whether mangroves possess defense antioxidative systems to minimize the harmful effect of ROS causing by PBDEs have seldom been reported. The present study aims to investigate the effects of a PBDE congener (BDE-47) on enzymatic and non-enzymatic antioxidants in different organs of *Kandelia obovata*, a typical true mangrove plant species in Hong Kong SAR.

The 8-week hydroponic culture experiment revealed that the growth of *K. obovata*, in terms of leaf number and chlorophyll content, at low levels of BDE-47 (0.1 and 1 mg l^{-1}) were comparable to the control, but were significantly different at high BDE-47 contamination (5 and 10 mg l^{-1}) and the differences became more obvious as the experiment proceeded. Both sampling time and levels of BDE-47 contamination had significant effects on the enzymatic antioxidant responses, including superoxide dismutase (SOD), peroxidase (POD) and catalase (CAT), in leaf, stem, propagule and root of *Kandelia* seedlings. The trends of enzymatic responses in all plant organs were similar. At Week 1, POD and CAT activities increased at all contamination levels of BDE-47, but the sharp increase in SOD activities was only observed at high BDE-47 levels. CAT activities continued increasing under prolonged exposure to BDE-47 but significant decline of SOD and POD activities was found at Week 4 and 8. For the non-enzymatic antioxidant responses, such as the content of total polyphenols (TP), extractable condensed tannins (ECT), protein-bound condensed tannins (PBCT) and fiber-bound condensed tannins (FBCT), did not cause any significant change after one week exposure to BDE-47. At Week 4 and 8, ECT concentrations in all organs exposed to high levels of BDE-47 decreased, but only roots and leaves showed reduction in TP concentrations and there was no significant difference in TP content in propagules. PBCT in roots and leaves declined only at high levels of BDE-47 at Week 8. The FBCT content of all BDE-treated organs was comparable to their respective controls during the experiment. These results suggested that enzymatic responses of *K. obovata* were more sensitive to BDE-47 than the non-enzymatic ones, and among the three antioxidative enzymes, CAT showed the consistent increasing trend after exposure and might be the most suitable biochemical indicator for BDE contamination.

Contact Information: Nora F.Y. TAM , Department of Biology and Chemistry, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong, China. Phone: (852) 2788 7793, Fax: (852) 2788 7406, Email: bhntam@cityu.edu.hk

TRACKING PREDATOR MOVEMENT ALONG AN ESTUARINE GRADIENT: EFFECTS OF TEMPERATURE AND SALINITY

Rebecca R Ward*, Ross Boucek* and *Jennifer Rehage*
Florida International University, Miami, Fl, USA

Abiotic factors play a major role in structuring ecological communities. At smaller temporal scales, abiotic conditions affect patterns of species movement and habitat use; while at a larger temporal scales, abiotic conditions influence patterns of species abundance and distribution. This structuring effect of abiotic conditions may be particularly important along ecotonal gradients where environmental heterogeneity is high. In the southwestern Everglades, marsh drydown drives freshwater fishes into mangrove habitats but the extent to which the estuary is used by these marsh taxa is unknown. At the same time, mangrove habitats are inhabited by tropical resident and marine transient fishes. We aimed to understand the influence of key abiotic conditions (temperature and salinity) on the movement and habitat use of two dominant mesoconsumers, largemouth bass (freshwater) and snook (estuarine) in the Shark River estuary. We hypothesized that bass movements would be strongly influenced by salinity, while snook movements would be most affected by temperature. We tracked fish movement using acoustic telemetry, and show preliminary data from the first dry season of tracking. Both these species are key recreational fisheries, thus research on these taxa provides an opportunity to integrate the effects of abiotic drivers including hydrology to the provisioning of important ecosystem services (e.g., fisheries).

Contact Information: Rebecca Ward, Florida International University, 11200 sw 8th st, esc-119, Miami, FL 33199, USA, Phone:305-348-0181, Email: rward021@fiu.edu

MONITORING THE COASTAL WETLAND GEOMORPHOLOGIC EVOLUTION BY SERIES OF HISTORICAL MAPS

Ming-Chee Wu[1], *Mon-Shieh Yang*[1], *Chao-Kuo Wang*[2] and *Shu-Mei Huang*[1]
[1]National Cheng Kung University, Tainan, Taiwan, ROC
[2]Tainan City Government, Tainan, Taiwan, ROC

Wetland is known as an essential ecosystem between the water and the land that obtains high primary productivities and with multifunctional capability such as high carbon sequestrations, and biodiversities. The net production of a costal wetland is prior to any other forms of oceanic system.

Maps are the most direct and lucid measure to record and represent the geographic evolution. Namely, the geomorphologic monitoring and evaluation of the costal wetlands are the foundation works for the environmental protection and management acts.

In this study, a series of middle-scale maps with specific historical time span for the coastal wetland, the Tai-Jiang Inner Sea, of Taiwan were compiled to obtain its geomorphologic evolution quantitatively and qualitatively. Namely, maps of Taiwan Fortress Maps of 1904, Taiwan Measured Topographic Maps of 1924, Economic Planning and Development I Topographic Maps for 1985, and Economic Planning and Development III Topographic Maps of 1999, are adapted for a long-term-scale investigation; in addition with the application of multi-temporal satellite images for a short-term-scale study.

As a result, an effective method by overlaying the series of historical maps and spatial statistic analysis to monitor and evaluate the environmental changes for coastal wetland were developed. The landform development and evolution of Tai-Jiang Inner Sea as well as the transitional landform for coastal wetlands such as lagoons, sandbars, and estuaries were strongly affected by the transference of a nearby river, the Tsen-Wen River; one of the major rivers in Taiwan.

The long-term-scale investigation, in recent 100 years, has provided the sedimentation and erosion trend along the coastal region of the Tsen-Wen estuary. Different spatial distributions were shown for the sandbar deposits; thus to the north portion, an increase of sandbar area has been shown; whereas the area of the southern portion sandbar was decreasing with a 61% of reduction. Areas of the wetlands as well as the lagoons are also shown to be reducing. The areal reduction for lagoons occurred since 1928. The total reduction of the lagoons is approximately 71.3%. All these phenomena indicated that the wetland has been reducing rapidly in recent years; it may because of the new coastal land development and heavy sediment discharge from the river. In conclusion with that the wetland ecosystems are facing a major challenge in environment protection and management, in the near future.

Contact Information: Mon-Shieh Yang, Department of Earth Sciences, National Cheng Kung University, Tainan City, Taiwan, ROC, Phone: +886-937660711, Fax: +886-6-2740285, Email: MSYang@IEEE.org

COASTAL WETLAND MONITORING BY HIGH-RESOLUTION SATELLITE IMAGERY

***Mon-Shieh Yang* [1]**, *Ming-Chee Wu*[1], *Shu-Mei YU* [2] and *Shu-Mei Huang*[1]

[1]National Cheng Kung University, Tainan, Taiwan, ROC

[2] Geosat Informatics & Technology Co. Tainan, Taiwan, ROC

Wetland is an important ecosystem, the complex ecosystems with multifunctional capability has vulnerable characteristic. Namely, the monitoring and the evaluation can be done sufficiently is very much significant. The study area it is located in south part of Taiwan, where Chi-Gu Coast is the largest wetland in Taiwan. The complex ecosystems include the sandbars and lagoon at the Chi-Gu estuary, and the north tidal land at Tseng-Wen estuary. The area is known for the habitat of the endangered water bird, Black-faced Spoonbills.

The purpose of this study is to develop an effectively method to monitor and evaluate environment change of coastal wetland. Multi-temporal satellite mage process and Geographic Information System (GIS) are adapted to perform the measurement for environmental changes and spatial statistical analyses, such that to establish the Wetland Evaluation Indices (WEI) based on the remote sensing technique. Based on the remote sensing technique, the Wetland Evaluation Indices are to be established. Along the study, a standard image processing procedures, for the above mentioned purposes, will be established. The objectives of the works includes coastal erosion/sedimentation process, sandbars and lagoon areas, water content in estuary sand banks, distribution of mangroves.

In this study, NDVI and GNDVI are employed for wetland soil moisture investigation, the results shows the winter season, the rainfall and rainy days are fewer than summer of this area, so the soil moisture is controlled by elevation and the area of dry soil will be greater than summer day. Due to this result, dry soil could to be regarded as stable soil body. The results also indicated that the stable soil body reduces from 2004 to 2008.According to the results, the on shore side beach of the three sandbars surrounding the lagoon were quickly being eroded; the sand body were then transported from the open-sea side and deposited at the inner-sea side causing the siltation of the lagoon. Health level of the windbreak forests was either degrading or dying, especially for those are located along the coastal regions at the front side of the western bank.

<u>Contact Information</u>: Mon-Shieh Yang, Department of Earth Sciences, National Cheng Kung University, Tainan City, Taiwan, ROC, Phone: +886-937660711, Fax: +886-6-2740285, Email: MSYang@IEEE.org

WETLAND ECOSYSTEMS PROCESSES & FUNCTIONS - FRESHWATER WETLANDS (MARSHES SWAMPS ISOLATED LITTORAL PEATLANDS)

ENVIRONMENTAL CORRELATES OF WETLAND PLANT LITTER DECOMPOSITION IN THE MID-ATLANTIC HIGHLANDS, USA

***James T. Anderson**, R. Tristan Gingerich* and *George Merovich*
West Virginia University, Morgantown, WV, USA

To study environmental controls of decomposition, we measured plant litter decomposition rates in 6 wetlands located in the Mid-Atlantic Highlands, USA. We used 4 common wetland litter species: broadleaf cattail (*Typha latifolia*), common rush (*Juncus effusus*), brookside alder (*Alnus serrulata*), and reed canary grass (*Phalaris arundinacea)*. We create a fifth litter type from a mix of common rush, brookside alder, and reed canary grass. We collected litter bags over 2 years, from December 2007 to December 2009, and we measured environmental variables near litter bags every 2 weeks. We then used 9 environmental parameters and 1 study parameter to construct and test the ability of 22 *a priori* models to predict the decomposition rate of each litter type. The environmental variables that most influenced, and therefore best predicted, decomposition rate varied among litter types. Brookside alder decomposition rate was best predicted by soil temperature, water pH, and the number of transitions between flooded and exposed conditions; reed canary grass decomposition rate was best predicted by air temperature, water pH, and soil temperature; common rush decomposition rates were best predicted by air temperature; broadleaf cattail decomposition rate was best predicted by hydroperiod and the number of transitions between flooded and exposed conditions; and the mixed litter decomposition rate was best predicted by air temperature and water pH. Overall, air and soil temperature and water pH were directly related to decomposition rate, but hydroperiod was inversely related. The number of transitions between flooded and exposed conditions was directly related to decomposition rates of common rush and broadleaf cattail and inversely related to the decomposition rate of brookside alder. Abiotic parameters including temperature, water chemistry, and hydrology differentially influence the rate of decomposition among common hydrophytic species in the Mid-Atlantic Highlands. Because varied environmental factors influence decomposition of different litter types, it is important to incorporate heterogeneity into wetland creation projects. Varying hydrology and water depths influence decomposition directly, but also lead to diverse vegetation communities, which can influence air and soil temperature.

Contact Information: James T. (Jim) Anderson, Environmental Research Center, West Virginia University, PO Box 6125, Morgantown, WV 26506-6125, USA, Phone:304-293-3825, Fax: 304-293-2441, Email: jim.anderson@mail.wvu.edu

DEGRADATION OF NATURAL WETLANDS RECEIVING PERMITTED SEWAGE DISCHARGES

J.E. Bodker
Dept. of Oceanography and Coastal Sciences, LSU, Baton Rouge, LA USA

A critical review of the processes associated with the discharge of permitted sewage into natural wetlands raises doubt about whether this process is a simple "win-win" situation without liabilities. Approximately 250 hectares of marsh has been undergoing various changes since it began receiving permitted sewage from the City of Hammond, Louisiana, in the fall of 2006. The most obvious changes were ponding, mud flats, dead vegetation, and conversion to a floating marsh.
Many questions about cause-and-effect relationships leading to this degradation were raised and continue to persist. A number of possible causes have been identified that could have contributed to the weakening and break down of this ecosystem including algal blooms, plant diseases, storm events, chronic stress on vegetation from excessive constituent levels, an invasion and dominance of floating and shallow rooted plant species, persistent flooding, herbivory, increases in alkalinity and pH, the alteration of micro biotic populations, and sediment export. Although the complexity of interacting causes makes it difficult to assign a measurable value to each impact, it is important to answer two fundamental questions: 1. What are the factors inherent to the discharge of nutrient rich water into natural wetlands that cause changes? 2. What standard methodologies can be established and used to produce data to quantify existing and potential impacts? Two stand out as primary and direct functions of change. These are: the rates of organic decomposition, and, the rates of export of decomposing matter. These factors are inherently linked as a relationship between prolonged nutrient enrichment and increases of water elevations and flow.
We measured decomposition rates of material from control and experimental areas saturated with water from the control site, the experimental site and unchlorinated well water. Multiple runs revealed consistent patterns showing that decomposition was accelerated in the sewage discharge zone. Additionally, sediment traps were used to measure settable solids (particulates) from both the control site and the discharge zone. Preliminary results show a great variation of particulates moving within and out of the discharge zone but in all comparative runs with the control site, particulates in transport were significantly higher in the area impacted by the sewage discharge. These results are consistent with the spatial patterns of marsh-to-water conversion and soil strength throughout the marsh, measurements of cellulose decomposition near and far from the discharge site, and lab experiments.

Contact Information: Ed Bodker, 39484 S. Hoover Rd., Ponchatoula, LA 70454, USA, Phone: 985-386-0352, Email: ebodker@aol.com

COMPARISONS OF NITROGEN CONTENT AMONG WETLAND PLANTS AND EFFECTS ON LOCAL ENVIRONMENT

C. Allisa Vincent, ***Julia A. Cherry*** and *Amelia K. Ward*
University of Alabama, Tuscaloosa, AL, USA

Chemical composition of wetland plants has well-known effects on their decomposition rates. However, little attention has been given to how chemical composition of wetland plants changes through a growing season within a specific taxon nor how the composition of different wetland plant taxa affect proximate sediment and water chemistry. Alder is a facultative wetland plant that also has nitrogen-fixing bacteria associated with its root nodules. Because of this feature and its expected high N content, alder potentially plays a prominent role in N input and fate in wetland ecosystems. We report here the initial results from a larger study investigating N and C content of 3 different wetland plant taxa over a growing season in a wetland formed by beaver activity in a forested watershed in the southeastern U.S. The primary goal of this research is to compare and contrast nitrogen content among soft rush (*Juncus effusus*), fragrant water lily (*Nymphaea odorata*), and hazel alder (*Alnus serrulata*) and identify any relationships among plant nitrogen content, water chemistry, and soil nitrogen in each of the plant zones. The period of the entire study was from April 2011 - November 2011. Our results presented here show differences among the 3 wetland plant taxa as well as between new and older vegetation within each taxon. On average *Nymphaea odorata* leaves had the highest percent nitrogen among the 3 plant taxa with little difference in N content between new and old/senescent leaves: new = 2.58% by weight (n = 16) and old = 2.45% by weight (n = 16). *Juncus effusus* had the lowest percent nitrogen among the 3 plant taxa with new leaves showing a higher average percent nitrogen than old leaves: new = 1.10% by weight (n = 26) and old = 0.85% by weight (n = 26). *Alnus serrulata* leaves had intermediate N content compared to the other 2 taxa and also exhibited the largest difference between new and old leaves: new = 2.06% by weight (n = 12) and old = 1.64% by weight (n = 12) with an average difference of 0.42% between the two. The consistently higher N content of *Nymphaea* compared to *Alnus* leaves was unexpected and may be caused by more structural content in alder leaves and/or efficient N uptake from the water via pores on the underside of the *Nymphaea* leaves in addition to root/rhizome uptake of N. This study suggests that *Nymphaea* leaves may return substantial N to sediments and overlying water when they senesce and decompose compared to the other plant taxa.

Contact Information: C. Allisa Vincent, University of Alabama, Department of Biological Sciences, Tuscaloosa, AL 35487, USA, Phone:205-348-1797, Fax:205-348-1403, Email: cavincent@crimson.ua.edu

NUTRIENT PROCESSING WITHIN COASTAL PRAIRIE WETLANDS: A NEXUS TO GALVESTON BAY, TX

Maggie G. Forbes, Jeffrey Back and ***Robert D. Doyle***
Baylor University, Center for Reservoir and Aquatic Systems Research, Waco, Texas

The Texas coastal prairie wetlands (CPWs) are small, rain-fed depressions and flats that were historically abundant along the coast. Despite significant loss, the CPWs together with their catchments still occupy approximately 40% of the landscape around Galveston Bay, Texas, USA. Many CPWs are unregulated because they are perceived as "isolated" and a significant nexus to regulated waters has not been established. Results from sampling of precipitation and surface water of 12 CPWs revealed that CPWs had significantly lower concentrations of nitrate-N than precipitation. A similar trend was observed for ammonia-N. Organic nutrient concentrations were several times higher in wetlands than in precipitation.

Based on water quality data and water budgets for six CPWs, net annual nutrient export/retention rates indicate that CPWs are strong (>90%) sinks for inorganic nitrogen and SRP; and moderate (50-70%) sinks for organic N and P. All CPWs exported significant quantities of dissolved organic carbon and may provide as much as half of the annual organic carbon load to the Galveston Bay system. Capture, storage, transformation, and pulsed releases of organic nutrients to Galveston Bay and its tributaries emphasize the role of CPWs in regulating water quality on a landscape scale. The conversion of CPWs and their catchments to urban and residential land uses would nearly double the total N load exported by Galveston Bay's lower watershed. Capture, storage, transformation, and pulsed releases of organic and inorganic nutrients to Galveston Bay and its tributaries emphasize the role of CPWs in regulating water quality on a landscape scale. We believe these finding demonstrate a significant nexus between CPWs and navigable waters of the United States.

Contact Information: Robert D. Doyle, Baylor University, One Bear Place #97388, Waco, Texas 76798, USA. Phone: 254-710-2911, Fax 254-710-2969, Email Robert_Doyle@baylor.edu

COMPARING NEWLY BUILDING WETLANDS IN THE ATCHAFALAYA BAY, LOUISIANA AND THE SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA

Lindsay Dunaj
University of New Orleans, New Orleans, LA, USA

Although most of the Louisiana coast is dominated by wetland loss, there are areas where natural processes are building new wetlands. Two bayhead deltas, at the mouth of the Atchafalaya River and at the Wax Lake Outlet, formed and became subaerial after an unusually high flood year in 1973. These outlets have shown the land building capacity of the Atchafalaya River and are currently building emergent deltaic wetlands.

Wetlands are currently building in the Sacramento-San Joaquin Delta of California as well. During the past 200 years, large areas within this delta were leveed and turned into highly productive agricultural lands eliminating what were formerly extensive tidal wetlands. In some areas these levees have failed during flood events, restoring the natural tidal action and beginning the regrowth of wetlands.

Vegetation is a critical component of both newly building wetland areas as it adds volume to the soil through roots and promotes positive surface elevation change through both above and belowground biomass. This research focuses on how plants contribute to the wetland building process in the Atchafalaya River Delta, the Wax Lake Delta and Liberty Island in the Sacramento-San Joaquin Delta. At each location, 20m long transects are established with 0.5m^2 plots at 4m intervals. Each plot is sampled for aboveground biomass, root specific gravity, soil bulk density, and soil organic matter. In the Louisiana deltas, the contributions of vegetation in newly emerging Atchafalaya deltas, dominated by *Sagittaria latifolia,* are compared to more mature wetlands in the Wax Lake Delta (dominated by *Colocasia esculenta)*. At Liberty Island the obvious dominant species is *Schoenoplectus spp.* Additionally, rod surface elevation tables (RSET's) are used in all three areas to monitor surface elevation change, and to facilitate a comparison of land building processes in Louisiana and California.

Preliminary results show Liberty Island has the most volume by percent added to the soil through the roots of the dominant species, and the Atchafalaya Delta has the least. Gravimetric results show *Schoenoplectus spp*. at Liberty Island also have the most aboveground biomass followed by *Colocasia esculenta*, and then *Sagittaria latifolia*. In terms of soil characteristics, Liberty Island shows a lower bulk density, but a higher organic matter percentage by weight than the Louisiana wetlands. Overall elevation change measurements for 2010-2011 show the Wax Lake Delta had the highest positive elevation change, whereas the Atchafalaya Delta had a negative elevation change. Early results from elevation change readings taken from Feb – Oct 2011 at Liberty Island fall in between the elevation change measurements from the two Louisiana deltas.

Contact Information: Lindsay Dunaj, Department of Earth and Environmental Science, University of New Orleans, 2000 Lakeshore Dr., New Orleans, LA 70148, USA, Phone:413-883-1156; Email: ldunaj@uno.edu

ECOLOGICAL PATTERNS AND PROCESSES IN GHOST TREE ISLANDS OF THE EVERGLADES

Sharon M. L. Ewe[1], *Binhe Gu*[2], *Jennifer Vega*[1] and *Kristin Vaughan*[1]
[1]Ecology and Environment Inc., Wellington, FL, USA
[2]South Florida Water Management District, West Palm Beach, FL, USA

Some areas of the historic Everglades have been significantly degraded due to water management practices initiated early to mid 20th century. This is no exception in Water Conservation Area 2A (WCA-2A) in South Florida. Many of the islands have disappeared completely from the landscape and are now known as "ghost" islands. As these islands were critical habitats in the Everglades and hotspots of biodiversity within the landscape, one of the goals of restoration is to prevent further loss of island extent and restore some of these areas. The purpose of this research was to provide a baseline understanding of the long-term changes to the extent, topography, and nutrient chemistry of these "ghost" islands.

We reviewed historical aerial imagery of ten islands (8 "ghost" islands, one "live", and one "transitional" island), surveyed the surface and bedrock microtopography (20 km of transects, points 10-20 m apart), assessed vegetation composition on the islands, and collected soil cores (30 cm and 60 cm) from various locations across these islands for bulk density and soil total phosphorus (TP) analysis. All 10 islands were distributed across a range of hydrologic gradients across WCA-2A.

A review of aerial imagery over the last 6 decades showed the significant and consistent loss of island extent across WCA-2A. In general, island extent decreases usually occurred quickly (within the span of a decade) before island size became static again. For example, woody species loss rate on Dineen's tree island (2A-15-6) was approximately 90% between 1962 and 1973 but has remained static since. Five of the islands sampled appear to have developed over pinnacle rock at the head while four islands appear to be over a flat bedrock surface, and one island appeared to have developed in a bedrock depression. All islands had higher TP compared to the marsh. Most of the islands had a TP "hotspot" (>1000 mg TP/kg soil) in the center of the historic head of the "ghost" island, an order of magnitude greater than the mid and near-tails. At the head of the island, soil TP concentrations were higher at deeper (>20 cm) in the cores while for the mid and neartail sites, TP was highest in the top 10 cm of the soil layer.

These data indicate that changes to these islands appear to be pulsed and that all three existing hypotheses of tree island formation are supported within the findings of this study. Additionally this study also provides empirical support of phosphorus hotspots on Everglades tree islands; the presence and persistence of the high TP values in these "ghost islands" indicate that restoration is possible as the soil patterns, albeit somewhat lower on the head of the island, are still present.

Contact Information: Sharon Ewe, Ecology and Environment Inc., 12300 South Shore Blvd., Suite 222, Wellington, FL 33414, USA, Phone:561-793-3849, Email: sewe@ene.com

HYDROLOGICAL AND BIOGEOCHEMICAL CONTROLS ON NITROUS OXIDE (N_2O) PRODUCTION AND CONSUMPTION IN ISOLATED WETLANDS IN GRASSLAND ECOSYSTEMS

***Jing Hu**, Kanika S. Inglett, Mark W. Clark* and *K. Ramesh Reddy*
Wetland Biogeochemistry Laboratory, Soil and Water Science Department, University of Florida, FL, USA

Nitrous oxide (N_2O) is one of the most potent greenhouse gases and its emissions from wetlands are influenced by their hydroperiod. Wetlands within agricultural landscape act as water and nutrient storage systems at landscape scale, and may lead to high N_2O emissions. Nitrous oxide emissions represent the difference between total N_2O production (by nitrification and denitrification) and N_2O consumption during denitrification. The production and consumption processes of N_2O are regulated by hydrology and biogeochemical properties of wetlands. Isolated wetlands, which have no surface water connectivity with nearby water bodies, are common feature in many watersheds. For example, in Florida, isolated wetlands account for ~ 13,000 ha (14% of the land area) within the four priority Lake Okeechobee basins which are dominated by agriculture.

A laboratory incubation study was performed to quantify potential N_2O production and consumption rates of soils collected along hydrologic gradients in isolated wetlands in grassland ecosystems. We collected soil samples (0-70 cm) from three regions representing long hydroperiod soils (LHS), short hydroperiod soils (SHS), and upland soils (US). Our results indicated the N_2O production rates in LHS were almost two-fold higher than that in SHS. There was no significant difference observed between the N_2O reduction rates of LHS and SHS. Rates of both N_2O production and consumption were very low in US. Both N_2O production and consumption rates were much higher in depths of 0-30 cm and declined with soil depth ($p<0.05$). The organic carbon (org-C) and nitrate (NO_3^-) amendment experiments revealed that the potential N_2O production rates in soils were limited by both availability of org-C and NO_3^- at 0-10 cm depth and were more limited by org-C at depths of 10-70 cm.

Contact Information: Jing Hu, 106 Newell Hall, PO Box 110510, Gainesville, FL 32611, USA, Phone:352-392-1803 (355), Fax: 352-392-3399, Email: hjing@ufl.edu

ECOLOGICAL WATER REQUIREMENTS BASED ON WATER LEVEL SIMULATION IN THE YELLOW RIVER DELTA

Yanyan Hua[1] and *Baoshan Cui*[1]

[1]School of Environment, Beijing Normal University, State Key Joint Laboratory of Environmental Simulation and Pollution Control, Beijing, China

This study focuses on the Ecological Water Requirements (EWRs) for wetlands and restoration in the *Phragmites australis* wetlands of the Yellow River Delta. Based on the continuous research on the problems of imbalances in the inflows from the Yellow River (including the flush water from xiaolangdi) and the water allocation in the study area, we reveal the influence and mechanism of water fluctuation on wetland ecological characteristic, using quantitative ecology and eco-hydrology methods. Water level-habitat response during the three different periods is simulated by"3S" technologies. In order to determine the proper water level threshold of the study area, the habitat suitability assessment system, as well as the proper water level threshold measurable system, is established. Then optimum water volume thresholds during different period are calculated. Aiming at the mismatching problem between the water compensation and the ecological system's own rhythm, timing water supplement program is set up, followed by the calculation of the potential scale of wetland restoration. This study achieves the reasonable water resources allocation in the study area and provides a scientific basis for decision making in the similar studies and management practice.

Contact Information: Yanyan Hua, School of Environment, Beijing Normal University, State Key Joint Laboratory of Environmental Simulation and Pollution Control, No. 19 Xinjiekouwai Street, Beijing 100875, China, Phone: + 86 10 58802079, Fax: + 86 10 58802079, Email: huayan1228@126.com

SOIL PHOSPHORUS CHARACTERISTICS IN TREE ISLANDS OF THE FLORIDA EVERGLADES

Daniel L. Irick[1], *Yuncong Li*[1], *Patrick W. Inglett*[1], *Willie Harris*[1], *Binhe Gu*[2], *Michael Ross*[3] and *Alan Wright*[1]
[1]University of Florida, Gainesville, FL, USA
[2]South Florida Water Management District, West Palm Beach, FL, USA
[3]Florida International University, Miami, FL, USA

The Florida Everglades is a phosphorus (P) limited, freshwater wetland ecosystem. Soil P in tree islands within the Everglades has been reported to greatly exceed concentrations of the surrounding marsh. Recent literature suggests tree islands may play an important role in soil nutrient distribution dynamics in the landscape as P sinks, however little data is available regarding the specific forms of P present in tree island soil. The soil P pool is composed of organic and inorganic forms, which if characterized can provide insight with respect to nutrient accumulation mechanisms and stability. Nutrient accumulation and stability in soil is a cyclical interaction among physical processes, chemical reactions and biological function of flora and fauna. Tree island ecosystems in the Everglades offer a unique opportunity to study mechanisms controlling soil P dynamics within a large freshwater wetland because the wide range (0.02 – 10%) of soil P concentrations reported in tree island soil suggests heterogeneous accumulation mechanisms among islands.

Characterization of soil P forms was approached by employing by chemical and physical analyses of surface soil (0-10 cm) from tree islands (n=20) in the Everglades. Sequential selective dissolution of P was conducted to quantify proportions of soil P forms among the total pool. Total elemental analysis of P associated cations was determined to evaluate correlations between metals present in soil and inorganic forms of P. Further characterization of soil P was conducted on a subset of samples using particle size separation, x-ray diffraction (XRD), scanning electron microscopy (SEM), and energy dispersive spectroscopy (EDS) for micro-elemental analyses and elemental association.

Inorganic P accounts for the majority of the P in tree island soil with elevated P concentration. Acid extractable P, defined as calcium- (Ca) or magnesium- (Mg) bound P, accounts for 87±5.5 % (mean ± SE) of the total P. A positive relationship between total P and Ca suggests Ca phosphates are the specific type of inorganic P present. Apatite was identified by XRD in soils with elevated P concentration. These soils also contained bone fragments. The high proportion of Ca-P observed in tree island soil coupled with a positive relationship between Ca and P concentration likely alludes to an exogenous P source. The presence of apatite and bone fragments in tree island soils indicates deposition of biogenic Ca-P mineral material. Deposition of biogenic apatite would suggest these unique habitats may accumulate P through complex ecological mechanisms extending across a broad landscape. The potential for apatite accumulation in tree islands may play an important role in nutrient distribution dynamics within the Everglades.

<u>Contact Information</u>: Daniel L. Irick, Soil and Water Science Department, Tropical Research and Education Center, University of Florida, 18905 SW 280th Street, Homestead, FL 33031, USA, Phone:305-246-7001, Email: dirick@ufl.edu

PLANT FUNCTIONAL TYPES IDENTIFICATION IN THE LOWER PARANÁ RIVER FLOODPLAIN, ARGENTINA

Natalia S. Morandeira[1,2], *M. Marta Borro*[1,2], *Gabriela González Trilla*[1,2], *M. Mercedes Salvia*[1,2], *Nora Madanes*[3] and ***Patricia Kandus***[1]

[1]LETyE, 3iA-UNSAM, Buenos Aires, Argentina
[2]Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina
[3]Grupo de Investigaciones en Ecología de Humedales, FCEN-UBA, Buenos Aires, Argentina

Large wetlands of temperate South American floodplains are mostly covered by herbaceous plants, which are expected to be adapted to a wide range of water availability and hydroperiods. While few species usually dominate at any particular location, at landscape and regional scales there is a large number of plant species, probably with functional redundancy. Plant Functional Types (PFT) relying on a shared set of key structural and functional traits, promise to be a tool to assess wetland environmental conditions. Beside traditional vegetation surveys and phytosociological descriptions, this approach may synthesize the complexity of wetland plant communities with less emphasis on taxonomy. We aimed to identify PFTs within the herbaceous plant communities of the Lower Paraná floodplain. We also evaluated the spatial association between dominant PFTs and environmental conditions determined by geomorphic setting, topographical position and soil condition.

In 47 sites stratified into distinct geomorphic settings and topographical positions, we estimated mean species coverage using Braun-Blanquet cover-abundance scale in three 1m^2 plots. Sub-surface soil samples (two layers, ca.0-25 and 25-45 cm depth) and plant community biomass were also collected in the plots. In each site, we randomly selected 5 adult individuals of each dominant species for trait recording. The data matrix had 53 plant observations x 20 functional and structural traits. Plant traits values were standardized and in order to avoid trait redundancy we excluded those significantly correlated with each other. The remaining 8 independent traits were: presence of hollow stems, plant height, number of leaves, leaf thickness (mm), leaf area (mm^2), leaf specific area (mm^2/g), leaf perimeter/length, total leaf nitrogen content (%N of dry weight). Through cluster analysis (Gower distance measure, Ward linkage method) we classified plant populations into 10 PFTs.

The traits that better discriminated PFTs were plant height, number of leaves, %N, leaf perimeter/length and leaf area. Morpho-ecological growth types were well discriminated: 5 PFTs were predominantly of broad-leaved species (mainly Polygonaceae, Asteraceae and Onagraceae), 4 of graminoid species (mainly Poaceae) and one PFTs of a sedge species (Cyperaceae). Two broad-leaved PFTs with distinct structural features had high N foliar content (and high phosphorus content). Multiple regression models suggest that both N and P leaf content could be explained by P content in the first soil layer, plant community biomass and belonging or not to Poaceae family. Contrary to our expectations, PFTs distribution was not related to geomorphic setting. However, 4 PFTs dominated only low or high topographic positions, which would be closely related to water table level dynamics and water permanence.

Contact Information: N.S. Morandeira, Laboratorio de Ecología, Teledetección y Ecoinformática; Instituto de Investigación e Ingeniería Ambiental, Universidad Nacional de San Martín. Belgrano 3563, (1650) San Martín, Buenos Aires, Argentina, Phone: +5411-45807300 ext.106, Email: nmorandeira@unsam.edu.ar

THE EFFECT OF NUTRIENT SUPPLY ON THE PRIMARY PRODUCTION AND THE PARTICIPATION OF *PHALARIS ARUNDINACEA* IN A WET GRASSLAND PLANT COMMUNITY

Miroslava Káplová [1], *Keith R. Edwards* [1] and ***Jan Květ*** [1, 2]

[1]Department of Ecosystems Biology, Faculty of Science, University of South Bohemia, České Budějovice, Czech Republic

[2]CzechGlobe, Center for Global Change Research, Czech Academy of Sciences, České Budějovice, Czech Republic

Since the 1950s, agricultural intensification has affected the structure and functioning of ecological systems including wet grasslands. Our study area, the wet grassland near Třeboň, Czech Republic, Central Europe, called "Wet Meadows" was historically a sedge and grass marsh, with *Carex gracilis (= C. acuta)* and *Calamgrostis canescens* dominating the plant community. This vegetation type has survived till now only in the wettest part of the "Wet Meadows". From the 16th century onwards, our study area was managed as a wet meadow with the hay being used mainly as bedding for domestic animals. Since the middle of the 20th century, increased nutrient additions, a long-lasting flood in 2002 and changed mowing patterns resulted in dominance by *Phalaris arundinacea*. The aim of our study was to determine how different nutrient conditions may affect the vegetation species composition and production in the not mown part of the *Phalaris arundinacea* - dominated wet grassland area. Here, the nutrient supply to the vegetation decreases with distance from the manured and mown wet grassland area. Species composition and. plant cover degree were determined from line intercepts. Aboveground biomass was harvested six times each in 2007 and 2008 and primary production then calculated. Ingrowth core bags were used to determine belowground production. Aboveground production was two times greater in the high nutrient versus the low nutrient area in both years, while belowground production was very similar. These data are being compared with earlier data on the production ecology of *Phalaris arundinacea* in Central European wetlands. Within our study area, the high nutrient part was still dominated by *Phalaris arundinacea*, but *Carex gracilis* came partly back as a co-dominant in the low nutrient part. The rapid change in species composition in the low nutrient part indicates that restoration of more diverse wet grasslands may occur within a few years after cessation of manuring and/or mineral fertilization. Nevertheless, other factors, such as the dynamics of water level, may interact with nutrient levels to govern the functioning of wet grasslands and, in consequence, also their species composition and vegetation structure.

<u>Contact Information</u>: Jan Květ, University of South Bohemia, Faculty of Science, CZ-37005 České Budějovice, Czech Republic, Phone: +420 387772259, Fax: +420 384721136, E-mail: Jan.Kvet@seznam.cz

AMBIENT EX-SITU DENITRIFICATION IN ISOLATED WETLANDS OF OHIO, NORTH CAROLINA, AND FLORIDA

C.R. Lane[1], *B.C. Autrey*[1], *Terri Jicha*[2], *LaRae Lehto*[2], *Colleen Elonen*[2] and *Lindsey Seifert*[2]

[1] U.S. Environmental Protection Agency, National Exposure Research Laboratory, Ecological Exposure Research Division, 26 W. Martin Luther King Blvd., MS-591, Cincinnati, OH 45268

[2] U.S. Environmental Protection Agency, National Health and Ecological Effects Research Laboratory, Mid-Continent Ecology Division, 6201 Congdon Blvd., Duluth, MN 55804

Isolated wetlands are completely surrounded by uplands and typically do not warrant federal protection under the Clean Water Act. Nevertheless they can be found at high densities in certain parts of the US and Canada (e.g., Prairie Pothole Region, Southern and Middle Atlantic Coastal Plains ecoregions). Understanding the ecosystem services, or benefits received by humans for ecosystem processes, performed in isolated wetlands can provide substantive progress towards reestablishing federal protection for some systems. One such ecosystem service is the assimilation of nutrient pollution through denitrification. Wetlands are known to perform high rates of nitrogen processing due to frequent anaerobic conditions, labile carbon sources, available nitrate-nitrogen, and adaptive microbial communities.

In this study, we composited six soil subsamples at each of 30 isolated wetlands across Ohio (n = 12), North Carolina (n = 6) and Florida (n = 12). The ex-situ ambient, or non-amended denitrification enzyme activity, was measured using the acetylene block method in each composite sample. Denitrification activity ranged from 0.000350 g N hr-1 kg dry weight (DW)-1 to 0.341652 g N hr-1 kg DW-1, and averaged 0.049672 g N hr-1 kg DW-1 (± 0.082324 g N hr-1 kg DW-1 standard deviation). Significant differences were found between denitrification rates in Ohio and those in both North Carolina and Florida, but no differences were found between wetlands in North Carolina and Florida. Palustrine emergent marsh (n =12) and palustrine forested (n = 18) wetlands also did not differ in denitrification rates. Significant correlations were found with soil nitrate concentration, soil carbon to nitrogen ratio, soil total phosphorus concentration, and ambient denitrification enzyme activity. These results suggest that denitrification in isolated wetlands may be a significant nitrogen sink, though landscape setting and nutrient loading may affect the link between these systems and downstream waters.

Contact Information: Charles R. Lane, U.S. Environmental Protection Agency, National Exposure Research Laboratory, Ecological Exposure Research Division, 26 W. Martin Luther King Blvd., MS-591, Cincinnati, OH 45268, USA, Phone: 513-569-7854, Email: Lane.Charles@epa.gov

RELATING SELF-REGULATION WITH ECOSYSTEM STRUCTURE AND FUNCTION IN NORTHERN PEATLANDS

Avni Malhotra and *Nigel Roulet*
McGill University, Montreal, QC, Canada

Northern peatlands are vulnerable to climate change and several research programs are focused on understanding the response of peatland biogeochemistry to changes in climate and land use. However, this research often centers on linear responses of peatlands to climate change variables and little attention is given to the self-regulation potential of peatland biogeochemical processes. Peatland models have related spatial heterogeneity to self-regulation and stable states in peatlands. We describe peatlands under the conceptual framework of Complex Adaptive Systems and hypothesize that peatlands have cross-scale feedbacks that are crucial to our understanding of self-regulation in these systems. Each of the spatio-temporal scale levels have varying degrees of heterogeneity, internal processes and external forcing. The core of my research will investigate the relationship between structure (microtopography and vegetation) and function (net ecosystem exchange and decomposition) in peatlands across varying scales and varying degrees of heterogeneity and external forcing. We will test these ideas at the Stordalen peatland in northern Sweden where 3 different types of peatlands with different degrees of heterogeneity and external controls (permafrost, hydrology, etc.) are present- therefore providing an ideal setting to compare degrees of self-regulation in peatlands. To contrast a dynamic and exogenously controlled site such as Stordalen, We will also collect data at Mer Bleue bog in eastern Canada. Mer Bleue is a more self-regulated peatland site where similar ideas can be tested on varying scales. Here, we present preliminary data on the relationship between microtopgraphy, water table fluctuation and vegetation from Stordalen and Mer Bleue bog.

Contact Information: Avni Malhotra, McGill University, Geography Department, 805 Sherbrooke Street West, Montreal, QC Canada H3A 2K6, Phone:514-398-4111, Fax: 514-398-7437, Email: avni.malhotra@mail.mcgill.ca

MODELING THE EFFECTS OF MACROPHYTE COMMUNITIES ON PHOSPHORUS RETENTION AT LOW CONCENTRATIONS

Darryl E. Marois and *William J. Mitsch*
[1]The Ohio State University, Columbus, OH, USA

Excess phosphorus (P) in surface water is one of the primary threats to the natural state of the Everglades ecosystem in southern Florida. This type of pollution promotes the dominance of invasive species such as *Typha domingensis* over native Everglades species such as *Cladium jamaicense.* One potential solution for this problem currently being implemented in Florida is the use of engineered wetlands to remove P from the water before it reaches the Everglades. The optimum design of wetlands for P removal to low concentrations (~10-30 ppb) is being investigated with mesocosms located in in the Florida Everglades. Eighteen mesocosms (6 m x 1 m x 1 m), contain 6 different vegetation communities including sawgrass (*Cladium jamaicense*), cattail (*Typha domingensis*), submersed aquatic vegetation (SAV) consisting of Southern naiad and *Chara*, water lily (*Nymphaea*), a combination of water lily (*Nymphaea*) and spikerush (*Eleocharis*), and the control, which was left to self-design. A dynamic computer model was developed based on these mesocosms to focus on the processes that affect P biogeochemistry and uptake.

The model, using the high-level simulation software, STELLA, consists of three interconnected submodels: phosphorus, hydrology, and vegetation. Data collected from the different mesocosms were used for the development, calibration, and validation of the model. Water quality data utilized includes inflow and outflow measurements of temperature, dissolved oxygen (DO), pH, concentrations of dissolved organic carbon (DOC), dissolved organic phosphorus (DOP), particulate phosphorus (PP), total dissolved phosphorus (TDP), and total phosphorus (TP), total dissolved solids (TDS), total suspended solids (TSS), and total organic carbon (TOC). Significant processes in the model include sedimentation, reflux, and macrophyte and algal productivity/nutrient uptake. The model results provide a better understanding of the significances of processes that contribute to P retention and release. It also allows for analysis of the relative importance of different vegetation communities on these processes and may aid in making management decisions in regard to designing wetlands for the control of phosphorus in low concentrations.

Contact Information: Darryl E. Marois, Olentangy River Wetland Research Park, The Ohio State University, School of Environment and Natural Resources 352 Dodridge Street, Columbus, OH 43202, USA, Phone:614-688-8410; Email: marois.5@osu.edu

AN INVESTIGATION OF PEATLANDS: FLOATING MAT FENS

Luke T. Martinson and *J.R. Boehrs*
Western Ecosystems Technology, Inc., Cheyenne, WY, USA

Peatlands are known to provide suitable habitat for unique and diverse species. Floating mat fens are a specific type of peatland which often contain sensitive species; however, species diversity is relatively limited. Few species are able to tolerate the constant inundation found in a floating mat fen system. These systems can be found in high elevation, subalpine habitats throughout the rocky mountain range. Ten floating mat fens were investigated along the eastern slope of the Big Horn Mountains in Johnson County, Wyoming. A soil pit was collected at each feature to verify the presence of peatland. Species lists were compiled for each individual feature. Aerial imagery was marked to identify vegetative signatures and sketches were completed showing species zonation.

Eight of the ten features display similar habitat configurations: broad outer bands of *Calamagrostis canadensis* and *Carex utriculata*; large areas of open water with *Nuphar* sp. and *Nymphea* sp.; *Carex limosa* and *Menyanthes trifoliata* floating vegetative mat(s). The floating mats have a minimum of 24 inches of peat. In these features, species zones are clearly defined and do not intermix.

One feature is an expansive fen in which the floating mat is connected along the perimeter, resulting in the absence of open water. The floating mat appears to be in three segments, each with an interior *C. limosa* and *M. trifoliata* monoculture. The peat layer was approximately 18 inches at this feature. The species zones are less define at this feature, with the formation of ecotones transitioning between species community.

The last feature has a broad shelf of *C. utriculata* transitioning into a *C. limosa* and *M. trifoliata* floating vegetative mat. The peat layer was approximately 20 inches at this feature. No open water exists at this feature. The *C. utriculata* zone was not a floating mat, but did have 18 inches of peat.

Eighty-percent of the features examined have similar configuration. All of the features surveyed are composed of only six species. One of the species (*C. limosa*) is considered sensitive.

Peatlands are unique and ecologically significant features. Conditions at floating mat fens provide an environmental suitable for rare species. Identification of these systems is important to ensure future preservation.

Contact Information: Luke Martinson, WEST Inc., Cheyenne, WY 82001, USA, Phone:307.214.7720, Fax: 307.637.6981, Email: lmartinson@west-inc.com

HYDROGEOLOGIC CONDITIONS THAT AFFECT RESTORED PITCHER PLANT BOG HABITAT, SE VIRGINIA, USA

***John McLeod**, G. Richard Whittecar* and *Kerby M.Dobbs*
Old Dominion University, Norfolk, Virginia, USA

The purpose of this research is to analyze a hydrogeologic setting that supports native pitcher plant bogs in the coastal plain of southeastern Virginia, and evaluate the effects that watershed-wide alterations to the vegetation have on groundwater dynamics. Longleaf pine savanna and pitcher plant bog ecosystem complexes were once common in Virginia's coastal plain, but fire suppression and other factors contributed to a significant decline in these wetlands. Because re-creation and maintenance of these savannas, such as the ones at the Joseph Pine Preserve in Sussex County, Virginia, require considerable effort and expense, effective management plans must be based upon a comprehensive understanding of the interaction between the geologic, hydrologic, and biotic elements that formed them.

The tidal-flat facies of the Bacons Castle Formation underlies the rolling landscape of the Preserve. Analysis of split-spoon cores, and vibracore samples revealed bogs formed at toe-slopes; in these locations, groundwater seeps from extensive sand layers sandwiched between thick clay beds. Examination of bog stratigraphy across the toe-slope using ground-penetrating radar reveals that colluvial sand sheets overlie dense clay layers. Hydrographs from monitoring wells in those sand beds show relative stable water table elevations above the bog root zone existed even during summer drought conditions in 2010. Diurnal water table fluctuations reflected evapotranspiration cycles. Comparisons of ET rates between adjacent areas with different vegetation densities indicate a 103% increase in the volume of groundwater withdrawn by dense mixed pine/deciduous hardwood forest compared to sparsely-wooded longleaf pine savanna. Also, analysis of groundwater fluctuations before and after prescribed burning of the long-leaf savanna ecosystem in spring 2011 show a reduction in post-burn evapotranspiration rates. These results suggest long-leaf pine savanna ecosystems managed with annual prescribed burning withdraw less groundwater than loblolly pine woodlands, effectively increasing the volume of water available to supply the pitcher plant bog. This study will provide resource managers with Information critical for restoring these rare wetland habitats.

Contact Information: John McLeod, Ocean, Earth and Atmospheric Sciences, Old Dominion University, Norfolk, VA 23529, USA, Phone:757-683-5197, Fax:757-683-5303, Email: mcleodfish@gmail.com

CRITICAL DETERMINANTS OF VEGETATION COMPOSITION AT ABANDONED PADDY TERRACES IN A MONTANE VALLEY: FOUNDER EFFECT AND WATER DEPTH

***Jihyun Park**, Mun-Gi Hon* and *Jae Geun Kim*
Seoul National University, Seoul, Republic of Korea

A lot of paddy terraces in montane valleys in Korea have been abandoned due to their low economic value as a result of inconvenience for cultivation and they have been developed into lentic wetlands consequently. Recently, these wetlands have been newly recognized as very valuable ecosystem because of diverse flora and fauna. Even though abandoned paddy terrace (APT) seem to have similar environmental conditions, vegetation compositions are obviously different throughout the terrace of several floors. However, there are a few investigations about the succession process or biodiversity in APT. Here we investigated the critical determinants of vegetation composition in APTs through the assessment of the relationships between environmental conditions and vegetation compositions in several APTs. We found that water depth was the only different environmental factor throughout all the floors in a terrace; e.g., water depth was a critical determinant of vegetation composition in APTs. In addition, we found obviously different vegetation composition in some floors where water depth was similar. From the vegetation analysis, we found that arrival sequence of plants in early establishment stage was important factor: e.g., founder effect was another critical determinant of vegetation composition.

Contact Information: Jihyun Park, Department of Biology Education, Seoul National University, Seoul 151-748, Republic of Korea, Phone: +82-2-880-9077, Email: jihyunp@snu.ac.kr

HYDROGEOLOGIC VARIATIONS ACROSS A BARRIER ISLAND THAT INFLUENCE INTER-DUNE WETLANDS, SE VIRGINIA, USA

Matthew C. Richardson *[1], G. Richard Whittecar [1]* and *R. Harold Whittecar [2]*
[1]Old Dominion University, Norfolk, Virginia, USA
[2]Sigma Environmental Services, Virginia Beach, Virginia, USA

False Cape State Park, located in southeastern Virginia Beach, Virginia, contains a transgressive barrier island complex. Non-tidal and fresh-water wetlands carpet broad overwash flats in the island center, and mantle the long inter-dune swales near the ocean shore. The appearance and subsequent disappearance of redoximorphic wetland soil features in the young, sandy soils of the inter-dune swales here may stem from changes in the patterns of groundwater recharge and discharge across the island. These soils are being monitored by members of the interagency Mid Atlantic Hydric Soils committee and features there may be proposed for formal recognition as Hydric Soil Indicators.

Hydraulic head data from monitoring wells indicate that a strongly asymmetric freshwater lens crests under the eastern half of the island. The asymmetric shape of the water table could be due to differences in either vegetation cover or permeability of stratigraphic packages. The densely-vegetated western half of the island experiences higher rates of evapotranspiration (ET) than the more open-canopied eastern half. Results of groundwater models that spatially vary ET rates, and thus recharge, generate an asymmetric freshwater lens across a hypothetical island with uniform permeability. However, sedimentation and stratigraphic differences may prove to be more important than ET. Transducer data show that aquifer responses to rapid recharge events vary across the island in ways which suggest different net permeabilities for sediment packages on either side of the island. Permeameter tests also indicate slight differences in the permeability between the soils of each respective island half. Stratigraphic analyses of vibracore and Ground Penetrating Radar (GPR) data will help in testing these working hypotheses.

Contact Information: Matthew Richardson, Ocean, Earth and Atmospheric Sciences, Old Dominion University, Norfolk, VA 23529 USA, Phone: 757-683-5197, Fax: 757-683-5303, Email: mrichard@odu.edu

LIFE CYCLE OF A TAPE GRASS (*VALLISNERIA AMERICANA*) BED

Jennifer J. Sagan
Water and Air Research, Inc., Gainesville, FL USA

Within the lower basin of the St. Johns River (LSJRB), Florida, a cyclical pattern of disappearance and resurgence of *Vallisneria americana* has been observed within Crescent Lake. Seasonal surveys conducted at a permanent monitoring station over a decade provided an opportunity to observe the mode and pattern of *Vallisneria* reestablishment at the site as related to water quality data. In addition, a seed bank study was conducted at the site to determine density of viable *Vallisneria* seeds in the sediment (356.2 m^{-2} ± 1209.2 m^{-2}). Reestablishment at the site occurred first by germination of seeds and then primarily by rhizomatous expansion. Small plants (< 0.03 m) first colonized near-shore areas, extending 8 – 20 m from shore, and at low occurrence (< 8%). Bed length and percent occurrence increased concomitantly over a year and a half to maximum values (90 m and 87%, respectively). Mean shoot length remained small (< 0.05 m) during the first year. Mean shoot length then doubled (0.05 m vs. 0.12 m) and then quadrupled (0.12 m vs. 0.48 m) at fifteen months and eighteen months, respectively, after bed reestablishment. Water quality data collected at the site showed a significant correlation between *Vallisneria* percent occurrence and declining water color values. This pattern of growth has been seen in other sections of the LSJR during recovery once salinity stress was reduced. *Vallisneria* appears to initially allocate resources to lateral expansion throughout the bed, possibly to reduce interspecific competition and to increase access to resources.

Contact Information: Jennifer J. Sagan, Water and Air Research, Inc., 6821 SW Archer Road., Gainesville, FL 32608, USA, Phone: 352-224-1541, Email: jsagan@waterandair.com

SILICON AVAILABILITY MODIFIES THE C:N:P STOICHIOMETRY AND CONTENTS OF CARBON COMPOUNDS IN GRASSES

Jörg Schaller
Institute of General Ecology and Environmental Protection, University of Technology Dresden, Germany

Silicon as non-essential element *in sensu strictu* for plant growth, nonetheless effects biotic stress resistance and may substitute carbon compounds in cell walls of grasses. Silicon availability changes during pedogenesis and is affected plant silicon turnover. Recent studies revealed an interaction between silicon availability in a narrow range and nutrients as well as cellulose and lignin, shown for bulk analysis of the whole plants. We tested the effect of silicon availability in a broad range on the C : N : P ratio, content of carbon compounds and on aboveground biomass production of *Phragmites australis*.

Our results show that individuals of *P. australis* grown under conditions of low silicon availability exhibit a different C : N : P ratio compared to plants grown under conditions of optimal silicon availability (maximum biomass). In contrast to this, in plants grown under high silicon surplus the C : N : P ratio is similar to the treatment with low silicon availability. We found altered N : P ratios, whereas C : N ratios changed only slightly. Furthermore, our results show that different levels of silicon supply changed the plant cellulose, lignin and phenol content depending on plant tissue function. Cellulose content in tissues with stabilization function is reduced contrasting enhanced cellulose content in tissues with photosynthesis function. Furthermore, higher silicon surplus decreased the phenol content in photosynthetic active tissues and increased the phenol content in culm. Only weak silicon to lignin interaction was found.

These findings point to the potential of silicon to alter the ecological stoichiometry of the main nutrients, carbon compounds and biomass production of grasses. Resulting from this, silicon may affect the biogeochemical cycles in ecosystems dominated by grasses and sedges in the course of litter decay.

Contact Information: Jörg Schaller, Institute of General Ecology and Environmental Protection, University of Technology Dresden, PF 1117, 01737 Tharandt, Germany, Phone:0049 351 463 31375, Fax: 0049 351 463 31399, Email: Schaller@forst.tu-dresden.de

EFFECTS OF RAISED TEMPERATURE AND NORTHWARD SPECIES MIGRATION ON EXPERIMENTAL TIDAL FRESHWATER MARSH COMMUNITIES FROM EUROPEAN AND NORTH AMERICAN ESTUARIES

Marisa Schönfeldt*[1]*, *Andrew Baldwin*[2] and *Kai Jensen*[1]
[1]Hamburg University, Hamburg, Germany
[2]University of Maryland, College Park, MD, USA

Tidal freshwater marshes occur in estuaries of the temperate zone at both sides of the northern Atlantic Ocean. They are known to be potentially vulnerable to climate change as their species diversity might be negatively affected by sea level rise and accompanied salt water intrusion as well as by increased temperatures leading to the dominance of highly competitive species. Possible compensating effects of northward species migration on these climate change consequences have not been investigated yet. Here we analyze how an increase in temperature and a northward migration of tidal freshwater species affect biomass production and diversity pattern of experimental marsh communities. We sampled soil seed banks from each of three estuaries in the temperate zone in Europe and in North Anerica. In Europe, the sampled latitudinal gradient included the Minho (Portugal), the Loire (France), and the Elbe (Germany) estuaries. In the US, the Waccamaw (South Carolina), the Pamunkey (Virginia), and the Connecticut estuaries were sampled. Sampling was carried out in February and March 2011. In each estuary, 66 cores of 100 cm^3 soil were taken from each of three sampled sites. To get a composite soil sample from each estuary, one third of each of the soil samples from each site was mixed. To mimic northward species migration, soil samples from the different estuaries within each continent were also mixed. Subsamples of these composite samples were exposed to two different temperature regimes (ambient, increased) in a greenhouse of the Botanical Garden at Hamburg University between May and October 2011. For this purpose, 550 cm^3 of soil material was spread over sterilzed soil in trays (39x28x14 cm). We recorded germination in May and June 2011 as well as species cover developing between May and October. Furthermore, final aboveground biomass of all occurring species was harvested in October 2011.
Preliminary results show that the average number of species per tray was similar between the continents, while biomass production was lower in European than in American samples. In both continents, the samples with the lowest aboveground biomass were those from the most northern estuary. The highest number of species occurred in the samples from the most southern estuaries. In the European samples, an increased temperature significantly increased biomass produced by forbs. In the American samples, an increased temperature led to a significantly higher biomass production of forbs, and of grasses. Furthermore, an increased temperature tended to reduce the number of species per tray. Finally, northward species migration significantly increased the number of species in both American and European samples but it did not influence biomass production.
We conclude that increased temperatures might lead to an increase of aboveground biomass production in tidal freshwater marshes. Without northward species migration, this might lead to reduced species diversity. These negative effects might be compensated if northward species migration is possible to occur along the shorelines of both sides of the Atlantic Ocean.

Contact Information: Kai Jensen, Hamburg University, Biocenter Klein Flottbek, Applied Plant Ecology, Ohnhorststr. 18, 22609 Hamburg, Germany, Phone: 40-42816576, Fax: 40-42816396; Email: kai.jensen@botanik.uni-hamburg.de

HYPOTHESIS TESTING OF EVERGLADES MARSH COMMUNITY INTERACTIONS USING STRUCTURAL EQUATION MODELING

***Allison C. Shideler**, Joel C. Trexler, Evelyn E. Gaiser*
Florida International University, Miami, FL, USA

The relative importance of hydrology, nutrients, and predation on wetland community structure may vary across space and time. We used structural equation modeling (SEM), which performs simultaneous multiple regression analysis on interaction webs, to determine the relative contribution of hydrology and nutrients on densities of small fish and invertebrates collected in the Everglades, Florida, USA. Nutrient and hydrology data, as well as primary producer (periphyton) biomass and composition, primary consumer (small fish and invertebrate) abundance, and secondary consumer (larger fish and invertebrate) abundance data were collected for six years at approximately 130 sites spanning a wide range of nutrient and hydrologic conditions. In addition to comparing the effects of hydrology and nutrients, our SEM also allowed the examination of the magnitudes of important direct and indirect effects over time. We found that the relationship between some sets of variables, such as that between periphyton biomass and herbivore density, remain stable over time, while other interaction strengths exhibit strong inter-annual variation. Additionally, comparison of alternative models enabled us to evaluate specific hypotheses of interest that cannot be fully explored through experimental studies. We developed an a priori hierarchy of models to evaluate hypothesized interactions using Information theoretic methods. Although previous analysis of omnivore gut content indicated that periphyton composes a nominal percentage of diet, we hypothesized that the link between periphyton and omnivores is important. We also hypothesized that size-structured interactions among trophic levels are important pathways in shaping community dynamics. SEM results supported these hypotheses, illustrating that SEM is a useful method for evaluating community interactions.

Contact Information: Allison C. Shideler, Florida International University, 3000 NE 151 St.,North Miami, Florida, 33181, USA, Phone: 305-919-4110, Fax: 305-919-4030, Email: ashidele@fiu.edu

CHOOSING BETWEEN EVILS: MANAGEMENT DILEMMAS IN SULFUR-RICH SUBSIDING PEAT MEADOWS

***José M.H. Van Diggelen*[1]**, *Alfons J.P. Smolders*[1,2] and *Leon P.M. Lamers*[2]
[1]B-Ware Research Center, Toernooiveld 1, 6525 ED, Nijmegen, the Netherlands
[2]Radboud University Nijmegen, Heyendaalseweg 135, 6525 AJ Nijmegen, the Netherlands

In European coastal lowlands, peat meadows are intensively managed for agricultural use. Due to drainage and manure application, peat degradation is very common, leading to land subsidence and eutrophication. Especially with rising sea water levels, subsidence is an undesirable development, while eutrophication leads to very poor water quality with development of floating algae and cyanobacteria in surrounding waters.

Since 2009, a large-scale field experiment has been carried out in Dutch peat meadows to investigate the effects of land use on the interactions between terrestrial and aquatic biogeochemical processes. As the peat layers near the coast are naturally enriched in reduced sulfur, drainage and subsequent oxidation results in strong mobilization of sulfate. Sulfate becomes reduced again in deeper anaerobic peat layers or drains to the ditches, where it provokes the mobilization of iron-bound phosphate in the sediment. Over time, the oxidized top layer of the meadows becomes depleted in sulfur and carbon, and enriched in iron. Phosphorus, released from peat decomposition and applied as manure, is immobilized very efficiently in this aerobic top layer.

To alleviate undesired peat decomposition and land subsidence, surface water levels in the ditches are raised, especially in areas serving as meadow bird reserves. Increased groundwater levels in the meadows, however, result in anaerobic conditions in the iron-rich top layer, leading to strong mobilization of phosphorus due to iron reduction and to enhanced run-off of phosphate to the surface water.

Our results highlight the conservation problems for sulfur-rich peatlands. High water levels, desirable to prevent land subsidence, result in high mobility of phosphate and direct eutrophication of surface waters. Low water levels, on the other hand, mobilize sulfate which leads to indirect eutrophication. Developing good management strategies therefore seems to be very difficult for these sulfur-rich peatlands, and the implications of our results will be discussed.

Contact Information: José M.H. Van Diggelen, B-Ware Research Center, Toernooiveld 1, 6525 ED, Nijmegen, the Netherlands, Phone: +31 243652812, Email: J.vanDiggelen@b-ware.eu

THE BIOCRITERIA OF ISOLATED WETLANDS IN THE NORTH AND SOUTH CAROLINA COASTAL PLAIN

***Ross Vander Vorste*[1]**, *Virginia Baker*[1], *Dan Tufford*[2], *Warren Hankinson*[2], *Chenille Williams*[2], *Amy Keyworth*[3], *Ray Milosh*[3], *Rich Bolich*[3], *John Dorney*[4], *Rick Savage*[1], *Robert Truesdale*[5], *Breda Munoz*[5], *Kim Matthews*[5], *Frank* Obusek[6]and *Heather Preston*[7]

[1]NC Division of Water Quality, Surface Water Protection Section (DWQ), Raleigh, NC, USA
[2]USA University of SC, Columbia, SC, USA
[3]NC Division of Water Quality, Aquifer Protection Section (DWQ), Raleigh, NC, USA
[4]Atkins North America, Raleigh, NC, USA
[5]RTI International, Raleigh, NC, USA
[6]NC Center for Geographic Information and Analysis (CGIA), Ashville, NC, USA
[7]SC Department of Health and Environmental Control (DHEC), Columbia, SC, USA

Isolated wetlands in the NC and SC coastal plain are a significant ecological resource in terms of habitat, water quality, and flood control. In NC, nearly a third of all amphibian species require predator-free habitats, such as isolated wetlands, to reproduce (Braswell pers. comm., 2006). These wetlands also harbor diverse plant and macroinvertebrate communities. The US Supreme Court ruling on the Solid Waste Agency of Northern Cook County (SWANCC vs. ACOE et. al., 2001) and the Rapanoes/Carabell cases (Rapanos and Carabell vs. ACOE, 2006) have removed federal jurisdiction protecting these isolated wetlands from development. In NC, these wetlands have remained protected since 2001. However, SC only gained the authority to regulate isolated wetlands in the coastal region in February 2010 and is currently trying to move forward in the protection of them state-wide.

We conducted two studies throughout eight counties in the coastal plain region of NC and SC between 2008 and 2012. The goal of these two studies was to gain a better understanding of the landscape dispersion and size of isolated wetlands through mapping, rapid assessment using the NC Wetland Assessment Method (NCWAM, 2010), and intensive assessment of the hydrology, water quality, and biocriteria. Biocriteria sites were chosen with a stratified random selection of the NCWAM sites that resulted in high, medium, and low scores. Preliminary surveys found 11 species of amphibians, three of which are dependent on isolated wetlands to reproduce. Aquatic macroinvertebrates preliminary surveys found a total of 43 taxa from three different functional feeding guilds and four habit guilds. The majority of the taxa were predators and swimmers, corresponding to the diverse group of beetles (Coleoptera) collected. Tolerance of the macroinvertebrate community was high, likely due to the stagnant nature and semi-permanent hydrology of these wetlands. Vegetation surveys indicated the plant communities could be categorized as small depression ponds, cypress savannahs, pocosins, hardwood flats, pine flats, and non-riverine swamp forests. Further field survey and analysis will be completed for this study in 2012. Intensive biocriteria assessment results will be compared to the NCWAM to further verify and validate the method and extrapolate the results across the region.

Contact Information: Ross Vander Vorste, NC Division of Water Quality, 2321 Crabtree Blvd. Ste 250, Raleigh, NC, USA, Phone: 919-733-3176, Fax: 919-733-6893, Email: ross.vandervorste@ncdenr.gov

THE CARBON (C) : NITROGEN (N) : PHOSPHORUS (P) : POTASSIUM (K) STOICHIOMETRY OF BOREAL PEATLAND ECOSYSTEMS

Meng Wang and *Tim Moore*
McGill University, Montreal, QC, Canada

The boreal peatlands are substantial C sinks, which store *ca*. one third of global soil C. They are being impacted by high load of atmospheric N deposition mainly because of anthropogenic activities. C:N:P:K stoichiometry focuses on the balance of critical nutrients in ecological interactions and processes and provides an integrative nutrient framework linking the biogeochemical patterns at the global scale with physiological constraints that operate under cellular or organism levels. The framework allows an examination of the effect of changes, such as enriched nutrient input and global climate changes in peatland ecosystems. This study will investigate the spatial and temporal variation of leaf-level plant stoichiometry in natural and fertilized boreal peatlands and the potential interactions with pore-water hydrology and chemistry, as well as with nutrient resorption and mineralization.

Preliminary work indicated that plant growth in Mer Bleue, an ombrotrophic bog in southeastern Ontario, shifted from N, P-colimitation to only P-limitation throughout the entire growing season under high N deposition rate (*ca*. 0.8 g m^{-2} a^{-1}), and there was no evidence of K-limitation. No significant difference of leaf-level N:P ratios among four dominant plant functional types (moss, shrub, forb and graminoid) was revealed. The nutrient resorption during leaf senescence was hypothesized to be an important process that contributed to the balance of N versus P in boreal peatlands, with a higher efficiency of P resorption over N. The dominant form of N in pore-water of the unsaturated peat layer was organic (*ca*. 90%), the reminder being NO_3^- and NH_4^+. In contrast, over 50% of P was in the inorganic form (PO_4^{3-}) which was considered to be an indicator of fast turnover of P in the peat soil. Nutrient mineralization and its response to external nutrient enrichment are being examined to determine the effects of mineralization on plant stoichiometry.

Contact Information: Meng Wang, Department of Geography and Global Environmental & Climate Change Centre, McGill University, Montreal, Quebec, Canada, H3A 2K6. Phone:514-518-1238, Email: meng.wang3@mail.mcgill.ca

TURION PRODUCTION AND NUTRIENT RESERVES IN *POTAMOGETON CRISPUS* L. ARE INFLUENCED BY SEDIMENT NUTRIENT LEVEL

Dong Xie[1,2] and *Dan Yu*[2]
[1]Nanjing University, Nanjing, P.R. China
[2]Wuhan University, Wuhan, P.R. China

The influence of sediment nutrient content on asexual propagule production in plants is poorly understood, especially in submersed macrophytes. To improve the understanding of turion (an aboveground, asexual propagule) production, *Potamogeton crispus* L. was planted in two experimental conditions that differed in their levels of sediment nutrients. After ten weeks of growth, sediment nutrient level significantly impacted the plants' vegetative and reproductive traits. Most vegetative traits of *P*. *crispus* (e.g., leaf mass fraction and stem mass fraction) were higher when plants were grown in nutrient-rich sediment compared with plants grown in nutrient-poor sediment. Reproductive traits (e.g., turion mass fraction and individual turion biomass) were higher in plants grown in nutrient-poor sediment compared with plants grown in nutrient-rich sediment. Plants grown in nutrient-rich sediment produced a larger number of small turions (< 50mg) and reserved more nutrients [total nitrogen (TN) and total phosphorus (TP)] in their turions, whereas plants grown in nutrient-poor sediment produced a greater number of large turions (> 100mg) and reserved more total nonstructural carbohydrate (the major proportion of TNC was starch) in their turions. Path analysis revealed that total plant biomass (strong positive effect), leaf and stem biomass (weak negative effects) had direct effects on total turion biomass, which consequently affected turion size and number. Moreover, ramet number and mean shoot height also had weak but direct effects (both negative effects) on turion size and number. These results demonstrate that sediment nutrient content mediates plant vegetative traits and can subsequently affect turion production and reserves in *P. crispus*.

Contact Information: Dong Xie, College of Life Science, Nanjing University, Nanjing, 430072, P.R. China, Phone: +86 25 83594560, Fax: +86 25 83594560, Email: xiedong0123@gmail.com; Dan Yu, The National Field Station of Freshwater Ecosystem of Liangzi Lake, College of Life Science, Wuhan University, Wuhan, 430072, P.R. China, Phone: +86 27 68756834, Fax: +86 27 68756834.Email: yudan01@public.wh.hb.cn

EFFECTS OF SNOW LOAD AND PLANT SHADE ON THE GROWTH OF *SPHAGNUM PAPILLOSUM* IN RELATION TO WATER DEPTH IN A COOL TEMPERATE BOG IN NORTH JAPAN

K. Yabe[1] and *T. Yazaki*[2]
[1]Graduate School of Design, Sapporo City University, Sapporo, Japan
[2]NARO Hokkaido Agriculture Research Center (NARO/HARC), Memuro-cho, Kasai-gun, Hokkaido, Japan

The growth of hummock Sphagnum species in bogs depends on hydrological and climatic conditions, with different hummock morphologies being found across geographical regions.

We investigated how plant shade and winter snow load regulate the growth pattern and height of Sphagnum papillosum hummocks in a cool temperate bog in Japan. Hummocks were subjected to 4 treatments across 2 years (1 hummock per treatment per year): no treatment (control), snow-load free (S), vascular-plant trimming (T), and snow-load free and vascular plant trimming in combination (S&T). Further, the effects of vascular plant cover and snow load were examined with respect to the linear growth and hummock height of Sphagnum.

Annual growth rates of S. papillosum were higher for the control (34−41 mm) than S&T treatment, and were intermediate for separate S and T treatments. In contrast to untrimmed hummocks, trimmed hummocks showed a negative correlation between water depth (measured from the capitulum to the water table) and growth. Hence, in summer, shading by vascular plants may prevent desiccation and facilitate the growth of Sphagnum.

Snow-loaded hummocks were weighed down by 3−11 cm. After snowmelt, the shoots continued to grow within the water depth range that allowed growth. Hence, heavy winter snow loads may depress the surfaces of hummocks closer to the water table, which stimulates Sphagnum growth, resulting in the recovery of hummock height.

Thus, the water stress caused by summer desiccation is critical in regulating the upper limit of hummock height in bogs subject to dry summer conditions and heavy winter snowfall.

Contact Information: Kazuo Yabe, Graduate School of Design, Sapporo City University, 1 Geijutsu-no-mori, Minami-ku, Sapporo 005-0864, JAPAN, Phone: +81-11-592-2300, Fax: +81-11-592-2614, Email: K.yabe@scu.ac.jp

WETLAND ECOSYSTEMS PROCESSES & FUNCTIONS - HYDROLOGIC PROCESSES

LONG TERM ECOLOGICAL RESEARCH IN THE UPPER PARANÁ RIVER FLOODPLAIN, BRAZIL: MAIN PATTERNS AND VARIATIONS.

Angelo Antonio Agostinho*, Luiz Carlos Gomes, Horácio Ferreira Júlio J* and *Sidinei Magela Thomaz*
Universidade Estadual de Maringá, Brasil

The flood regime is considered the most important force in determining seasonality in river-floodplain systems. Floods usually promote pulses of nutrients and supply floodable areas with minerals, increasing productivity. The population dynamic and life cycle of the biota in the floodplain also depends on the flood pulse. However, dams may alter the hydrological cycle downstream, with impacts on the biota. In the upper Paraná River, there are more than 150 large reservoirs, with only one relevant lotic stretch (230 km). In this stretch there is an extensive floodplain and large tributaries still not dammed, where is located the Site 6 of the Brazilian Long Term Ecological Research (PELD). Based on data collected since 1986 (1986-1988; 1992-1995; 2000-2010), we evaluated the downstream impacts of dams on the floodplain located immediately below Porto Primavera Dam, to answer the following questions: i) what are the main impacts caused by the cascade of dams upstream the plain? ii) which are the main ecosystem function affected? iii) which is the possible framework to serve as basis for conservation of the area? To achieve proposed goals, we analyzed several abiotic (discharge, nutrients, sediments and Secchi depth) and biotic (chlorophyll, phytoplankton, zooplankton, periphyton, benthos, macrophytes and fish) variables. Redistribution of the seasonal discharge promoted by dams provoked losses in floodable area and altered connectivity among the plain components. These alterations, along with reduction in nutrients and sediments (increased Secchi depth), impacted all components of the plain, including losses in productivity, proliferation of submerse macrophytes and visual predators, especially non-native species (*Hydrilla* and *Cichla* spp). In addition, alterations in the timing of floods influenced the structure of fish assemblages, particularly the long distance migratory ones. Years under the influence of El Ñino still allow more spaced rhythms of floods that favor survival of several species already sporadic upstream in the basin Data obtained during the last decades pointed out that the conservation of the area should restore connectivity by reestablishing the hydrological cycles. Therefore, ecohydrology is a potential theoretical framework to serve as basis for conservation of the area. Proper water quantity during appropriate timing may be the hydrological solution to reestablish ecosystem functions, bringing environmental and socio-economic benefits to the biota and to people who live in the last stretch of the Paraná River with running water.

<u>Contact Information</u>: Angelo Antoniom, Agostinho, Universidade Estadual de Maringá, Av Colombo, 5790 - Bl H90, Maringá, 87020-900, Brazil, Phone: 554430114610, Email: agostinhoaa@nupelia.uem.br

ESTIMATION OF DEPRESSION STORAGE ON WETLAND WATERSHEDS

***Devendra M. Amatya*[1]**, *Joseph K.O. Amoah*[2]
[1]Center for Forested Wetlands Research, USDA Forest Service, Cordesville, SC, USA
[2]Department of Civil and Environmental Engineering, Florida A&M University, Tallahassee, FL, USA

Spatial distribution and quantity of surface depressions perform functions that alter the hydrology, habitat, water quality, plant communities, and biogeochemical processes in a wetland watershed. Traditionally, depression storage is determined through model calibration or lumped with soil storage components. This paper investigates a holistic approach for estimating surface depressional storage capacity (DSC) in watersheds using digital elevation models (DEM). The methodology includes implementing a lumped depressional storage capacity (LDSC) model and a distributed depression storage capacity (DDSC) model to extract geometric properties of storage elements from DEMs of varying grid resolutions, and then employing a criterion to determine representative DSC. The LDSC model is developed for a single watershed, while the DDSC model is applied to several delineated subwatersheds within a watershed. DSC is quantified on six relatively flat coastal plain watersheds with land slopes less than 0.4%. Brute Force optimization method is used to verify estimated DSC by calibrating DRAINMOD, a lumped-parameter hydrologic model, with observed streamflow and water table depth for wet and dry periods. For the wet periods, the differences between calibrated DSC and LDSC model estimated DSC values were within 50%, but deviations were much higher during dry periods. Simulation results showed that DSC values obtained using Brute Force optimization procedure are dependent on climatology while those estimated through techniques developed in this study are independent of seasonal variation of climatological data. Established methodology was extended to directly quantify DSC in subwatersheds, and the values applied to DRAINWAT, a distributed-parameter, watershed-scale hydrologic model to simulate streamflow. Flow comparison suggests good agreement between observed and simulated monthly streamflow for wet periods while performing satisfactorily for dry periods. The techniques developed herein are useful for investigating quantitative as well as qualitative effect of depressional storage changes on wetland ecosystems.

Contact Information: D. M. Amatya, Center for Forested Wetlands Research, USDA Forest Service Southern Research Station, 3734 Highway 402, Cordesville, SC 29434 USA, Phone: 843-336-5612, Fax: 843-336-5068, Email: damatya@fs.fed.us

WATER TABLE DYNAMICS OF HYDRIC SOILS IN THE LOWER COASTAL PLAIN OF SOUTH CAROLINA

Devendra M Amatya and *Carl C Trettin*
USDA Forest Service, Cordesville, SC

Sustainable protection, restoration, and management of forested wetlands and their functions require an accurate understanding of hydrologic processes including the water table dynamics of the hydric soils. Seasonal water table dynamics of forested wetlands on shallow, poorly drained soils of the coastal plain are driven by rainfall and evapotranspiration. However, understanding the water table dynamics for a given area generally requires a long period of water table record. This presentation evaluates nine years (2003-11) of continuous water table record on the poorly-drained Wahee soil occurring in a 1st order watershed (WS80) at Santee Experimental Forest and five and half years (2006-11) of record on four soil types (Lenoir, Goldsboro, Rains, and Lynchburg) varying from poorly to moderately well drained occurring in a 3rd order watershed (WS78). Elevations of these wells varied from approximately 6 - 12 m a.m,s.l. The vegetation at the location of these wells on the *Ultisol* soil order was primarily longleaf (*Pinus palustris)* and loblolly pine (*Pinus taeda L.*) stands. The study period included a very dry year with less than 1000 mm of rain in 2007 when water table dropped to a depth of 2.9 m in mid-October to a very wet year with more than 1600 mm rain in 2003 when the water table on WS80 with Wahee soil was frequently ponded or near the surface.
Results showed the water table depth varying widely as affected by soil type and climate. Among the soils, the Goldsboro (moderately well-drained) had the deepest water table (2.4 m) in contrast to the Lenoir (poorly-drained) had a water table at 1.3 m depth during summer (August) of 2006 and 2007. Similarly, while water table frequently ponded on the Rains soil it never reached above 30 cm on the Goldsboro soil. Analysis of water table frequency duration curves showed the water table staying within 30 cm depth for 14 consecutive days in March of all years, except the moderately well drained Goldsboro soil, which is non-hydric. Using these records, seasonal mean water table depths and periods of water within 30 cm depth during the growing seasons and whole year at all wells were also calculated to assess the effects of seasonal climatic variation. The long-term data being continuously collected at these relatively undisturbed forested watersheds can serve as a reference for wetland hydrology criteria, vegetation and habitat management, flood plain analysis, and for designing BMPs on developed lands. Since long-term monitoring is often cost-prohibitive, these data can also be used for calibration and validation of hydrologic models such as MIKESHE, DRAINMOD, which are often applied to evaluate long term wetland hydrologic status and associated functions as affected by the soil, topography, vegetation and climatic variation.

Contact Information: Devendra Amatya, USDA Forest Service Center for Forested Wetlands Research, 3734 Highway 402, Cordesville, SC 29434, USA, Phone: 843-336-5612; Fax: 843-336-5068, Email: damatya@fs.fed.us

WATER RESIDENCE TIME AND NITROGEN LOSS IN A LOUISIANA DELTA: A MODELING APPROACH

***Ben L. Branoff*[1]**, *Robert R. Twilley*[2], *Victor H. Rivera-Monroy*[1], *Edward Castañeda-Moya*[1], *Azure E. Bevington*[1] and *Kelly M. Henry*[1]

[1]Department of Oceanography and Coastal Science, Louisiana State University, Baton Rouge, LA, USA
[2]University of Louisiana at Lafayette, Lafayette, LA, USA

Highly eutrophic conditions in the Mississippi River and its distributaries have been cited as the primary cause of a large hypoxic "dead" zone off of Louisiana's coast in the Gulf of Mexico. Elevated nitrate concentrations in the river (>100uM) coupled with river engineering and rapidly subsiding coastal wetlands, have become major forces controlling ecosystem function and structure over the past two decades. To alleviate this ongoing loss of natural wetland resources as well as the offshore hypoxic condition, large scale freshwater diversions have been proposed to create active deltaic regions where land and wetlands are built by the riverine sediments. One such delta became sub aerial in the 1970's at the Wax Lake Outlet and continues to expand as a result of a Mississippi River diversion. Although nitrogen removal has been observed in the system, the relative role of the different ecosystem components in this removal is yet to be fully determined. A model of nitrogen cycling in this system will be potentially useful in determining the relative importance of deltaic characteristics to the fate of various nitrogenous compounds. By incorporating the measured physical, chemical and biological processes, such a model has been constructed to represent the nitrogen cycle in the prograding deltaic wetlands of the Wax Lake outlet. The model has been calibrated to simulate field measurements of nitrogen storages and transformation rates along strategic transects and throughout an annual cycle. Modifying key variables in the model, such as water residence time, has significant effects on the loss of nitrate and other nitrogen fluxes at the surface of the wetland-water interface. These processes have implications to efficiency of nitrogen loss in developing deltaic coastal wetland environments.

Contact Information: Ben Branoff, Louisiana State University, 3237 Energy Coast and Environment Building, Baton Rouge, LA 70803, USA, Phone: 386-506-7997, Email: bbrano1@tigers.lsu.edu

RELATING HYDROLOGY TO WETLAND PLANT COMMUNITY DISTRIBUTION

Peter V. Caldwell[1], *Michael J. Vepraskas*[2], *James D. Gregory*[2], *R. Wayne Skaggs*[2] and *Rodney L. Huffman*[2]

[1]USDA Forest Service, Raleigh, NC, USA

[2]North Carolina State University, Raleigh, NC, USA

Hydrology is often considered the most important element of wetland restoration because it drives vegetative community composition and controls important wetland functions such as denitrification and carbon sequestration. As a result, understanding the relationship between hydrology and vegetation is critical for the success of wetland restoration projects. Unfortunately, there are few long-term datasets available with which to quantify this relationship because collecting these data is a time consuming and expensive undertaking. In this paper, we show how hydrologic models may be used to estimate the long-term hydrology associated with a variety of wetland vegetative communities, and we quantify key differences between several communities commonly found in the Atlantic Coastal Plain, USA.

Our study sites were in Pond Pine Woodland, Nonriverine Swamp Forest, High Pocosin, and Bay Forest communities located in three undisturbed Carolina Bay wetlands in Bladen County, NC. We measured soil physical properties and collected water table and weather data over a two year period to parameterize and calibrate DRAINMOD hydrologic models for 14 plots distributed among these communities. We then forced these models with 40 years of historic weather data to generate estimated long-term water table hydrographs for each plot, and compared hydrographs among the four vegetative communities. We found that the long-term median water level was 8 cm below the land surface in plots supporting Pond Pine Woodland and 9, 2, and 8 cm above the land surface for those supporting Nonriverine Swamp Forest, High Pocosin, and Bay Forest, respectively. When the land surface was inundated, the median duration of inundation was 91 d year^{-1} for plots supporting Pond Pine Woodland and 317, 243, and 307 d year^{-1} for Nonriverine Swamp Forest, High Pocosin, and Bay Forest, respectively. Our models suggested that plots supporting Pond Pine Woodland received an average of 15% of their water input from groundwater inflow, whereas the other communities we modeled did not appear to receive groundwater inflow.

The results of our study support the notion that hydrology is a key driver in wetland vegetative community distribution, and illustrate the utility of hydrologic models, when calibrated for site-specific soil and landscape conditions, to serve as important tools for cost effectively estimating long term plant-hydrology relationships. While our study investigated a small number of communities in a specific geographical area, this methodology can be further refined and used to quantify the hydrology of other wetland communities.

Contact Information: Peter V. Caldwell, Eastern Forest Environmental Threat Assessment Center, USDA Forest Service, Raleigh, NC 27606, USA, Phone:919-515-1560, Fax:919-513-2978, Email: pcaldwell02@fs.fed.us

EVALUATING METHODS FOR DETERMINING WHETHER A SITE MEETS WETLAND HYDROLOGY CRITERIA

George M. Chescheir and *R. Wayne Skaggs*
North Carolina State University, Raleigh, NC, USA

Determining whether or not a given site meets wetland hydrology criteria can be a difficult and expensive task. Especially if recent activities on or near the site have changed the hydrology. Current wetland hydrologic criteria are defined in terms of a specified amount of time the water table is within a specified distance from the soil surface during a specified growing season. Methods for determining wetland hydrology, therefore, involve continuous monitoring of the water table for a period of time. Due to the variability of rainfall, the length of the monitoring period becomes an issue: the longer the period, the better the quality of the determination, but also, the greater the cost of the determination. Methods are being used to make determinations about wetland hydrology with short term monitoring data, but these methods need more evaluation in terms of their accuracy and the amount of data needed to make accurate determinations. The objective of this study is to use long-term data sets and computer model simulations to evaluate the accuracy and limitations of methods for determining whether or not a site meets wetland criteria.

The methods evaluated in this study are the Threshold Wetland Simulation (TWS) method, and the US Army Corp of Engineers Technical Standard for short-term water table analysis using the Direct Antecedent Rainfall Evaluation Method (DAREM) and a modified version of the DAREM. The TWS method involves comparing observed water table depths to those simulated by a model (DRAINMOD in this case) for a site on the threshold between wetland and upland conditions. The Technical Standard using DAREM identifies periods in the observed water table that meet wetland conditions and then determines if the antecedent rainfall is within a normal range. The methods are evaluated using data from nine field sites in eastern North Carolina with three to six years of continuous water table and on-site rainfall records. The sites represent three wet sites, three dry sites and three marginal sites. Each method is used with data from monitoring periods of 6 months, 1 year and 2 years to determine the hydrologic status of each site. The results of the methods are evaluated relative to a more rigorous determination of the wetland status. The more rigorous determination involves calibration of the DRAINMOD model to the entire observed water table data set for a site and then using the calibrated model to simulate the site over 40 years of weather record. This long-term simulation allows for an accounting of the number of years that the site meets wetland criteria in a 40 year period. Performances of the short-term methods are evaluated in terms of correct determinations, false positives, false negatives, and periods when determinations cannot be made. The amount of monitoring data needed for each method to perform well is also evaluated. The results of this study will give decision makers a better understanding of the accuracy and limitations of methods for determining whether or not a site meets wetland criteria.

Contact Information: George M. Chescheir, Department of Biological and Agricultural Engineering, North Carolina State University, PO Box 7625, Raleigh, NC 27695-7625, USA, Phone:919-515-6741, FAX:919-515-7760, Email: cheschei@ncsu.edu

CONNECTIVITY OF EVERGLADES LANDSCAPES (CEL): A TOOL FOR RELATING CHANGING FLOW CONDITIONS TO FUNCTIONAL QUALITY OF EVERGLADES LANDSCAPES

Jay Choi[1], *Laurel Larsen*[1], *Martha Nungesser*[2], *Katherine Skalak*[1] and *Jud Harvey*[1]

[1]U.S. Geological Survey, Reston, VA, USA

[2]South Florida Water Management District, West Palm Beach, Fl, USA

The patterned landscape of the Everglades with its self-organized ridges and sloughs that formed parallel to flow is valued for maximizing hydrologic connectivity and small-scall topographic variability in this floodplain ecosystem. Connectivity and microtopography are directly related to functional quality of the Everglades ecosystem through contributions to sustaining variable water depths that support diverse plant communities, while maintaining open, well connected sloughs for fish migration and high quality feeding habitat for wading birds. Man's alteration of flow due to structural modifications over the past century, e.g. canals, levees and pump stations, has substantially altered the direction ground surface slope (due to subsidence) and altered peat accretion rates as well as flow velocity. Extensive loss of landscape patterning also occurred in the past century, although at present there are few broadly integrated assessments of landscape pattern loss and how it has affected the integrity and function of the ridge and slough landscape. Here we use Everglades Depth Estimation Network (EDEN) station data and new connectivity metrics (Larsen et al., submitted) to examine the relation between flow direction, water-surface gradients, and ridge and slough landscape pattern alignment. We compare present-day conditions with past changes in hydrologic connectivity that occurred between 1940 and 2004. The greatest decreases in hydrologic connectivity over the past seventy years coincide with the greatest mismatches between present-day landscape pattern alignment and present-day flow directions. We plan to provide outcomes in a widely available and user friendly computer format for use by scientists and managers engaged in prioritizing specific hydrologic restoration actions for the Everglades.

Contact Information: Jay Choi, National Research Program, U.S. Geological Survey, MS430, National Center, Reston, VA 20192, USA, Phone:703-648-5437, Fax:703-648-5484, Email: jchoi@usgs.gov

DEVELOPMENT OF A FLOODPLAIN CONNECTIVITY METRIC FOR THE IMPROVEMENT OF NUTRIENT FLUX MODELING IN MONITORED STREAM NETWORKS

Durelle T. Scott and ***Daniel D. Chuquin***
Virginia Polytechnic Institute and State University, Blacksburg, VA, USA

Excess nutrient delivery to downstream water bodies (e.g. Gulf of Mexico, Chesapeake Bay) results in hypoxic zones and degradation of water quality in estuaries across the globe. Spatially variable sources and landscape/river factors are used to predict nutrient fluxes through river networks. This study explores the role of floodplains as nutrient sinks within river networks. When floodwater is transported into a floodplain, water Contact with the floodplain sediments can promote both phosphorus sedimentation and nitrate denitrification. One approach to test the importance of floodplain inundation within rivers networks is through SPARROW, a USGS model. Our first objective here is to calculate a spatially varying factor that incorporates floodplain exchange and residence time for stream reaches throughout a river network. The floodplain metric is being developed through geospatial analysis of river floodplain topography and long-term USGS stream gaging stations. We are testing our procedures within watersheds in the southeastern and Mid-Atlantic region of the United States. Our second objective is to incorporate the floodplain metric into SPARROW models of the Chesapeake Bay and southeastern region to test the statistical significance of floodplain connectivity on explaining nitrogen and phosphorus loads.

Contact Information: Daniel D. Chuquin, Department of Biological Systems Engineering, 200 Seitz Hall, Virginia Tech, Blacksburg VA, 24061, USA, Phone:757-710-0857, Email: dchuquin@vt.edu

DEVELOPMENT OF SUB-AREA SURFACE-WATER MODELS WITHIN THE EVERGLADES DEPTH ESTIMATION NETWORK (EDEN) MODEL DOMAIN

Paul A. Conrads[1], *Zhixiao Xie*[2], *Bryan J. McCloskey*[3] and *Pamela Telis*[4]
[1]USGS South Carolina Water Science Center, Columbia, SC, USA
[2]Florida Atlantic University, Boca Raton, FL, USA
[3]USGS, St. Petersburg Science Center, St. Petersburg, FL, USA
[4]USGS Florida Water Science Center, Jacksonville, FL, USA

The Everglades Depth Estimation Network (EDEN) has provided principal investigators and water-resource managers water-depth and water-surface maps of the freshwater portion of the Florida Everglades since 2006. Often an investigator or manager only has a particular interest in a specific location within the Everglades such as one of the Water Conservation Areas (WCAs) or Everglades National Park (ENP). The development and use of sub-area (or sub-domain) models, rather than the monolithic EDEN model encompassing the entire freshwater domain of the Everglades, offers some advantages. These advantages include: the elimination of the need to model water-level discontinuities between sub-basins; the improvement of marsh water-level prediction near canals because of elimination of virtual "pseudo" gages used to model water-level discontinuities; a more computationally efficient model architecture for evaluating and testing aspects of the surface-water model; the facilitation of the development of new EDEN hydrologic data and analysis applications using a subset of the 240 gages of the full EDEN; and, smaller output data file sizes for analysis of a particular area of interest.

Subarea models have been developed and used in the current (2012) EDEN V2 model for WCA1, WCA2B, WCA3B, and Pennsuco Wetlands. An experimental subarea model also was developed for WCA3A-South. The five subarea models have improved performance statistics as compared to the monolithic EDEN V1 model. For the WCA1, WCA2B, and WCA3B subarea models the root mean squared error of water-level estimates of independent benchmarks was reduced by 0.2, 0.54, and 9.15 centimeters (cm), respectively. The WCA3A-South sub-area model had a lower cross-validation root mean squared error as compared to the EDEN V1 model (13.74 and 39.75 cm, respectively) and a lower mean error (0.12 and 0.33 cm, respectively). The poster presentation will describe the development of the subarea models and the current (Spring 2012) status of the subarea models and their applications.

<u>Contact Information</u>: Paul A. Conrads, USGS South Carolina Water Science Center, Stephenson Center – Suite 129, 720 Gracern Road, Columbia SC, 29210, USA, Phone: 803-750-6140, Fax: 803-750-6181, Email: pconrads@usgs.gov

QUANTIFY HOW STAGE VARIABILITY AFFECTS PLANT SPECIES POPULATIONS USING PALEOECOLOGICAL AND HYDROLOGICAL TIME SERIES DATA

Paul A. Conrads[1], *Edwin A. Roehl Jr.*[2] and *Christopher Bernhardt*[3]
[1]U.S. Geological Survey, Columbia, SC
[2]Advanced Data Mining Services, LLC, Greer, SC
[3]U.S. Geological Survey, Reston, VA

Intact soil cores from Everglades' marshes provide valuable data on historical changes in vegetation and hydrologic conditions. We developed empirical models to quantify the historical effect of meteorological and hydrologic forcing on plant species compositions in the Loxahatchee National Wildlife Refuge (LNWR) for a 110-year period ending in 2011. Empirical models that predict plant species distributions at sites within LNWR were developed by linking temporally sparse seed bank data from soil cores with continuous multi-decadal daily meteorological and hydrologic time series data. The meteorological data included rainfall and maximum daily temperatures that spanned the entire study period. The hydrologic data included stage data from two gages in the LNWR established in1954. These stage data were hindcasted to be concurrent with the meteorological data by using correlation models that fit measured stages as a function of the meteorological parameters. The historical plant species data came from seven peat cores from the LNWR. Different depths from each core were carbon-dated and assayed for relative percentages of 83 plant species using pollen counts. The oldest dates were more than 1,000 years old; however, only core data that overlapped the study period were used, for a total of 67 assays among the seven cores. Twenty-three of the species had ratios of at least 5 percent for one or more of the 67 assays, hereafter referred to as the "top23".

Using the assays as input vectors, the top23 were grouped using the k-means clustering into four plant classes that represented the extent to which the various species have historically appeared together. This reduced the modeling problem to one of predicting the relative ratios of the four plant classes from the hindcasted stage time-series data. A separate empirical model was developed for each class using a multi-layer perceptron artificial neural network, which provides multivariate, nonlinear curve fitting. The models predicted the relative ratios of the classes and the sums of the predictions are near 1. The coefficient of determination (R^2) of the models varied from 0.87 to 0.96, indicating that the relative ratios of the plant classes are predictable, and therefore controllable, from stage forcing. The presentation will describe the development of the models and their potential use to evaluate the effect of alternative stage management practices on plant distribution.

Contact Information: Paul A. Conrads, USGS South Carolina Water Science Center, Stephenson Center – Suite 129, 720 Gracern Road, Columbia SC, 29210, USA, Phone:803.750.6140, Fax:803.750.6181, Email: pconrads@usgs.gov

TOWARDS AN INDEX OF HYDROLOGICAL INTEGRITY FOR WETLAND DOMINATED LANDSCAPES

Irena F. Creed[1]*, Suzanne Bayley*[2]*, Adam Spargo*[1] and *David Aldred*[1]
[1]University of Western Ontario, London, ON, Canada
[2]University of Alberta, Edmonton, ON, Canada

Wetlands are being lost at an alarming rate throughout North America due to development. The full value of the consequence of this loss is not fully understood or recognized due to 1) inadequate or incomplete wetland inventories (only mapping permanent and not ephemeral wetlands, and only capturing "easy to observe" wetland area defined by open water and not the true dynamic wetland extent defined by saturated soils), and (2) a lack of appropriate indicators to assess the hydrological and ecological integrity (health, function, and value) of these wetlands. While techniques and tools are emerging to assess some aspects of wetland health (e.g., indicators of ecological integrity, with an emphasis on biodiversity), the hydrological aspect of wetland health (i.e., indicators of hydrologic integrity) requires a deeper understanding and this can be accomplished using a theoretical framework coupled with technical approaches.

We propose a framework for conservation of hydrological integrity of wetlands. The framework consists of a set of hydrological principles for ensuring hydrological integrity of wetland dominated landscapes. While some of these principles may be widely recognized, their implementation is often not comprehensive or complete. The hydrological principles include (1) delineating hydrological system boundaries by considering the entire hydrological system within which management actions take place; (2) conserving critical hydrological features (flood and pollution control potential); (3) maintaining hydrological connectivity; (4) respecting temporal variability (acknowledging historic factors that influence hydrological processes); (5) respecting spatial heterogeneity (acknowledging geographic factors that influence hydrological processes); and (6) maintaining redundancy and diversity of hydrological processes, which contributes to a resilient wetland ecosystem. From these six principles we derive an index of hydrological integrity.

We then showcase this approach by fusing GIS and digital terrain analysis with optical and radar remote sensing techniques for measuring and monitoring metrics that reflect these hydrological principles. For a regional watershed in the prairie pothole landscape of central North America, individual metrics are identified for each wetland within the landscape; these metrics are then combined to estimate indicators of hydrological integrity for each wetland; and finally, the hydrological integrity for the entire hydrological system is determined by combining the values of all wetlands within each hydrological system. The importance of structural and functional connectivity of wetlands within the landscape are then showcased by scenario analysis, demonstrating how wetland loss in one area may affect the hydrological function of the entire landscape by considering development-mediated feedbacks to the integrity of the entire hydrological system.

This work reflects a scientific journey of "enlightenment" over the past five years, and we seek critical comments from wetland scientists, managers and decision makers so that we can work towards a framework for assessing hydrological integrity of wetland ecosystems based on consensus within the scientific community.

<u>Contact Information</u>: Irena F. Creed, Department of Biology, The University of Western Ontario, London, Ontario, Canada, N6A 5B7, Phone: 519-661-4265, Fax: 519-661-3935, Email: icreed@uwo.ca

APPLICATION OF THE MIKE SHE MODEL TO ASSESS THE HYDROLOGIC CRITERIA FOR DEFINING WETLANDS IN THE LOWER COASTAL PLAIN

***Z. Dai*[1]**, *D. Amatya*[2] and *C.C. Trettin*[2]
[1]University of New Hampshire, Durham, NH, USA
[2]SDA Forest Service, Cordesville, SC, USA

Jurisdictional wetlands are defined in part by the presence of specified hydrologic conditions that occur during the growing season. Proposed changes to the growing season specification for the wetland hydrology criteria could affect the extent and distribution of jurisdictional wetlands. Given the paucity of data to assess the ramifications associated with changes to the wetland criteria, the application of hydrologic models offers the capability to simulate such effects. In the southeastern U.S., the majority of the wetlands occur in the coastal plain, a region characterized by very low relief and shallow water table soils. Accordingly, simulating the hydrology of coastal plain watersheds can be difficult because of the low topographic gradient where surface and subsurface water interaction becomes a critical factor. MIKE SHE is a physically-based, spatially distributed hydrologic model that is capable of addressing such interactions; we applied it to a gauged forested watershed in the lower coastal plain of South Carolina that contains a mosaic of uplands and wetlands. The calibrated model showed that it was effective for simulating both the daily stream flow and water table dynamics including the the uncertainty bounds associated with input parameters for this type of watershed. Predictions of daily stream flow and water table depth within the watershed had model efficiency rating (E) ranging from 0.84-0.98, well above the threshold of 0.75, the rating of “very good”. Accordingly, MIKE SHE should be an effective tool for assessing how changes in the hydro-meteorologic criteria affect the distribution of jurisdictional wetlands within the watershed. Here we present results of simulations assessing the effect of changing the growing season from the 28°F date criteria to the proposed 365 days criteria. The simulation results are validated against 5 years of measured daily water table data from wells along a transect from the upland into the bottomland hardwood swamp on the study watershed. The ability to validate model simulations with long-term field data offers the opportunity to consider the applicability of using models as a basis for assessing the effects of change in wetland hydrologic criteria using long-term climatological and watershed records.

Contact Information: Zhaohua Dai, USDA Forest Service, 3734 Hwy 402, Cordesville, SC 29434, USA, Phone: 843-336-5606, Email:zdai@fs.fed.us

HYDRO-BIOGEOCHEMICAL AND ENVIRONMENTAL-MANAGEMENT FUNCTIONS OF WETLAND NETWORKS IN LANDSCAPES

Georgia Destouni[1,2], *Nandita Basu*[3], *Matthew J. Cohen*[4], *Helen Dahlke*[1], *Fernando Jaramillo*[1], *Jerker Jarsjö*[1], *James W. Jawitz*[4], *John Juston*[5], *Elin M. Karlsson*[6], *Antonis D. Koussis*[7], *Steve Lyon*[1,2], *Katerina Mazi*[1,2,7], *Johanna Mård-Karlsson*[1], *Carmen Prieto*[1,2], *Suresh C. Rao*[6], *Ype van der Velde*[1] and *Nikki Vercauteren*[1]

[1]Stockholm University, Stockholm, Sweden
[2]Navarino Environmental Observatory (NEO), Messinia, Greece
[3]University of Iowa, Iowa City, Iowa, USA
[4]University of Florida, Gainesville, Florida, USA
[5]Royal Institute of Technology, Stockholm, Sweden
[6]Purdue University, West Lafayette, Indiana, USA
[7]National Observatory of Athens, Athens, Greece

A main application goal of ecohydrological science is to amplify opportunities of achieving water quality improvements, biodiversity enhancements and sustainable development, by improved understanding and use of ecosystem properties as a management tool. This paper draws on and synthesizes main result implications for the function and possible enhanced use of wetland networks in the landscape as such a tool, from a series of hydro-biogeochemical and environmental economics studies of nutrient/pollutant loading and abatement in different Swedish hydrological catchments. Results show large potential of wetland networks to reduce the cost of abating nutrient and metal loads within and from hydrological catchments, and emphasize some main research questions for further investigations of actual possibilities to realize this potential. The questions regard in particular the ability of wetland networks to extend the travel times and reduce the uncertainty of hydrological nutrient/pollutant transport through catchments.

The paper further presents and discusses some main joint conclusions of the participants in a recently held International Workshop on Ecohydrology and Integrated Water Resource Management (1) at the Navarino Environmental Observatory in Messinia, Greece (2), regarding essential goals for collaborative international efforts in wetland network research. The goals include to investigate on different spatiotemporal scales and in different world regions: a) the dynamics of natural and managed wetland networks across a gradient of different climate, human disturbance, energy and organization conditions; b) the reciprocal interactions between wetland networks and associated hydrological catchments; c) how climate change and different human activities in the wetland network catchments influence these interactions (in b) and generally the ecohydrology of individual wetlands and the whole wetland networks; and d) the ecosystem services provided by networks of wetlands.

(1) http://navarinoneo.geo.su.se/index.php/en/past-events/91-ecohydrology-and-integrated-waterresource-management-workshop
(2) http://navarinoneo.geo.su.se/index.php/en/

Contact Information: Georgia Destouni, Department of Physical Geography and Quaternary Geology, Stockholm University, SE-106 91 Stockholm, Sweden. Phone: +46 8 16 4785, Email: georgia.destouni@natgeo.su.se

WATERSHED-SCALE EFFECTS OF ISOLATED WETLANDS ON DOWNSTREAM HYDROLOGY: MODELING APPROACHES

Heather E. Golden[1], *Heather A. Sander*[2], *Charles R. Lane*[1], *Katie Price*[3] and *Ellen D'Amico*[4]

[1]US Environmental Protection Agency, Office of Research and Development, Ecological Exposure Research Division, Cincinnati, OH, USA

[2]University of Iowa, Department of Geography, Iowa City, IA, USA

[3]S Environmental Protection Agency, Office of Research and Development, Ecosystems Research Division, Athens, GA, USA

[4]Dynamac Corporation, Cincinnati, OH, USA

Geographically Isolated Wetlands (GIWs) are depressional features on an eroding landscape that are entirely surrounded by uplands. These wetlands are purported to provide an array of ecological and watershed values and functions, including increasing biodiversity, modifying watershed biogeochemical cycling, and water storage and recharge. The 2001 Solid Waste Agency of Northern Cook County (SWANCC) vs. the US Army Corps of Engineers ruling by the US Supreme Court limited the protection of GIWS under the Clean Water Act (CWA). The subsequent 2006 Rapanos vs. United States decision suggested that GIWs could be afforded increased CWA protection if a *significant nexus* between GIWs and navigable downstream waters could be identified. This ruling unveiled a key area of research for informing policy and decision-making: the development of approaches to determine whether a hydrological, chemical, or biological significant nexus exists between GIWs and navigable waters. However, due to the recentness of this decision, approaches for determining whether such connections between GIWs and downstream waters remain limited.

Models are critical tools for assessing the hydrologic connectivity of GIWS to surface and ground water systems and evaluating the effect of GIWs on downstream hydrologic functions. Herein we detail an empirical approach to examine whether hydrologic connectivity between isolated wetland complexes and downstream hydrology exists and how this potential connectivity may affect downstream watershed hydrology. We use simulated streamflow data from the Soil and Water Assessment Tool (SWAT) for over 500 subbasins in the Neuse River Watershed of North Carolina, USA, and an array of landscape metrics derived from spatial data sets, including those associated with GIWs, land cover, and soils. These variables are used to assess the statistical relationships between streamflow and multiple landscape parameters to determine whether those parameters associated with GIWs are related to streamflow variability. We provide preliminary findings from this empirical modeling approach and explore potential mechanistic modeling approaches that could assist in determining hydrological connections between GIWs and navigable waters. This work provides supportive science, via hydrological modeling approaches, towards identifying a significant nexus between GIWs and downstream navigable waters.

Contact Information: Heather Golden, Office of Research and Development, National Exposure Research Laboratory, Ecological Exposure Research Division, 26 W. Martin Luther King Drive, MS-579, Cincinnati, OH 45268, USA, Phone: 513-569-7773; Email: golden.heather@epa.gov

FIELD FLUMES TO FLOODPLAINS: REVEALING THE INFLUENCE OF FLOW DYNAMICS AND FLOOD PULSES IN STRUCTURING RIVER AND WETLAND ECOSYSTEMS

***Jud Harvey**, Laurel Larsen* and *Katherine Skalak*
U.S. Geological Survey, MS430, National Center, Reston, VA

As a predictive science, hydroecology often has focused on static processes occurring during steady baseflow in rivers and wetlands. However, decades of research have demonstrated the role of flood dynamics in modulating physical-biological interactions that have wide-ranging implications for managing lotic ecosystems in urban and agricultural areas, grazing lands, and in forested watersheds. As a means to understand the role of flow dynamics, researchers are increasingly moving towards study designs that explicitly address natural floods or experimentally altered flows in streams. Studies often focus on both dissolved and fine particulate materials, their redistribution by storm flow, and physical effects of bedform migration, and expansion and contraction of naturally occurring storage zones in the channel, in the hyporheic zone beneath the streambed surface, and on the floodplain. In this framework investigators are seeking not only to identify the factors causing “hot spots” of biogeochemical transformation in streams, but also the “hot moments” related to flow variation and its interactions with geomorphic, sediment, and solute dynamics. Examples illustrating these advancements come from hydraulic studies that simultaneously address solute and sediment dynamics and retention, as well as the longer term co-evolution of pulsed flow and geomorphic and vegetative feedbacks. The relation between flow dynamics and ecosystem services also is examined. From the perspective of ecosystem services, desirable outcomes include enhancement of processes that remove contaminants and excessive levels of nutrients from flowing waters into long term storage, as well as hydrogeomorphic processes that contribute to self-sustaining aquatic ecosystems that support healthy food webs and are resilient to floods and droughts.

Contact Information: Jud Harvey, National Research Program, U.S. Geological Survey, MS430, National Center, Reston, VA 20192, USA, Phone: 703-648-5876, Fax: 703-648-5484, Email: jwharvey@usgs.gov

MILLENNIAL PRE-SETTLEMENT STABILITY OF SEDGE MEADOW HABITATS IN TWO PIEDMONT RIVER VALLEYS

William Hilgartner[1], *Dorothy Merritts*[2], *Robert Walter*[2], *Michael Rahnis*[2], *Christopher Bernhardt*[3], *Jeff Hartranft*[4], *Ali Neugebauer*[2], *Mark Voli*[2], *Hanna Jantzi*[2], *Amy Moser*[2] and *Candace Grand Pre*[2]
[1]Johns Hopkins University and Friends School of Baltimore, Baltimore, MD
[2]Franklin and Marshall College, Lancaster, PA
[3]U.S. Geological Survey, Reston, VA
[4]Department of Environmental Protection, Harrisburg, PA

Paleoecological analyses of macrofossil seeds, charcoal and pollen from a core (LFC1), from Little Falls, northern Baltimore County, MD and a sequence of samples from Big Spring Run, Lancaster County, PA were combined with geomorphic data and a record of historical land use to provide a 5000-yr and 3000-yr history of two river valley wetlands respectively. Analysis of seeds in LFC1 reveals that tussock sedge (*Carex stricta*) was the dominant sedge, along with 9 other sedge taxa including *Carex stipata* and *Carex scoparia*, forming a tussock sedge wetland association from 4300 y BP to ca. A.D. 1775. A running Sorenson's Similarity index average of 58% (all values ≥ 40%) confirmed the 4000-yr period of stability of the paleo-wetland. The wetland hydrology was primarily spring-fed from the valley margins persisting at surface ground water level with gently flowing water in rivulets, as evidenced by an absence of paleo-channels characteristic of bedload transport regimes and the characteristic hydroperiod of *Carex stricta*. The wetland persisted despite major storm events, regional beaver activity, fire, and anthropogenic disturbances. Initial change began ca. 1730 when *Carex stricta* declined and alder (*Alnus serrulata*) became established, synchronous with an increase in ragweed pollen (*Ambrosia* sp.) from land clearance. Extermination of the tussock wetland happened rapidly within a 60 year period between A.D. 1775 and 1835, when 1- 2 m of silt and clay sediment from land clearance (legacy sediment) accumulated in mill ponds behind a downstream dam. Eventual breaching of the milldam by the early 1830s created an incised, high-banked meandering river channel which exposed the historic sediment and underlying paleo-wetland, gravel layer, and valley bedrock.

At Big Spring Run, PA, where a sequence of samples was examined *Carex prasina* type was dominant among other sedge taxa including *Carex stipata*, from 3000 yr BP to European Contact (250 yr BP). At another site closer to the headwaters *Carex stricta* has been recovered. These species indicate that an extensive sedge meadow with varying degrees of saturated soils persisted in the valley during this 2800-yr pre-settlement period. At A.D. 1710-1750 a shift to a *Carex hystericina* wetland was followed by *Eleocharis ovata,* with the change indicating increasing sediment supply and extension of mudflats. A period of ponding followed as indicated by a shift to *Alisma plantago-aquatica*. A meter of silt and clay mill pond sediment buried this wetland from the mid to late 1700s, and possibly into the 19th c.

Tussock sedge and other sedge seeds have been recovered from other buried Piedmont river valleys suggesting that these sedge-dominated wetlands were more extensive, persisted undisturbed for centuries, and ultimately suffered the same fate from widespread damming and land clearance. Understanding this history can provide important guidelines for stream restoration and conservation of the endangered bog turtle (*Glyptemys muhlenbergii*), a habitat specialist of tussock sedge wetlands.

Contact Information: William Hilgartner, Johns Hopkins University and Friends School of Baltimore. Mailing (Home Office) Address: 137 Hopkins Rd, Baltimore, MD 21212. Cell: 443-834 -6116, Email: hilgartner@jhu.edu

DETERMINATION OF FLOW VELOCITY IN THE EVERGLADES AT DIFFERENT SCALES: RESULTS FROM SF_6 TRACER RELEASE EXPERIMENTS AND ACOUSTIC DOPPLER VELOCIMETER MEASUREMENTS

Sara Ferrón[1], *Laurel Larsen*[2], ***David T. Ho***[1] and *Victor C. Engel*[3]
[1]University of Hawaii, Honolulu, HI, USA
[2]US Geological Survey, Reston, VA, USA
[3]Everglades National Park, Homestead, FL, USA

Flow in wetlands and other shallow-water environments is notoriously difficult to quantify. Typical methods measure water velocity at small spatial scales (0.09-0.25 cm^3), due to limitation of available technology. Recently, deliberate SF_6 tracer release experiments have proven to be a very powerful tool for determining sheet flow patterns in the Everglades over large spatial scales, which is essential for setting flow restoration targets. Whereas the integrated flow-vector Information derived from the tracer release experiments provides synoptic data over a given period of time, the deployment of acoustic Doppler velocimeters (ADV) at fixed stations allows long-term time series velocity measurements, which are needed to examine the temporal variability.

A series of deliberate SF_6 tracer release experiments were conducted in the degraded wetland area between the L67A and C levees, as part of the on-going DECOMP Physical Model (DPM) program, which address scientific, hydrologic, and water management issues related to restoring sheet flow in the Everglades. These tracer experiments aim to determine the large-scale surface flow dynamics before and after operation of the gated culverts that will be constructed as part the DPM in the L-67A levee, and thus to evaluate the impacts of these structures on sheet flow patterns. Through the course of three of these SF_6 tracer experiments that were conducted to examine the pre-operating conditions, a set of ADVs were deployed at multiple locations within the SF_6 tracer footprint. A direct comparison of the water velocities measured from the two methods will be presented and discussed. Within error, mean velocities acquired by the ADVs within the tracer patch were consistent with those of the SF_6 tracer, differing by not more than 0.07 cm s^{-1}. Flow directions also agreed within error, though the uncertainty in flow direction for the ADV measurements was about 50^0 greater than that of the SF_6 experiment. Mean flow directions were up to 40^0 different between the two methods. Our results suggest that point velocity measurements are generally representative of large-scale velocity magnitudes but are subject to local perturbations in direction (e.g., by steering around clumps of vegetation or wind-induced movement of stems in the water column). The high temporal resolution of ADV measurements and high temporal variability of ADV data on the scale of seconds to minutes contributes to greater uncertainty in long-term averaged ADV data relative to data generated from large-scale tracer release experiments. The combination of long-term point velocity measurements with ADVs at multiple monitoring stations and multiple large-scale SF_6 tracer releases before, during, and after DPM experimental flow pulses, will characterize wetland surface-water flow phenomena in unprecedented detail.

<u>Contact Information</u>: Sara Ferrón, Department of Oceanography, University of Hawaii, 1000 Pope Road, Honolulu, HI 96822, USA, Phone: 808-956-7072, Fax: 808-956-9225, Email: sferron@hawaii.edu

RESOLVING KILOMETER-SCALE FLOW PATTERNS IN THE EVERGLADES USING SF_6 TRACER RELEASE EXPERIMENTS: IMPLICATIONS FOR HABITAT RESTORATION

David T. Ho[1], *Sara Ferrón*[1], *Victor C. Engel*[2] and *Evan A. Variano*[3]
[1]University of Hawaii, Honolulu, HI, USA
[2]Everglades National Park, Homestead, FL, USA
[3]University of California, Berkeley, CA, USA

Shallow, slow moving surface water called "sheet flow" plays a critical role in sediment transport and nutrient fluxes throughout the Everglades. The Everglades Tracer Release Experiment (EverTREx) introduced the SF_6 tracer technique as a promising tool to measure sheet flow patterns at large (>10^4 m^2) spatial scales in an environmentally safe, inexpensive and robust manner. A total of 11 SF_6 tracer release experiments have been conducted in the Everglades since 2006, covering a range of landscapes and flow conditions.

The first series of experiments (EverTREx 1 to 5) were conducted in Water Conservation Area (WCA) 3A and 3B to compare surface water dynamics in degraded versus well-preserved landscapes. Results from these experiments revealed that in well-preserved areas, flow was aligned with the longitudinal axis of the ridges and sloughs, whereas in more degraded landscape the flow was not aligned with the local landscape patterning but rather followed the hydraulic gradient generated by water management control structures and the canal-levee network. These findings suggest the loss of the regular patterning which characterized the historic Everglades ridge and slough community may be partially due to the re-alignment of regional hydraulic gradients due to water management features. Additionally, dispersion coefficients calculated for EverTREx experiments are larger than previous values reported for smaller scale experiments in the Everglades, implying that the hydrodynamic dispersion of substances may occur more rapidly than previously thought.

The second set of experiments (EverTREx 6 to 11) were conducted in an impounded zone approximately 1.6 km in width between the L67A and C levees/canals as part of the DECOMP Physical Model (DPM), an on-going large-scale field study that aims to address scientific, hydrologic, and water management issues related restoring sheet flow in the Everglades. The specific objective of these tracer experiments is to determine the large-scale direction and velocity of surface water flow before and after operation of the gated culverts that will be constructed as part the DPM in the L-67A levee, and thus to evaluate the impacts of these structures on sheet flow patterns.   Tracer measurements during pre-operation conditions have shown large spatial and temporal variability of the flow direction and advection throughout the DPM footprint. The implications of these results and the earlier EverTREx experiments for future large-scale sheetflow and habitat restoration efforts will be discussed.

<u>Contact Information</u>: David T. Ho, Department of Oceanography, University of Hawaii, 1000 Pope Road, Honolulu, HI 96822, USA, Phone: 808-956-3311, Fax: 808-956-9225, Email: ho@hawaii.edu

THRESHOLD SIMULATION METHOD FOR DETERMINING WETLAND HYDROLOGIC STATUS

William F. Hunt
Department of Biological and Agricultural Engineering, North Carolina State University

This paper presents the concept of using Threshold Wetland Simulations (TWS) and short term water table records to determine the wetland hydrologic status of a site. A Threshold Wetland is defined for this purpose as a site that barely satisfies the wetland hydrologic criterion. Parameters characterizing Threshold Wetlands can be identified by conducting long-term water table simulations with computer simulation models. In this evaluation, Threshold Wetland Simulations were conducted using DRAINMOD. Analyses of four soils showed that, for threshold conditions, the water table fluctuations for the TWS are nearly independent of soil type, drainage configuration, and surface depressional storage. The TWS method was applied to determine wetland hydrologic status on three example sites in eastern North Carolina. Results indicate that a single TWS, computed with weather data for the monitoring period, can be used to analyze observed water table data to reliably determine wetland hydrologic status for a wide range of soils and boundary conditions.

Contact Information: William Hunt, North Carolina State University, PO Box 7625, Raleigh, NC 27695-7625, USA, Phone: 919-515-6739, Email: wfhunt@ncsu.edu

SEDIMENTATION PATTERNS ON THE RESTORED REACH OF THE KISSIMMEE RIVER FLOODPLAIN

Cliff R. Hupp and *Edward R. Schenk*
U.S. Geological Survey, Reston, VA, USA

The Kissimmee River Basin is the major source of water draining to Lake Okeechobee, which in turn, is the source of flowing water to the Everglades. This fluvial system historically consisted of a broad typically, annually inundated riparian wetland similar in character to tropical Southern Hemisphere large rivers. The river was channelized in the 1960's draining several thousand hectares of wetland. Presently a portion of the system experiences the world's largest river restoration program, with over 10,000 hectares of wetlands being reconnected to 70 river km of naturalized channel. We monitored riparian wetland sediment dynamics between 2007 and 2010 measuring sediment deposition, erosion, texture, organic content, and bulk density at 87 sites in the restored reach and 14 sites in a yet unrestored reference reach. Discharge and sediment transport were measured at the downstream end of the restored reach. Restoration has returned periodic flood flow to the riparian wetland and provides a mean sedimentation rate of 11.3 mm/yr over the study period. There were three flooding events during the study, two as annual flood events and the third as a greater than a 5-year flood event. Sedimentation from the 2 annual floods was within the normal range for alluvial Coastal Plain rivers. Sediment deposits consisted of over 20% organics, similar to eastern blackwater rivers. Elevation, distance from channel, and vegetation type may be important determinants of the variable amounts of deposit. The large event, relative to annual peak flows, distributes considerable mineral sediment near the channel and even larger amounts of organic sediment away from the channel; annual events largely redistribute organic material across the floodplain. Mean organic content after the large event was 28% with a maximum above a single station of 82%, suggesting that substantial amounts of carbon may be sequestered with or as sediment. The Kissimmee River is unique in North America for its hybrid alluvial/blackwater nature. The source of most floodplain sediment is the suspended sediment transported by the Kissimmee River. Fluvial suspended-sediment measurements for the three flood events indicate that a majority of the sediment (70%) was sand, which is important for levee construction. Three to 16% of the total suspended sediment load for the three flood events was organic and important in floodplain deposition. Sediment yield for the Kissimmee River is similar to low gradient rivers draining to the Chesapeake Bay and southeastern U.S. in general. Flow to the restored reach is still hydrologically manipulated to maintain upstream lake levels, a condition that complicates restoration assessment. However, reconnection of the river to its floodplain potentially traps large amounts of organic rich sediment that would otherwise impact Lake Okeechobee and perhaps the Everglades.

Contact Information: Cliff R. Hupp, National Research Program, U.S. Geological Survey, MS430 National Center, Reston, VA 20192, USA, Phone: 703-648-5207, Fax: 703-648-5484, Email: crhupp@usgs.gov

THE ROLE OF RIVER-FLOODPLAIN CONNECTIVITY IN NITROGEN REMOVAL

Durelle Scott and ***C. Nathan Jones***
Virginai Tech, Blacksburg, VA, USA

Worldwide, receiving water bodies are experiencing hypoxia due to increased Nitrogen (N) and Phosphorus (P) loadings. This increase in nutrients is due to agricultural fertilization/urban stormwater and the alteration of natural riverine processes. Specifically, floodwaters have been restricted to the river channel, increasing flood peaks, decreasing river-floodplain connectivity, and reducing the ecosystem services of the riverine system. Under natural conditions, overbank events transport nutrient rich floodwaters into floodplains, promoting nitrogen removal through steep REDOX gradients at the sediment-water interface. In the Southeastern United States, this process has been restricted by levees and river channelization. Therefore, our hypothesis is that increasing the interactions between the river and floodplain will decrease the nitrogen flux to the Gulf of Mexico. To support this hypothesis, floods within two floodplain systems were analyzed. The first, a medium sized river in Southern Louisiana was intensively sampled during multiple flood events. Nutrient samples were taken in several locations across floodplain and hydraulic flowpaths were modeled. Results from this study suggest that nitrogen removal was actually limited by the amount of nitrogen transported into the floodplain. Also, the historic 2011 flood was monitored in the Atchafalaya Basin Floodway System for over 12 weeks. The Atchafalaya is a large river system which serves as a diversion of the larger Mississippi River. Conservative tracer and nutrient data were taken over the entire breadth of the basin, allowing us to examine differences in nitrogen removal between hydraulically connected and disconnected regions. The results from these two studies provide valuable insight into the hydrology and biogeochemistry of floodplains within the Southeastern United States and ultimately the potential for reducing nutrient export to the Gulf of Mexico.

Contact Information: Nathan Jones, Virginia Tech, 315 Seitz Hall, Blacksburg, VA 24060, USA, Phone:540-231-2449, Email: cnjones@vt.edu

MEASURING AND MODELING SPATIOTEMPORAL VARIATION IN VEGETATIVE FLOW RESISTANCE IN WETLANDS AND FLOODPLAINS

Katherine Skalak[1], *Judson W. Harvey*[1], ***John W. Jones***[2], *Laurel Larsen*[1], *Gregory* Noe[1] and *Nancy Rybicki*[1]
[1]U.S. Geological Survey, National Research Program, 12201 Sunrise Valley Drive, Reston, VA
[2]U.S. Geological Survey, Eastern Geographic Science Center, 12201 Sunrise Valley Drive, Reston, VA

In flowing aquatic environments, the complex interaction between flow and vegetation often determines the resulting hydroecology and geomorphology. Landscapes adjust to changes in flow caused by vegetative resistance, especially in environments where vegetation is the primary resisting force, such as low-gradient floodplains and wetlands. The critical research needs that remain for predicting flow in these environments are the spatiotemporal integration of data and improved estimation methods of vegetative resistance based on relatively easily measured variables. Flow resistance is generally not measured directly; it is measured through parameters that can be directly related to flow resistance (i.e., frontal area per unit volume (a) and stem diameter (d)). Although a and d are time consuming to measure, vegetation biomass is commonly and readily measured in field surveys and may be estimated through remote sensing, and thus has potential for predicting flow resistance at large scales.
We have developed empirical predictive relationships for a and d based on biomass samples of herbaceous wetland vegetation harvested at 80 locations in the Florida Everglades. Vegetation communities included wet prairie, open water sloughs, sawgrass, and cattail. Our results suggest that a is directly related to biomass through a power function and that d is linearly related to biomass. The product ad, which is proportional to the biovolume (biovolume $=\frac{\pi}{4}ad$) is also closely related to biomass. The relationships for d and ad as a function of biomass are generally independent of plant community with the exception of cattail, due to lower plant tissue density. Furthermore, we found that spatial and temporal variations in d, ad, and plant tissue density are explained by species diversity, plant community, water depth, phosphorus concentration, and season. Finally, significant correlations were found between above-water live biomass and the remotely sensed spectral index normalized difference vegetation index (NDVI). Our findings indicate that it is feasible to estimate spatiotemporal variation in vegetative flow resistance to improve hydrologic modeling and guide restoration efforts in the Everglades and in wetlands and floodplains elsewhere.

<u>Contact Information</u>: Katherine Skalak, U.S. Geological Survey, 430 National Center, Reston, VA, 20192, USA, Phone: 703-648-5435, Email: kskalak@usgs.gov

HYDROLOGIC PROCESSES IN A PATTERNED PEATLAND

***David A. Kaplan*[1], *Danielle L. Watts*[1], *Jing Yuan*[1], *Matthew J. Cohen*[1] and *James B. Heffernan*[2]

[1]University of Florida, School of Forest Resources and Conservation, Gainesville, FL

[2]Duke University, Nicholas School of the Environment, Durham, NC

The Everglades is a 6000 km^2 patterned sub-tropical peatland where coupled ecohydrological feedbacks are hypothesized to have formed the patterned “ridge-slough” landscape. Under historic flow conditions, elongated ridges and connected sloughs were oriented parallel to the flow direction, with significant implications for the landscape’s ability to convey water. Hydrological modifications during the 19th and 20th century have drastically altered the timing and magnitude of flow, resulting in more uniform landscapes with far less hydrological connection and more tortuous flowpaths, with detrimental ecological effects. While hydrology is known to be the primary abiotic driver of wetland structure and function, the hydrologic processes by which water drives patch elongation in the Everglades—and how the ecosystem’s physical, chemical, and biological components feed back to the hydrological cycle—remain unresolved and active areas of research.

Identifying the process or processes connecting hydrology and patterning in the Everglades is critical to the development of effective restoration and management plans. Three primary hypotheses have been put forward to explain development and degradation of the ridge-slough landscape, each relying on a distinctly different hydrologic process: 1) phosphorous accumulation driven by differential evapotranspiration in ridges and sloughs; 2) sediment entrainment and deposition driven by flow velocity differences between ridges and sloughs; and 3) feedbacks to between landscape discharge competence and hydroperiod, which in turn affects the prevalence of ridges and sloughs (the self-organizing canal hypothesis). While modeling efforts in support of nutrient and sediment redistribution hypotheses have shown some promise in generating ridge-slough-like patterns, there is a general lack of empirical hydrological evidence to support these theories (e.g., strong, directional hydraulic gradients to drive nutrient redistribution or sufficient flow velocities to support differential sediment redistribution). To investigate the third hypothesis, we present a series of results from field and modeling studies, including: 1) measured carbon budgets of ridges and sloughs that show a marked response of carbon equilibria to hydrology; 2) measured hydraulic gradients between ridges and sloughs that run counter to the proposed mechanism of below-ground P transport; 3) spatially distributed hydrologic modeling that highlights the significant effect of landscape anisotropy on equilibrium flooding depth; 4) spatial analysis of pattern metrics that suggest hydroperiod, not velocity, may be the primary hydrologic driver organizing the patterned landscape; and 5) analytical modeling of the ridge-slough mosaic that suggests that discharge competence can explain the spontaneous divergence of ridges and sloughs without additional spatial processes (e.g., sediment redistribution or nutrient focusing).

Contact Information: David A. Kaplan, Ecohydrology Laboratory, University of Florida, School of Forest Resources and Conservation, University of Florida, 319 Newins-Ziegler Hall, PO Box 110410, Gainesville, FL 32611-0410, USA, Phone: 352-846-0829, Fax: 352-846-1277, Email: dkaplan@ufl.edu

ISOLATED WETLANDS - THE GROUNDWATER CONNECTION – 2. HYDROGEOLOGY

***Amy J. Keyworth*[1]**, *Dan Tufford*[2], *Rick Bolich*[1], *Chenille Williams*[2], *Warren Hankinson*[2], *Virginia Baker*[3], *Ray Milosh*[1], *Ross Vander Vorste*[3] and *John Dorney*[4]

[1]NC, Division of Water Quality, Aquifer Protection Section, Raleigh, NC
[2]University of South Carolina, Columbia, SC
[3]NC, Division of Water Quality, Wetlands Program Development Unit, Raleigh, NC
[4]Atkins North America, Raleigh, NC

Wetlands are critically important ecosystems that provide ecological value and hydrologic and water quality functions. Although the importance of the ecological and functional value of wetlands in the landscape is well documented, there are still significant gaps in our knowledge of "isolated" wetlands (IWs), especially in regards to water quality and hydrology. Additionally, IWs are particularly vulnerable to losses from development and agriculture because they are often surrounded by developable uplands, are often small in size (less than an acre), and lack protection at the federal level and have varying degrees of regulatory protection at the state level. This project seeks to gain a better understanding of the hydrologic connectivity to a nearby downslope water body.

Thirteen IWs are being studied, eight in North Carolina and five in South Carolina. The wetlands, surrounding uplands, and an area near the adjacent receiving streams or surface water bodies were cored extensively to determine stratigraphy. Wells were installed in a transect from the IW to the downstream water body and water level and water quality data are being obtained for a one year period beginning in May of 2010. Aquifer pumping tests were conducted at three of the NC sites. Preliminary results indicate an unimpeded groundwater connection between the IW and its receiving surface water body in all cases.

All the wetlands in the study were found to be surface expressions of depressions in the surficial sand aquifer, but there were geologic differences between the wetlands. These differences are expressed hydrologically as perched water tables, partially confined aquifers and systems with layers of varying hydraulic conductivity. This talk will examine how these stratigraphic differences affect the hydrologic regime of these IWs. The Information on IWs gained from this study can be used to improve management decisions and provide better protection for these ecosystems.

Contact Information: Amy J. Keyworth, Aquifer Protection Section, Division of Water Quality, NC Department of Environment and Natural Resources, 1636 Mail Service Center, Raleigh, NC 27699-1636, USA, Phone: 919-715-6183, Fax: 919-715-6048, Email: amy.keyworth@ncdenr.gov

HYDROLOGIC CONNECTIVITY AS A WINDOW INTO FLUVIAL LANDSCAPE PATTERN ORIGIN, DEGRADATION, AND RESTORATION

Laurel G. Larsen[1]*, Jungyill Choi*[1]*, Martha K. Nungesser*[2] and *Judson W. Harvey*[1]
[1]U.S. Geological Survey, Reston, VA, USA
[2]South Florida Water Management District, West Palm Beach, FL, USA

Quantifying hydrologic and ecological connectivity has contributed to understanding of transport and dispersal processes, along with assessment of ecosystem degradation or potential for restoration. However, there has been little synthesis across disciplines. One outstanding need in hydrology and ecology is a way to quantify directional connectivity that is consistent, robust to variations in sampling, and transferable across scales or environmental settings. Understanding connectivity in a particular direction (e.g., streamwise, along- or across-gradient, between sources and sinks, along cardinal directions) provides critical Information for predicting contaminant transport, planning conservation corridor design, and understanding how landscapes or hydroscapes respond to directional forces like wind or water flow. Here we synthesize progress on quantifying connectivity and develop a new strategy for evaluating directional connectivity that benefits from graph theory applications in ecology and percolation theory applications in hydrology. The new maximum flow index is sensitive to existence of any hydrologic connection along the direction of interest, whereas the directional connectivity index is sensitive to linearity of connections along that direction. Both indices exhibit minimal sensitivity to image rotation or resolution within a given range and respond intuitively to progressive, unidirectional change. Moreover, they are generalizable to a range of scales and different types of functional connectivity assessments. Connectivity-orientation curves (i.e., directional connectivity computed over a range of bearings) provide a quantitative, Information-dense representation of environmental structure that can be used for comparison or detection of subtle differences in the physical-biological feedbacks driving pattern formation.

Case-study application of the directional connectivity index to the Everglades revealed that loss of directional hydrologic connectivity occurs more rapidly than loss of slough area and is a more sensitive indicator of declining ecosystem function. The directional connectivity index can be applied to provide insight into landscape formation processes, act as an early-warning indicator of environmental degradation, and serve as a planning tool or performance measure for conservation and restoration efforts in the Everglades and elsewhere.

Contact Information: Laurel Larsen, National Research Program, U.S. Geological Survey, MS430, National Center, Reston, VA 20192, USA, Phone: 703-648-5891, Fax: 703-648-5484, Email: lglarsen@usgs.gov

SPECIFIC YIELD AT ECOSYSTEM AND LANDSCAPE SCALES TO INFER LOCAL AND REGIONAL HYDROLOGIC FUNCTIONS OF ISOLATED WETLANDS

Daniel L. McLaughlin and *Matthew J. Cohen*
School of Forest Resources and Conservation, University of Florida, Gainesville, FL, USA

Ecosystem functions provided by isolated wetlands include microclimate regulation, carbon sequestration, water storage, and surficial aquifer buffering, all of which are regulated by hydrologic processes and surrounding land use. Continuous surface water and groundwater data were collected at twelve cypress domes along a land use continuum to determine and compare hydrologic fluxes, flow direction, and temporal patterns of inundation. Particular focus was directed towards applying the White method to empirically quantify daily evapotranspiration (ET) and net groundwater flows using diurnal surface water fluctuations. Surface water applications of this method, however, crucially require an understanding of the variation of specific yield (S_y) with stage. We give the stage-dependent S_y function the term ecosystem specific yield (ESY), the shape of which is determined by site bathymetry, surficial soil properties, and the degree of equilibration (spatial and temporal) between inundated and non-inundated wetland areas. ESY relationships were empirically determined using measured ratios of rain to induced rise to infer stage-specific values of $S_{y,}$ which rejected the common assumption of constant S_y near unity for all standing water conditions. Moreover, the shape of the ESY curves matched the geometry of stage histograms, illustrating the reciprocal influences of ESY on stage stability.

With an appropriate site-specific ESY, the White method can estimate wetland ET and groundwater exchange, hydrologic processes related to important ecosystem functions and that control water budgets both locally and regionally. Results here suggest that land use intensity amplifies ET losses through increases to leaf area index, thereby influencing ecosystem productivity, carbon sequestration, and microclimate services. Groundwater exchange was more controlled by climatic conditions than land use, regularly switching between basin infiltration and exfiltration in response to wet and dry cycles. This switching behavior derives in part from S_y differences between the upland and wetland environments, which together determine the composite landscape S_y. Modeling to spatially scale this source-sink dynamic demonstrated the effect of "isolated" wetlands on regional surficial aquifer dynamics, with increasing wetland area and density yielding a higher landscape S_y, which dampens water table variation. As such, even isolated wetlands provide water storage capacitance within the landscape, buffering the surficial aquifer and ultimately downstream water bodies. From the local to the landscape scale, the concept of specific yield has important implications to both water budget methodologies and mechanisms controlling water level stability and groundwater-surface water interactions.

Contact Information: Daniel L. McLaughlin, School of Forest Resources and Conservation, University of Florida, Gainesville, FL, USA, Phone: 352-846-0353, Fax: 352-846-127, Email: mclaugd@ufl.edu

WIDESPREAD 18TH-20TH C. BURIAL OF HOLOCENE WET MEADOWS IN THE MID-ATLANTIC REGION, USA, AND THEIR RESTORATION POTENTIAL

Dorothy Merritts[1], *Robert Walter*[1], *Allen Gellis*[2], *Jeff Hartranft*[3], *William Hilgartner*[4], *Michael Langland*[5], *Paul Mayer*[6], *Ward Oberholtzer*[7] and *Michael Rahnis*[1]

[1]Franklin and Marshall College, Lancaster, PA, USA
[2]U. S. Geological Survey, Baltimore, MD, USA
[3]Department of Environmental Protection, Harrisburg, PA, USA
[4]Johns Hopkins University and Friends School of Baltimore, Baltimore, MD, USA
[5]U. S. Geological Survey, Harrisburg, PA, USA
[6]U. S. Environmental Protection Agency, Ada, OK, USA
[7]LandStudies, Inc., Lititz, PA, USA

Our study of 1st- through 4th-order watersheds in the mid-Atlantic US led to a new understanding of landscape evolution and geomorphic response to European settlement. Instead of long-term fluvial processes, many modern streams are artifacts of post-settlement anthropogenic activity, including deforestation and agricultural cultivation beginning ca. 1700 AD that led to greatly increased soil erosion rates. Construction of tens of thousands of low-head dams ca. 1700 to 1900 for waterpower led to regional base level rise of ~1.2 m and trapped much of the increased sediment load in valley bottoms. As dams for water power became obsolete, their failure (and removal) has led to base level fall and incised modern streams with high banks (mean height ~1.2 m) of fine sediment. The classic model of a single-thread meandering stream channel generating a broad floodplain over geologic time is incorrect for these mid-Atlantic streams. Instead, a transition from stable Holocene wet meadows with small, vegetated channels to relatively large, modern stream channels incised into millpond mud is delineated clearly in the geologic record. Understanding this record is crucial to developing strategies for floodplain, wetland, and riparian ecological restoration in regions affected by this sequence of widespread historic phenomena. Microstratigraphy, radiocarbon dating ($n=109$), and macrofossil studies indicate long-term stability and resilience of Holocene wetlands, in particular sedge-dominated wet meadows that produced organic-rich mucks along mid-Atlantic region valley bottoms. Wet meadows persisted at the groundwater level for at least several millennia, and in some places for more than 8-10 millennia along Piedmont valley bottoms. Sedimentation in millponds buried pre-settlement wetland landscapes during the 18th and 19th c., but at least one unburied wet meadow remnant at a location with no milldam remains as a "living fossil" landscape for comparison with buried wetlands.

Currently we are conducting a large-scale restoration experiment at Big Spring Run, southeastern PA, to remove historic sediment that buries a late Holocene wet meadow that existed from at least 4000 yrs BP to 1710 AD. More than ten years of pre-restoration monitoring (including continuously operating water gages and sediment/turbidity samplers, piezometers for surface and groundwater chemistry, and monumented channel cross sections and clay pads for sediment budget analysis) preceded removal of historic valley bottom sediment in 2011. Post-restoration monitoring currently is underway. Restoration involved removing historic sediment to the level of the Holocene buried wetland soils at the groundwater table. Restoration goals include reestablishing hydrologic connectivity between surface and groundwater flow at the level of the Holocene wet meadow, promoting frequent overbank flow, and rehabilitating the ecologic function of the buried wetland. Anticipated reductions in sediment and nutrient loads and indicators of wetland function, such as presence of obligate wetland plant species, may inform future restoration efforts and will be used to establish a new restoration Best Management Practice.

<u>Contact Information</u>: Dorothy J. Merritts, Department of Earth and Environment, Franklin and Marshall College, Lancaster, PA, 17604-3003, USA, Phone:717-291-4133, Fax: 717-291-4186, Email: Dorothy.merrits@fandm.edu

AN EFFECTIVE TOOL FOR POST-RECLAMATION WETLAND DESIGN: WETLAND HYDROPERIOD WATER BALANCE MODEL

***Bradley S. Pekas*[1]**, *Theodore A. Smith*[2], *Gary P. Uebelhoer*[1] and *Yuan Li*[1]
[1]Environmental Consulting & Technology, Inc., Tampa, FL, USA
[2]Mosaic Fertilizer LLC, Lithia, FL, USA

Where the water table is shallow and evapotranspiration (ET) can potentially have a significant influence on the overall water balance (or budget) of a wetland system, the interaction between surface water, the vadose zone, and the water table controls wetland hydrology. The wetland hydroperiod model developed by Environmental Consulting & Technology, Inc. (ECT), on behalf of The Mosaic Company[3], presents a wetland water balance model capable of accounting for numerous interactions between the surface water, the vadose zone, and the water table.

Although it has many potential applications, one fundamental purpose of this wetland model is to estimate the post reclamation hydrology of wetlands after mining. Three areas (or cells) are incorporated into the model: the upgradient upland, the wetland, and a downgradient area which may exhibit either upland or certain wetland characteristics. The wetland model calculates water balance on a daily basis for these three model cells. The net recharge of this model incorporates various inflow and outflow parameters for the model cells inclusive of precipitation, runoff, ET, groundwater influx, wetland discharge/outflow, and optional irrigation/augmentation or drawdown resulting from nearby withdrawals.

The wetland model includes a series of individual worksheets for design and input parameters as well as calculations related to different daily variables at each model cell. It also produces a set of hydrographs and stage duration curves as well as the water balance overview. The selection of a simulation period is to provide reasonable assurance that the wetlands could function through seasonal fluctuations, as well as drought and wet conditions. The wetland simulations are recommended to start during the wet season, or when the depth of water in the wetlands should be at or approaching the anticipated design elevations. The model is rainfall driven, using historic data for calibration and to represent future response to similar rainfall patterns. The example used a time period of approximately 9.5 years, from July 1, 1996 through December 31, 2005, encompasses routine seasonal fluctuations plus includes a drought period in 1999/2000 and a wet period in 2003/2004.

Although based on similar principles and equations, the use of this wetland model is less difficult and may in many circumstances be more cost-effective than the application of complex numerical models. A previous version of this wetland model was successfully applied to evaluate the hydraulic conditions and hydroperiods for 20 selected post reclamation created wetlands at Mosaic South Fort Meade extension property in Hardee County, Florida. The new version of this model has been recently tested with monitoring data for five (5) selected wetlands at Mosaic Ona Mine in Hardee County with correlation coefficient ranging 0.97-1 and absolute mean error ranging 0.2-0.7 ft. Therefore, this wetland hydroperiod model is proved to be an effective tool to provide reasonable representation of corresponding hydographs, and is suitable for use to estimate the post-reclamation wetland hydroperiods.

Note 3 – It is the current intention of The Mosaic Company to copyright this wetland hydroperiod model

<u>Contact Information</u>: Bradley S. Pekas, Environmental Consulting & Technology, Inc., 1408 N. Westshore Boulevard, Suite 115, Tampa, FL 33607, USA, Phone: 813-289-9338, Fax: 813-289-9388, Email: bpekas@ectinc.com

FLOOD EXPOSURE AND PLANT COMMUNITY CHARACTERISTICS IN RESTORED FLOODPLAIN WETLANDS

Geoffrey E. Pociask[1], *Jeffrey W.* Matthews[2] and *Eric T. Plankell*[1]
[1]Illinois State Geological Survey, Prairie Research Institute, University of Illinois, Champaign, IL, USA
[2]Illinois Natural History Survey, Prairie Research Institute, University of Illinois, Champaign, IL, USA

Flood depth, duration, and frequency are important components of wetland hydrology and influence the characteristics of wetlands. While seasonal, low magnitude flood regimes may support stable and diverse wetland plant communities, prolonged or frequent, extreme flooding may create conditions that lead to less diverse wetland plant communities. In this study, we analyzed flood regime and plant communities at 20 floodplain wetland restoration sites in Illinois, USA, with contributing watershed areas ranging from 4 to ~1.8 million km^2, to provide a watershed-scale evaluation of the influence of flood exposure on wetland plant community characteristics. We used a flood exposure index (FEI) calculated from continuous hydrologic data to characterize the flood regime at each site. Plant communities in the restored wetlands were evaluated using 11 indices including species richness, floristic quality index (FQI), and mean wetland indicator status (WIS). We used linear regressions to relate characteristics of the vegetation to FEI. Results show moderately strong, inverse correlations of species richness, FQI, and percent of perennial species with maximum annual FEI, suggesting that higher magnitude flood exposure causes reduced species richness and altered plant community composition when viewed from a watershed scale. Contrary to the expectation of a strong positive correlation of percent hydrophytes and WIS with FEI, the analysis showed a marginally significant, weak relationship with average percent of hydrophytes, and no correlation with WIS. This lack of correlation may be due to several factors that influence plant communities at the local scale such as topographic heterogeneity, site drainage after floods, and adjacent land use. The results of the analysis suggest that consideration for flood exposure should be given when evaluating the progress of wetland restoration, particularly when species richness or metrics that include species richness (e.g., FQI) are used to evaluate attainment of performance standards.

Contact Information: Geoffrey E. Pociask, Illinois State Geological Survey, Prairie Research Institute, University of Illinois, 615 E. Peabody Dr., Champaign, IL 61820, USA, Phone: 217-265-8212, E-mail: pociask@illinois.edu

TRANSPORT ACROSS THE AIR-WATER INTERFACE WITH EMERGENT VEGETATION

Evan A. Variano and ***Cristina M. Poindexter***
University of California, Berkeley, CA, USA

The goal of this work is to provide a parameterization of the air-water gas transfer rate in wetlands, and do so in terms of easily measured environmental variables. This parameterization is intended to support biogeochemical modeling in wetlands by providing an interfacial flux of key importance. Our approach uses laboratory experiments describe the oxygen transfer across an air-water interface in a model wetland with emergent vegetation. The oxygen transfer is sensitive to the externally imposed wind, currents, waves, and vertical thermal convection, as well as the vegetation characteristics. We vary these systematically, determining the gas transfer (or "piston") velocity that describes interfacial gas flux. We measure velocity vector fields near the air-water interface using particle image velocimetry, and use these measurements to help explain the mechanisms behind the measured trends in oxygen transfer. The explanatory power of these measurements includes the relationship between plant geometry and surface divergence. We explore the potential impact of our results on wetland modeling and management, for issues such as carbon sequestration and methane emission.

Contact Information: Evan Variano, 623 Davis Hall, Berkeley, CA 94720-1710, USA, Phone: 510-642-2648, Fax: 510-642-2648, Email: Variano@ce.berkeley.edu

ESTIMATING EVAPOTRANSPIRATION IN A LARGE SUBTROPICAL WETLAND ECOSYSTEM AT MULTIPLE SPATIAL SCALES

***Amartya K. Saha*[1&2]**, *Pamela L. Sullivan*[1&2], *David Lagomasino*[1&2], *Rene' M. Price*[1&2], *Jordan Barr* and *Vic Engel*

[1] Southeast Environmental Research Center, Florida International University, Miami FL
[2] Department of Earth and the Environment, Florida International University, Miami FL
[3] National Park Service, Everglades National Park, Homestead FL

Evapotranspiration (ET) is a major component of the hydrological cycle in subtropical wetlands. However the lack of methods for direct measurement of ET has led to a variety of independent approaches to estimate ET. This study estimates ET across the Everglades National Park, a large subtropical wetland savanna with heterogeneous plant communities using a host of estimation approaches at scales ranging from the individual tree level to regional ecosystem level. The approaches are individual tree and stand level sap flux, diurnal groundwater level based method, 5 vapor transport models, the energy budget based Bowen ratio method and satellite-based energy balance. The vapor transport models estimate ET purely based on meteorological data that are the main drivers of ET: net solar radiation, relative humidity, air temperature and windspeed. The FAO-Penman Montieth, Shuttleworth Penman-Monteith, modified Turc and the Abtew method gave estimates in the range of 1300 mm/y, while the Priestley Taylor yielded 3800 mm/y. With the exception of the Shuttleworth PM model, these models are meant for well watered single crop use, or for graminoid wetlands having no significant woody plant communities. The Shuttleworth PM model accounts for woody vegetation as parameterized by leaf area index and vegetation height. We added a sinusoidal function to this model to include dry season water stress effects due to drying of the sloughs as well as salinization of groundwater in coastal forests. The energy budget approach (Bowen Ratio) estimated ET to be 1200 mm/y while scaled up daily stand level sapflow data indicated transpiration averaged around 1000 mm y^{-1} in a hardwood hammock from 2007-2010. Estimates of ET from diurnal water table fluctuations using the White Method indicated that groundwater ET on tree islands averaged 1250 mm y^{-1}. Regional scale ET estimates were determined using a satellite-based energy balance approach and accounted for the spatial variability in surface temperature, albedo, land cover type, and inundation The variability of estimates indicates the necessity of employing independent approaches to decrease the uncertainty arising from any single method of estimating ET. The dynamic connection of ET with land cover change and climate change necessitates improved accuracy of ET estimates especially at the basin scale for water resource management and the preservation of watershed ecosystems.

Contact Information: Amartya Saha, Florida International University, 11200 SW 8th Street, Miami, FL 33199, USA, Phone: 305-348-6163, Email: riparianbuffer@gmail.com or asaha@bio.miami.edu

A PHYSICAL MODEL OF FLOW RECONNECTION TO ACHIEVE ECOLOGICAL RESTORATION IN THE EVERGLADES

Katherine Skalak[1], *Vic Engel*[2], *Jud Harvey*[1], *David T. Ho*[3], *Laurel Larsen*[1], *Sue Newman*[4], *Barry Rosen*[5], ***Colin Saunders***[4], *Fred Sklar*[4] and *Joel Trexler*[5]

[1]U.S. Geological Survey, Reston, VA, USA
[2]Everglades National Park, Homestead, FL, USA
[3]University of Hawaii, Hilo, HI, USA
[4]South Florida Water Management District, West Palm Beach, FL, USA
[5]Florida International University, Miami, FL, USA

Flow alteration has resulted in widespread degradation of shallow aquatic ecosystems, which highlights the need for scientifically defensible strategies for restoration. The $10.9 billion Everglades restoration is a massive and complex effort with numerous societal and scientific challenges. Degradation of the unique Everglades ecosystem has been driven over the past century by human activities that have compartmentalized the flow, decreased mean water levels, and caused nutrient enrichment. The restoration aims to improve the quantity, quality, timing, and distribution of water by re-engineering barriers (i.e. canals and levees) to maximize hydrologic connectivity while meeting societal needs for flood control, water retention, drinking water supply, irrigation, and transportation.

The DECOMP Physical Model (DPM) is an unprecedented prototype experiment undertaken at the landscape scale that will introduce temporary controllable culverts in an upstream levee and a 900 m gap in a downstream canal-levee feature. Pulsed high flows will be repeatedly released into the downstream landscape in order to address two key uncertainties: the ecological benefit of sheet flow and the ecological consequences of various canal backfilling options (complete, partial, none). To address both uncertainties, a before-after-control-impact (BACI) statistical design will be used. Baseline measurements will be made up to 24 months prior to the impact and compared to measurements made during and one year after pulsed flow events. Measurements will be made at control sites outside the region experiencing the pulsed flow. Hydrology and sediment transport have been assessed through an extensive hydrologic monitoring network outfitted with acoustic Doppler instrumentation, pressure transducers, particle size analyzers (LISSTs), and staff gauges in addition to state-of-the-art tracer technologies. Particulate and dissolved biogeochemistry, vegetation, and wildlife responses have been assessed through numerous data collection efforts.

Preliminary results emphasize the importance of the interrelationships between flow, particle dynamics, vegetation, and microtopography in ecosystem structure and function. Pre-release data indicate that ambient flow velocities are not sufficient to entrain bed sediment and that vegetation density exerts substantial control on the spatial variability in flow. Large-scale tracer experiments reveal that flow is often transverse to the direction of landscape elongation as a result of water management activities. Particle biogeochemistry results indicate that epiphyton particles, more readily entrainable than bed floc, are more labile than floc and hence more ecologically reactive. Over 36 species of cyanobacteria were identified associated with floc. We have documented interchange of both small and large fishes between the marsh and the L-67C canal tied to changes in water stage. Canal sediment accumulation in L-67C exhibits a north-to-south gradient and is ~10-fold higher than ambient sedimentation in marshes, indicating canals are potentially important sinks of sediment from the surrounding marsh. This work continues to establish baseline conditions in anticipation of elevated flows and canal backfill treatments. Given the critical importance of wetlands (both natural and created) in ongoing national restoration efforts, DPM provides a unique opportunity to assess the simulated natural functioning of a severely degraded wetland of national significance. Results will have implications for both the Everglades and wetland and stream restoration efforts worldwide.

<u>Contact Information</u>: Katherine Skalak, U.S. Geological Survey, 430 National Center, Reston, VA, 20192, USA, Phone: 703-648-5435, Email: kskalak@usgs.gov

ASSESSING THE ROLE OF MOBILE ORGANIC SEDIMENT IN A FREE-FLOWING EVERGLADES

Laurel G. Larsen[1], *Sue Newman*[2], *Katherine Skalak*[1], *Morgan Maglio*[1], *Trevor Langston*[1], ***Geoff Sinclair***[1], *Jai Singh*[1] and *Judson W. Harvey*[1]
[1]U.S. Geological Survey, Reston, VA, USA
[2]South Florida Water Management District, West Palm Beach, FL, USA

Restoration of sheetflow in the central Everglades is being tested through the Decompartmentalization Physical Model (DPM), an unprecedented kilometer-scale experiment in which high-flow pulses of water (>3 cm/s) will be released through a portion of the Everglades formerly isolated from flow. The sediment redistribution hypothesis (Larsen et al. 2007) suggests that periodic high flows that redistribute flocculated organic sediment from sloughs to ridges are necessary to maintain the ecologically critical flow-parallel patterning of the ridge and slough landscape. To test the role of sediment redistribution in transporting particulate organic C and P in a free-flowing Everglades, we have been measuring physical and biogeochemical characteristics of potentially entrainable organic sediment pools (bed floc, metaphyton, suspended sediment) within the DPM footprint. In 2010 and 2011, pre-release sampling and characterization was performed across a spatially extensive network of sites. These sites will be repeatedly sampled during flow releases in 2012 and 2013 and during the subsequent year.

Measurements reveal that particle-size distributions for floc and metaphyton populations were typically biomodal, with aligning peak values on the order of 10 and 100 μm. Relative to floc, metaphyton tended to be weighted toward larger aggregate sizes, with more phosphorus bound in labile and microbial fractions. Based on the alignment of particle size distribution modes and the nutrient patterns, degraded metaphyton aggregates appeared to dominate the population of bed floc. Water-column suspended particles were unimodal, coinciding with the smaller mode of the floc and metaphyton size distributions. Suspended particle size distributions were dynamic, however, with aggregation occurring at night and aggregate breakup and settling occurring during the day. Consistent with previous findings (Harvey et al. 2011), our results indicated that the more readily entrainable metaphyton particle population was also more labile than floc and may have a potentially greater immediate impact on stimulating production and less of an impact on long-term peat topography. As a result of a fire affecting the DPM study area in 2011, the pool of potentially entrainable metaphyton and floc particles diminished considerably, with remnant aggregates exhibiting lower N:P ratios and a higher percentage of P held in the refractory fraction. The two years of data collected during pre-release conditions form a solid baseline for assessing the impact of higher flows on the redistribution of particulate nutrients and organic sediment and provide an increased understanding of the ecological role of aggregated organic sediment in wetlands worldwide.

Contact Information: Geoff Sinclair, National Research Program, U.S. Geological Survey, MS430, National Center, Reston, VA 20192, USA, Phone: 703-648-5476, Fax: 703-648-5484, Email: geoffreyasinclair@gmail.com

USING A HYDROLOGIC MONITORING NETWORK TO EVALUATE THE ROLE OF ENHANCED FLOW IN EVERGLADES RESTORATION
QUANTIFYING VELOCITIES IN THE EVERGLADES AND IMPLICATIONS FOR ENHANCED FLOWS AND RESTORATION

*Morgan Maglio, Laurel Larsen, Katie Skalak, Trevor Langston, Jay Choi, **Jai Singh*** and *Jud Harvey*
U.S. Geological Survey, National Research Program, Reston, VA, USA

Flow velocities and hydraulic retention times are critical drivers in sediment transport, nutrient cycling, and function of aquatic ecosystems. Therefore, quantifying flow and its ecological impacts in channels and wetlands is a critical research need. One focus of the Everglades restoration effort is restoring the quantity, quality, timing, and distribution of water deliveries by removing existing hydrologic barriers (i.e. levees and canals). The Decompartmentalization Physical Model (DPM) was designed with the aim of assessing the effectiveness of flow restoration and canal backfilling. DPM utilizes temporary controllable culverts in an upstream levee and a 900 m gap in a downstream canal-levee feature, which will elevate velocities by an order of magnitude (to greater than 3 cm/s). Elevated velocities will entrain and redistribute fine sediment and associated particulate phosphorus between different plant communities, which is hypothesized to be important in maintaining biodiversity and landscape pattern.

The USGS has installed an extensive network of instrumentation for monitoring flow velocities, bed shear stress, and water depths before, during, and after pulsed-flow releases within and outside the affected footprint. The hydrologic monitoring network consists of 20 stations outfitted with acoustic Doppler instrumentation, pressure transducers, particle size analyzers (LISSTs), and staff gauges. Hydraulic measurements are coupled to analyses of particle biogeochemistry and transport properties, vegetation characterization, and water quality sampling. These measurements will provide a greater understanding of controls on and effects of flow and sediment transport across extensively vegetated landscapes and will support ongoing development of numerical models of wetland landscape evolution in response to restoration or environmental perturbation.

Two years of pre-release characterization show ambient flow velocities that are consistent with the reported average (< 1 cm/s), which is far too low for sediment entrainment. Spatial variability in flow velocity is primarily attributable to variability in vegetation density. Water management operations drive many of the temporal changes in flow magnitude and direction, which is often transverse to the orientation of landscape features. A wildfire occurring in summer 2011 substantially thinned the vegetation canopy, resulting in higher mean flow velocities during the second year of pre-release characterization. Though daily-average velocity trends are relatively smooth, high instantaneous velocity variability reflects wind-driven movement of vegetation stems through the water column and the nightly occurrence of thermal overturn. This unique opportunity to gain a complete understanding of the multiple controls on flow characteristics and the effects of variable flow on the functioning of this severely degraded wetland will have implications for both the Everglades and wetland and stream restoration efforts throughout the world.

<u>Contact Information</u>: Jai Singh, National Research Program, U.S. Geological Survey, 430 National Center, Reston, VA 20192, USA, Phone: 703-648-5467, Fax: 703-648-5484, Email: jdsingh@usgs.gov

CRITERION FOR WETLAND HYDROLOGY: EFFECTS OF GROWING SEASON AND SATURATION DURATION

R. Wayne Skaggs
North Carolina State University, Raleigh,NC, USA

The criterion for wetland hydrology is based on the presence of saturated conditions for a continuous period of a given duration during the growing season. A recent Regional Supplement to the Corps of Engineers Wetland Delineation Manual for the Atlantic and Gulf Coastal Plain proposes changes in the growing season that would extend it to 365 days in many locations. A computer simulation study was conducted to examine the effect of changes in the growing season on lands that would satisfy the criterion for wetland hydrology at Plymouth, NC. The model DRAINMOD was used with 50 years of weather data to predict daily water table depths on sites that would satisfy the existing wetland hydrologic criterion under growing seasons defined by median dates of 28^{o}F air temperature and a 365 day (365d) growing season. Results showed that the proposed change in the growing season, without changing other elements of the hydrologic criterion, will substantially reduce the saturation (or high water table) requirements for wetland hydrology. A site that would have a water table within 30 cm of the surface for a continuous period of 14 days in 50% of the years during a 365d growing season at Plymouth, NC would satisfy the same criterion for a continuous period of only 7 days during the standard 28F growing season. Average drainage and drawdown rates for a threshold site for the 365d growing season would be about 3 times higher than corresponding rates for a threshold site for the 28F growing season. Lateral impacts of a drainage ditch on adjacent wetlands, as determined by current methods, would be reduced by an average of 42% by changing the growing season to 365d at this location. Increasing the growing season to 365 days would substantially reduce saturation requirements at the wet end of the wetland spectrum (12.5% of the growing season) which is typically required for restoration of prior converted wetlands in mitigation projects. More research is needed to develop scientifically rigorous, regionally specific criteria for wetland hydrology, but, based on past research, a logical path forward for determining such criteria can be defined.

<u>Contact Information</u>: Wayne Skaggs, North Carolina State University, PO Box 7625, Raleigh, NC 27695-7625, USA, Phone:919-515-6739, Email: wayne_skaggs@ncsu.edu

CONFIDENCE INDEX COMPUTATION FOR THE EVERGLADES DEPTH ESTIMATION NETWORK (EDEN) WATER-LEVEL SURFACES

Pamela A. Telis[1] and *Bryan McCloskey*[2]
[1]U.S. Geological Survey, Jacksonville, FL, USA
[2]U.S. Geological Survey, St. Petersburg, FL, USA

The Everglades Depth Estimation Network (EDEN) supports the restoration of the Everglades by providing scientists and water-resource managers with current water-level and water-depth Information for the entire freshwater part of the greater Everglades (Telis, 2006). The EDEN water-surface elevation model uses the daily median values of up to 240 of the EDEN network water-level gages to create spatially continuous interpolations of the water-surface elevation (Pearlstine, 2007; Volin, 2008). These daily surfaces are created on a 400 x 400 meter grid (Jones and Price, 2007a) for the period January 1, 1990 to current.

A confidence index (CI) map is produced each day and provides a general indication of confidence in the accuracy of the modeled water levels by grid cell. The CI for a grid cell is a geometric mean based on three parameters weighted by level of significance; 1) distance from the nearest water-level gage multiplied by a constant based on the type of data at the gage that day (i.e. measured or observed), 2) distance from canals or model domain boundaries, and 3) cross-validation error for the nearby gage from the water-surface model. Each parameter is normalized to range between 0.1 and 1. For example, the parameter for distance from the nearest gage equals 1 at the gage and 0.1 greater than 10,000 meters from the gage and linearly prorated based on distance between the gage and 10,000 meters. The final computed CI for a grid cell ranges from 1 for the highest confidence and 0.10 for the lowest confidence. The CI is intended to provide a general guideline to users about the accuracy of the water level estimated by EDEN and users are cautioned to not extend the confidence index beyond the limits of the data. For example, the modeled water level at a grid cell close to a gage where the model estimates and the gage data closely agree should have a higher CI than the modeled water level at a grid cell near a canal or boundary and distant from a gage where our knowledge of the hydraulics is less certain. Limited resources for Everglades water-level monitoring have resulted in fewer gages. The decrease in data density may decrease the accuracy of the EDEN water-level estimates and subsequent computation of water depths. Research is needed to evaluate data density impacts on the input parameters to determine the confidence or, more precisely, an error band around the EDEN water-level estimates.

<u>Contact Information</u>: Pamela A. Telis, U.S. Geological Survey, Florida Water Science Center, 701 San Marco Blvd., Jacksonville, FL 32205, USA, Phone: 904-232-2602, Fax: 904-899-5097, Email: patelis@usgs.gov

REVISIONS TO THE EVERGLADES DEPTH ESTIMATION NETWORK (EDEN) SURFACE-WATER MODEL

***Pamela A. Telis*[1] and *Zhixiao Xie*[2]**
[1]U.S. Geological Survey, Jacksonville, FL, USA
[2]Florida Atlantic University, Boca Raton, FL, USA

The Everglades Depth Estimation Network (EDEN) surface-water model models daily, near-real-time water-level surfaces for the greater Everglades using a network of approximately 240 water-level gages. When combined with the EDEN ground-elevation model for the Everglades, daily surfaces of water depth are produced and provide scientists and managers with hydrologic data to support biological and ecological assessments that measure the way the ecosystem responds to implementation of the Comprehensive Everglades Restoration Plan (CERP).

In 2007, Pearlstine (Pearlstine et al, 2007) modeled water levels using Geostatistical Analyst Wizard in ESRI ArcGIS 9.1 based on water levels measured at a network of gages throughout the Everglades. This first version of the EDEN surface-water model (EDEN V1) provides daily continuous mathematical representation of the water surface in a 400-by-400 meter grid spacing stored in NetCDF format which allows rapid retrieval of geo-coded time-series data and input to ArcGIS.

Feedback from users of the EDEN V1 model, gage network and other data updates, and improved understanding of the flow dynamics, particularly near canals, encouraged the EDEN team to reassess and revise the water-surface model. A summary of the revisions to the EDEN V1 model to develop the EDEN V2 surface-water model are:

<u>Model platform changes</u> - Python programming and the ESRI ArcGIS9.3.1 Geoprocessing package replaces WinBatch and ESRI ArcGIS 9.1 and creates a more efficient model that is easier to run and update.

<u>Expansion of the EDEN domain</u> - The model domain is expanded to include the remainder of Big Cypress National Preserve and Everglades National Park along the southwest coast of Florida.

<u>Development of subarea models for selected basins</u> - Subarea models developed for Water Conservation Areas 1, 2B, and 3B, and Pennsuco Wetlands better represent the hydrology of these basins. These surfaces are then merged to the full-domain model for the final daily water surface.

<u>Changes to canal files</u> - Several canal files were updated, added, or deleted to better represent the hydraulic conditions near canals.

<u>Updated water-level gage data</u> - Water-level gage data for the EDEN V2 model is updated by adding, deleting and revising gage data based on new Information about the gage network.

A series of difference maps were created for the EDEN model domain to illustrate differences in daily water surfaces obtained using version 1 and version 2 models. Some users may find that, for their study area, the newly revised surfaces are not significantly different from the previous surfaces and will not require updated analyses of the hydrologic data.

<u>Contact Information:</u> Pamela A. Telis, U.S. Geological Survey, Florida Water Science Center, 701 San Marco Blvd., Jacksonville, FL 32205, USA, Phone: 904-232-2602, Fax: 904-899-5097, Email: patelis@usgs.gov

USE OF EVERGLADES DEPTH ESTIMATION NETWORK (EDEN) TO EVALUATE THE WATER CONSERVATION AREA 3A SNAIL KITE TRANSITION STRATEGY

Pamela A. Telis[1], *Bryan McCloskey*[2], *Heather C. Tipton*[3] and *Kevin Palmer*[3]
[1]U.S. Geological Survey, Jacksonville, FL, USA
[2]U.S. Geological Survey, St. Petersburg, FL, USA
[3]U.S. Fish and Wildlife Service, Vero Beach, FL, USA

Historically, Water Conservation Area 3A (WCA3A) supported a large percentage of the endangered Everglades snail kites that nested and foraged in the Everglades. In the 2000's, the snail kite productivity began to decline correlating with a decrease in the apple snail egg production. These observations may stem, at least in part, from a shift in water-management operations. Wet season water levels were maintained too high for too long in the fall and winter followed by a rapid recession to extremely low water levels during and after the breeding season. In 2008, the U.S. Fish and Wildlife Service (USFWS) initiated the Multi-Species Transition Strategy for WCA3A to address the reduction in snail kite and apple snail productivity and juvenile snail kite survival. The EDEN datasets were used to evaluate recommended water-level modifications in that Strategy.

To reduce adverse impacts on endangered snail kites habitats attributed to water-management operations, the USFWS and researchers proposed a range of seasonal water levels or depths to improve snail kite and apple snail habitat requirements. The Strategy was expanded to address other imperiled species and natural resources, offering recommendations about specified trimester water levels and rates of water-level change. These recommendations use the average water level at three long-term gages in northern, central, and southern portions of WCA3A to guide water-management operations. However, USFWS biologists recommended that modeling be conducted to better understand how recommended water levels translate across the WCA3A landscape.

In a pilot effort, EDEN modeled water levels and depths for WCA3A are used to evaluate the WCA3A Multi-Species Transition Strategy emphasizing hydrologic conditions for snail kites and apple snails. Several technical issues are tested, such as the efficacy of the three-gage average approach to assessing ideal water depths in wet prairie for these species during the breeding season, the variance of water depths for combinations and ranges of the three-gage average, and comparison of potential alternative performance metrics that improve hydrologic conditions for these species.

An EDEN tool based on the water-level recommendations in the Strategy allows resource managers to monitor conditions real-time for species such as snail kites and apple snails and anticipate critical conditions before they occur giving water managers time to respond.

Contact Information: Pamela A. Telis, U.S. Geological Survey, Florida Water Science Center, 701 San Marco Blvd., Jacksonville, FL 32205, USA, Phone: 904-232-2602, Fax: 904-899-5097, Email: patelis@usgs.gov

ISOLATED WETLANDS – THE GROUNDWATER CONNECTION -1. WATER TABLE MONITORING

Daniel L. Tufford[1]*, Amy J. Keyworth*[2]*, Rick Bolich*[2]*, Chenille Williams*[1]*, Virginia Baker*[3] and *John Dorney*[4]
[1]University of South Carolina, Columbia, SC
[2]NC, Division of Water Quality, Aquifer Protection Section, Raleigh, NC
[3]NC, Division of Water Quality, Wetlands Program Development Unit, Raleigh, NC
[4]Atkins, Raleigh, NC

Isolated wetlands (IW) are so named because they lack a surface water connection to waters of the United States. This regulatory context has resulted in recent changes in whether and how they are treated by agencies responsible for regulating IW under the Clean Water Act (CWA). Although no surface connection exists it is generally understood that IW have a groundwater connection to regulated waters. It is necessary to understand the nature of this connection so that accurate assessments can be made of the ecological processes and functions of IW in helping achieve the goals of the CWA.

From 2008-2011 two projects studied subsurface hydrologic connectivity of IW to nearby regulated surface water on the Coastal Plain in North (NC) and South Carolina (SC). Transects of water table monitoring wells with water level loggers were deployed at ten IW in NC and five in SC. For three of the IW, wells were deployed around the wetland to see if flow occurred in any direction other than toward the surface water. Climate conditions during the studies ranged from severe drought to very wet. All wetlands showed subsurface hydrologic connectivity to adjacent surface water although the connection had different characteristics among IW and varied seasonally at each IW. Subsurface hydrology was dependent on precipitation patterns and position on the landscape. While most IW had a temporally continuous subsurface connection to the adjacent surface water, for two IW at one location it only existed during very wet conditions. Radial flow was detected at some sites and in one case the subsurface water flowed through the IW from upslope land on one side toward the lower elevation adjacent surface water on the opposite side. There were two droughts, one severe, during the studies. Water table elevation was severely depressed but in most cases the subsurface connection did not break. The water table elevation rises rapidly in response to precipitation in the IW and the sandy upland soils of the Coastal Plain. Sustained recovery from drought requires wet conditions for several weeks.

Contact Information: Daniel L. Tufford, University of South Carolina, Department of Biological Sciences, 715 Sumter St., Columbia, SC 29208, USA, Phone: 803-777-3292, Fax: 803-777-3292, Email: tufford@sc.edu

HYDROLOGIC CRITERION OF HYDRIC SOILS

Michael J. Vepraskas
North Carolina State University, Raleigh, NC, USA

Wetlands in the United States that are protected by state and federal laws are identified by their hydric soils, wetland hydrology, and hydrophytic vegetation. Hydric soils are easily identified by color characteristics termed *hydric soil field indicators* that form under saturated and anaerobic conditions. However, wetland hydrology is difficult to assess on site, because reliable field indicators have not been identified. This presentation will describe how selected hydric soil field indicators relate to wetland hydrology requirements that require a water table be within 30 cm of the surface for 14 days or more during the growing season in over half the years. Studies were conducted at five sites in North Carolina in both wetland and upland plots. Soils ranged from Aquic Paleudults to Typic Haplosaprists across all sites. The water-table simulation model DRAINMOD was calibrated to soil conditions in individual plots. Long-term rainfall data were used with the calibrated models to compute 40 years of daily water table data to represent both wet and dry years. It was found that the hydric soils with field indicators composed of organic materials in layers over 20 cm thick (Histosol and Histic epipedon field indicators) met wetland hydrology requirements each year, and in addition were ponded with water for periods between 67 to 139 days on average each year during the growing season. Plots in mineral soils having the Dark Surface (S7) indicator as well as the Sandy Mucky Mineral (S1) indicator also met the saturation requirements for wetland hydrology every year, and were ponded for only 3 days per year on average. Other mineral soils with an Umbric Surface (F13) or a Depleted Matrix (F3) field indicator met wetland hydrology requirements in approximately 95% of the years, and had water tables within 30 cm of the surface for 40 days per year on average. The Redox Depressions (F8) field indicator occurred in a small depression that was saturated for 87% of the year for periods averaging approximately 30 days. These results showed that hydric soil field indicators can be calibrated to long-term water table data that will allow precise assessments of wetland hydrology on-site. Similar studies can be conducted to identify reliable wetland hydrology field indicators.

Contact Information: Michael J. Vepraskas, Soil Science Department, Box 7619, NC State University, Raleigh, NC 27695-7619, USA, Phone: 919-515-1458, Fax: 919-515-2167, Email: Michael_vepraskas@ncsu.edu

TESTING WETLAND HYDROLOGY CRITERIA MODELING WITH LONG TERM WATER TABLE DATA

Thomas M. Williams
Baruch Institute of Coastal Ecology and Forest Science, Clemson University, Georgetown, SC, USA

A particular site is a wetland under the Clean Water Act if it exhibits vegetation, soils and hydrology that are associated with soil saturation and anaerobic conditions. For undisturbed sites, vegetation and soil characteristics are generally sufficient for unambiguous determination of the wetland status of a site. However, for many sites vegetation and soils may not be in equilibrium with the current hydrology. Also, soils and vegetation are generally highly altered on proposed restoration sites. A method is needed to determine if a site has wetland hydrology in absence of soil or vegetation indicators.

The measurement of wetland hydrology requires only a simple field procedure of constructing a shallow well and monitoring of water table position. In the southeastern US, the main difficulty in determination of wetland hydrology is rapid changes in water table depth due to variability of weather patterns. How much water table depth data is required to satisfy the requirement that the wetlands criteria are met in half of all years?

Skaggs et al. (1995) have proposed a simulation modeling (Threshold Wetland Simulations,TWS) approach that allows wetlands hydrology evaluation using short term monitoring at a site. A long term study of water table position near Georgetown SC provides an opportunity to examine the reliability of such an approach.

From 1975 through 1989 a series of 45 shallow water table wells were monitored on Hobcaw Forest, east of Georgetown SC. Fourteen of these wells were located on Leon soil series, a particularly difficult series that may or may not exhibit hydromorphic indicators. Analysis of the data from wells on Leon series in this study also showed wide variation hydromorphic indicators and periods of saturation, including sites of clearly wetland hydrology and others clearly non-wetland. Many of the wells, located on Leon soils in this study, have short term continuous recordings for various periods between 1975 and 1989, allowing application of the TWS technique. In this presentation results of application of TWS will be compared to wetland hydrology determination based on the entire 14 year water table record, which generally reflected the presence or absence of hydromorphic soil features.

Contact Information: Thomas M. Williams, Baruch Institute of Coastal Ecology and Forest Science, PO Box 596, Georgetown, SC. 29442, USA, Phone 843 546 6318, Fax 843 546 6296, Email: tmwllms@clemson.edu

UNCOUPLING EFFECTS OF CLIMATE CYCLES AND LAND USE UPON WATER-LEVEL DYNAMICS AND AMPHIPOD DENSITIES IN WETLANDS OF THE PRAIRIE POTHOLE REGION

Mark T. Wiltermuth[1,2] and *Michael J. Anteau*[1]
[1]U.S. Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, ND
[2]North Dakota State University, Environmental and Conservation Sciences Program, Fargo, ND

Amphipods (freshwater shrimp, scuds) are important forage for waterfowl and waterbirds that must acquire and maintain nutrient reserves for migrating and breeding. Amphipods occur commonly in larger, more-permanent prairie wetlands and density of amphipods can indicate wetland and water quality because they are sensitive to contaminants, disturbances in uplands, and invasive species. Historically, productivity and density of amphipods in prairie-pothole wetlands primarily was driven by inter-annual hydrological dynamics. The abundance and quality of wetlands in the Prairie Pothole Region has declined likely due to landscape modifications, primarily agriculture. In 2004 and 2005, amphipod densities throughout the upper Midwest (including North Dakota) were markedly lower than they were historically. We compared amphipod densities from wetlands throughout North Dakota in 2010 and 2011(pulse years in cycle) to those from there in 2004 and 2005 (drying years in cycle). We tested our hypothesis that wetlands in highly modified landscapes have higher and more stable water levels than wetlands in less modified landscapes. Further, we examined how amphipod densities were influenced by water-level change, agricultural intensity and soil quality in the catchment, wetland habitat characteristics, and fish densities. The ability to uncouple and understand the influences of hydrological regime and landscape modification upon productivity of prairie wetlands is a prerequisite step to modeling effects of climate and land-use change.

Contact Information: Mark Wiltermuth, North Dakota State University, 8711 37th St SE, Jamestown, ND 58401, USA, Phone: 701-253-5567, Email: mark.wiltermuth@ndsu.edu

GROUNDWATER FLOW REVERSAL AT A RAISED BOG IN SAROBETSU MIRE, MID LATITUDE PEATLAND

H. Yamada[1], *R. Hiraoka*[2], *Y. Tanaka*[2] and *T. Hirano*[1]
[1]Research Faculty of Agriculture, Hokkaido University, Sapporo, JAPAN
[2]Graduate School of Agriculture, Hokkaido University, Sapporo, JAPAN

Reversals in the groundwater flow direction were observed at raised bogs in high-latitude peatlands. Upwelling is believed to have resulted from evaporation during the dry season. This internal hydrological mechanism is important to evaluate fluxes of dissolved carbon as DOC, CO2 and CH4 and to elucidate the raised bog formation process. However, the control factors have never been clarified using time series measurements in mid-latitude peatlands, which show no clear seasonal difference between dry and wet seasons. Therefore we investigated the reversal and its control factors in a raised bog located in Sarobetsu Mire (45° 6'N, 141°41'E), northern Japan.

We selected two study sites: top and low lawns in the raised bog (1 km diameter, 6 m above sea level). Their elevation difference between the highest and lowest ground surface was around 0.4 m. The peat depth was about 3–7 m. Annual mean precipitation was around 1000 mm yr-1. Commonly, the snow depth is greater than 0.5 m in winter (from late November through April).

Vertical hydraulic gradients were monitored continuously using automatic recording piezo meters during 2008–2011. Vertical ground water fluxes were calculated according to Darcy's Law using vertical hydraulic conductivity, which was measured at each site. Additionally, precipitation, evapotranspiration, and soil temperature were measured at each site.

Reversals were observed at both sites. The vertical flux of the top was smaller than that of the low lawn, and the former ranged from -0.3 to 0.2 mm d-1 (plus is upwelling). Weak upwelling was observed in summer (July–September) and winter. Soil has never frozen in winter because the soil temperature was higher than 0°C. The summer upwelling tended to delay the peak of evapotranspiration. Therefore, results suggest that summer upwelling resulted from the evaporation effect. In winter, the upwelling flux was higher than during the summer upwelling. Although the low lawn flux invariably showed down-welling, upwelling occurred in winter as it did at the top site. Results show that larger reversal occurred during snow fall than during the summer. Groundwater lost in summer might be absorbed from snow melt by reversal at mid-latitude peatlands that have snow fall.

Contact Information: Hiroyuki Yamada, Research Faculty of Agriculture, Hokkaido University, Kita 9 Nishi 9, Kita-ku, Sapporo 060-8589, JAPAN, Phone: +81-11-706-4183, Fax: +81-11-706-4183, Email: hiroyama@env.agr.hokudai.ac.jp

WETLAND ECOSYSTEMS PROCESSES & FUNCTIONS - LANDSCAPE ECOLOGY

USE OF ASSISTED MIGRATION AND COMMUNITY ZONATION PATTERNS TO BUILD A CLIMATE-RESILIENT COASTAL LANDSCAPE

Loretta L. Battaglia and *Hannah J. Kalk*
Southern Illinois University, Carbondale, IL, USA

Conspicuous zonation of coastal plant communities occurs along gradients of soil moisture, salinity, and nitrogen availability. Species composition shifts along these gradients correspond to changes in key ecosystem functions such as primary production, decomposition and nutrient cycling. Species that occupy coastal transition ecosystems spanning marine to terrestrial habitats are among the "first responders" to global climate change. Two highly certain effects of global climate change, sea-level rise and shifts in tropical storm regimes, have the potential to dramatically affect biota in these relatively narrow belts of coastal vegetation that are distributed along a gentle, but ecologically significant, topographic gradient. Low-lying coastal ecosystems along the northern Gulf of Mexico (NGM) are already experiencing sea level rise, and the rate of rise is expected to increase in the coming decades; tropical storms are also predicted to intensify and deliver massive storm surges farther inland.

A major challenge to successful restoration of systems experiencing rapid climate change is determining appropriate targets. In some cases, anticipatory restoration may be the most cost-effective and ecologically beneficial approach given that biophysical conditions are changing and are likely to continue to change in the future. Along the NGM, recent hurricane storm surges have resulted in the federal buyout of numerous properties for which appropriate restoration targets are unclear. Community translocation, the intentional relocation of species assemblages within or outside of their native range, may provide an opportunity to instill ecological resilience and ease the transition of these sites to assemblages better adapted to future conditions. We collected replicate propagule sods from intact plant community zones across the coastal transition at Grand Bay NERR and distributed them onto five degraded properties in a randomized design.

After one year, diverse assemblages with numerous indicator species from the original zones had established, and noxious species were greatly reduced on all restoration plots relative to untreated areas. The response of vegetation following application of freshwater marsh and maritime pine island sods from downslope communities indicated that they were well suited to the sites; sods of wet pine flatwoods also responded favorably. Variation among replicate sites suggests that proximity to source populations of non-target species can also drive patterns of community composition and dynamics. Results of our study demonstrate that establishment of seaward assemblages is possible in upland habitats and suggest that anticipation of climate change should be incorporated into development of coastal restoration targets and planning. Development of an adaptive framework for restoration of coastal ecosystems will require a better understanding of constraints on futuristic restoration, responses of experimental assemblages to new abiotic conditions, functional capacity of restored communities, and resilience of these ecosystems to climate change.

Contact Information: Loretta Battaglia, Southern Illinois University, Mailcode 6509, Carbondale, IL 62901, USA, Phone: 618-453-3216, Email: lbattaglia@plant.siu.edu

MOVEMENT AND ACTIVITY PATTERNS OF FISHES IN A DYNAMIC LANDSCAPE

Michael R. Bush and *Joel C. Trexler*
Florida International University, Miami, FL, USA

Fish movement can influence community structure in a spatially and temporally heterogeneous landscape such as seasonally flooded wetlands of the Everglades, Florida, USA. Water levels rise in the Everglades beginning in the rainy season, June through November, and slowly decline throughout the dry season, December through May. This seasonal pattern of hydrologic variation is closely tied to several biological processes, including fish movement. Under historical conditions it is assumed that fishes were found throughout the landscape in the wet season and forced to deep-water refuges as the dry season progressed, though much of the ecosystem remained flooded in all but very dry years. In recent decades, the Everglades have been divided by an extensive network of canals and levees, disrupting this flow pattern, and drained such that much of the ecosystem now dries in all but relatively wet years. In order to document small fish movement in response to seasonal hydrological variation, we used drift fences that intersect in an X pattern with traps facing each of four directions to estimate catch per unit effort (CPUE), a measure of trap encounter rate, and movement directionality. We supplemented those data with density estimates from 1-m^2 throw traps, and used the ratio of CPUE and density as an index of activity. Fifteen sampling locations were established ranging from 0 to 8 km from canals. For large fishes (Florida bass and bowfin), we surgically implanted radio tags that were relocated on a weekly basis.

We found that canal and levee proximity and hydroperiod play a role in fish density, directionality of movement, and activity, and the effects of these variables were species-specific. For example, eastern mosquitofish tended to move towards the canal in the late wet season, while bluefin killifish showed movement away from the canal at that time. Dollar sunfish showed similar activity throughout the landscape and but directionality, regardless of canal or levee proximity, and showed greater activity during the late wet season. Movement by large fishes was widely varied and not species specific, with some fishes moving large distances in both the canal and marsh over a short period of time, while other fishes barely moved. Marsh movements did tend to be shorter than canal movements. These and other species-specific results indicate that the presence of manmade structures can affect community structure and ecological processes moderated by fish movements in wetlands.

<u>Contact Information</u>: Michael R. Bush, Department of Biology and Southeast Environmental Research Center, Florida International University, North Miami, FL 33181, USA, Phone: 305-919-4110, Email: MikeRBush@gmail.com

TREE ISLANDS: LANDFORMS AND UNDERLYING BIOTIC FEEDBACKS

Paolo D'Odorico[1], *Vic Engel*[2], ***Joel A. Carr***[1] and *Matthew Baddock*[1]
[1]University of Virginia, Charlottesville, VA, USA
[2]Everglades National Park, Homestead, FL, USA

Tree islands are ecogeomorphic features found in patterned freshwater wetlands such as the Everglades (FL), the Pantanal swamps (Brazil), and the Okavango delta (Botswana). They are typically bordered by marshes and wet prairies, in a highly heterogeneous landscape where woody plants coexist with lowland herbaceous vegetation thereby forming wet savannas. These landscapes exhibit an uneven distribution of soil resources, with soil phosphorus concentrated under the canopies of trees (fertility islands), whereas limited P availability is found in the marshes. This patchy landscape sustains high levels of biodiversity.

Despite the important role they play in providing habitat for a variety of plant and animal species – including in particular numerous species of migrating birds – the ecogeomorphic processes determining the stability and resilience of tree islands remain poorly understood. In particular, it is unclear what controls the relation between form and processes in tree islands and in their surrounding landscapes. Here use a number of morphometric indicators to characterize the size, shape, density, and spatial arrangement, of tree islands in the Everglades freshwater wetlands. By comparing changes in these indicators over the past 60 years we contrast the geomorphic properties of tree islands that have persisted or disappeared ("ghost islands"). We use these results to identify processes determining the stability and resilience of tree islands. To this end, we develop a process-based model that relates vegetation dynamics to nutrients and soil accretion/loss through ecogeomorphic feedbacks and interactions with hydrologic drivers. We show that the stable coexistence of tree islands and marshes emerges as an effect of their both being (meta-) stable states of the system.

Tree islands are found to have only a limited resilience: changes in hydrologic conditions or vegetation cover may cause an abrupt shift to a stable marsh state. Tree island susceptibility to abrupt and discontinuous transitions to a marsh state needs to be accounted for while developing a plan for their management, conservation and restoration.

<u>Contact Information</u>: Paolo D'Odorico, Department of Environmental Sciences, University of Virginia, Box 400123, Charlottesville, VA 222904, USA, Phone: 434-924-7241, Email: paolo@virginia.edu

MAPPING FLOODPLAIN DYNAMICS OF THE AMAZON RIVER BASIN USING THE SPACE-BORNE ALOS PALSAR SYNTHETIC APERTURE RADAR

Bruce Chapman[1], *Laura Hess*[2], *Bruce Forsberg*[3] and *Kyle McDonald*[4]

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA
[2]University of California, Santa Barbara, California, USA
[3]Instituto Nacional de Pesquisas da Amazonia, Manaus, Brazil
[4]The City College of New York, City University of New York, New York, New York, USA

The extent and variability of inundated wetland areas play a key role in ecosystem dynamics. Despite their importance, current knowledge of the extent of global wetlands and the seasonal variability of surface waters is poor. Global land cover datasets derived from moderate-resolution optical sensors generally include few or no wetland classes other than open water, and do not capture the high temporal variability of surface waters. Coarse-resolution global mapping of seasonal inundation allows consistent multi-year comparison of inundated areas; however, the spatial resolution is not sufficient for some applications and validation of coarse-resolution results is difficult without finer-resolution datasets for comparison.

Consequently, NASA has funded a research task to assemble global inundated wetlands products based on data from a variety of space-borne sensors. Data from one set of sensors will be used to characterize global-scale seasonal inundation at coarse resolution (10 kilometer or worse). Moderate resolution results (100 meters or better) will be based on space-borne L-band Synthetic Aperture Radar (SAR) data from the Japan Aerospace Exploration Agency's (JAXA) ALOS PALSAR instrument.

ALOS PALSAR data are provided to this task through an international science program led by JAXA called the Kyoto and Carbon (K&C) initiative. The objective of the K&C Initiative is to support data and Information needs of international environmental conventions, carbon cycle science, and conservation of the environment. The initiative established a global systematic observation strategy for ALOS PALSAR that includes repetitive and consistent mapping of the world's major wetland regions.

The Amazon River basin is a major focus area of the ALOS K&C initiative. The entire Amazon River basin from the source to the sea is mapped at 100-meter resolution every 46 days. This data set therefore provides an unprecedented opportunity to study this river's floodplain dynamics at high spatial and temporal scales.

Contact Information: Bruce Chapman, Radar Science and Engineering Section, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, USA, Phone: 818-354-3603, Email: bruce.chapman@jpl.nasa.gov

EXOGENOUS AND ENDOGENOUS CONTROLS IMPACT EVOLUTION AND RESILIENCE OF WETLAND VEGETATION PATTERNS

Yiwei Cheng[1], *Marc Stieglitz*[1,2], , *Greg Turk*[3], *Joshua Ross*[1] and *Victor Engel*[4]

[1] School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta, GA, USA
[2] School of Earth Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA, USA
[3] School of Interactive Computing, Georgia Institute of Technology, Atlanta, GA, USA
[4] South Florida Natural Resources Center, Everglades National Park, Homestead, Florida, USA

The emergence of spatial vegetation patterns in wetland ecosystems is a consequence of exogenous (e.g. topography) and endogenous (e.g. spatial vegetation feedbacks) controls. However, to date, there have been no systematic studies to understand the relative roles these two controls play in determining the vegetation patterns. Such understanding is critical to improving future prediction of the responses of wetland ecosystems to perturbations. In this study, the relative degrees to which topography (exogenous control) and spatial vegetation feedbacks (endogenous control) operate are systematically elucidated by studying the evolution and the maintenance of wetland vegetation patterns across a series of landscapes of different geomorphologies. Results show that the dynamic behaviors of the vegetation patterns vary for different geomorphologies, impacting the response of the vegetation pattern to alterations in rainfall and nutrient input regimes.

Contact Information: Yiwei Cheng, School of Civil and Environmental Engineering, Georgia Institute of Technology, 790 Atlantic Dr, Atlanta, GA 30332-0355, USA, Phone: 404-512-2698, Email: gtg985z@mail.gatech.edu

DIFFERENTIAL USE OF WETLAND HABITAT BY SMALL FISHES AND A LARGE PREDATOR IN COASTAL MARSHES OF EASTERN GEORGIAN BAY, LAKE HURON

Jonathan D. Midwood and ***Patricia Chow-Fraser***
McMaster University Department of Biology, Hamilton, ON, Canada

Coastal wetlands provide critical spawning and foraging habitat for fishes. In the Laurentian Great Lakes, diurnal migration of fishes into and out of wetlands is well documented. Movement of fishes among coastal wetlands is more poorly understood but has important implications for conservation and the fish metacommunity. In the predominantly small (<2 ha) coastal wetlands of eastern Georgian Bay, Lake Huron, sustained low water levels have altered fish habitat. In order to manage these wetlands and maintain fish community diversity, it is essential to understand how fishes utilize small, locally situated wetlands. In the summer of 2010 we assessed fish movement in two regions, Tadenac Bay and Moon Island. In each region, 4-5 wetlands located in close proximity were sampled eight times. Fish caught in each wetland were tagged with a wetland-specific colour. Majority of fishes were small-bodied (<125 mm), with pumpkinseeds (*Lepomis gibbosus*) accounting for 70% of the total catch. In 2010, a total of 5694 fish were tagged and 146 of these were recaptured (2.6 %). Of these, 9 (6.2%) were recaptured in a wetland different from where they had been tagged. In 2011, we resampled wetlands in Tadenac Bay to determine over-wintering movements. Of the 3359 fish caught, 23 were tagged (0.7%), and of these only 1 (4.3%) traveled beyond the wetland where it had been originally tagged. For both within-season and annual movements, the majority of fishes recaptured did not travel beyond their wetland of origin. Also in 2011, we implanted radio tags in 12 northern pike (*Esox lucius*) to track their movements among coastal wetlands. Majority of the pike moved beyond our study area. Pike that frequented wetland areas tended to be young (2-5 years) and small (<600 mm). On average, these smaller pike moved among wetlands that were 1.4 km apart, although some moved as far as 3.9 km. Our results suggest that while the vast majority of small-bodied fishes remain in a single wetland throughout the year, large mobile predators use multiple wetlands over relatively large areas during the active season. Results from this study will aid in our understanding of fish metacommunity dynamics, and provide a rationale for delineating wetland complexes at a scale that is appropriate for protecting critical fish habitat in the Great Lakes coast.

Contact Information: Jonathan D. Midwood, McMaster University Department of Biology, 1280 Main St. W., Hamilton, ON, Canada, L8S4K1, Phone: 905-525-9140 ext 27461, Fax: 905-522-6066, Email: midwoojd@mcmaster.ca

RESPONSE OF WETLAND INVERTEBRATE COMMUNITIES TO LOCAL AND LANDSCAPE FACTORS IN OKLAHOMA.

Micah D. Meyer and ***Craig A. Davis***
Oklahoma State University, Stillwater, OK, USA

North central and northwestern Oklahoma contains large areas of depressional wetlands that are important components of the landscape. These wetlands support migrating, breeding, and wintering waterbirds and increase overall biodiversity of region. The wetlands also provide flood storage and groundwater recharge. An important component of wetland health is the invertebrate community. Invertebrates not only provide a food resource for waterbirds but can also impact nutrient recycling and productivity within wetlands. Previous research determined that landuse has an impact on invertebrate communities within these wetlands. Nevertheless, other local and landscape factors may also affect these invertebrate communities. We examined the role landscape factors, such as proximity to other wetlands, size of wetland, wetland density, and landuse composition, had on invertebrate communities to determine whether landscape factors or conditions within the wetland are more important drivers in shaping composition and abundance of these invertebrate communities.

We sampled invertebrates from 58 wetlands during the spring and summer of 2009 and 2010. Research wetlands were located in the alluvial terraces north of the Salt Fork of the Arkansas and Cimarron Rivers in north central Oklahoma. In addition to collecting nektonic, epiphytic, and benthic invertebrate samples, we collected data on vegetation and water quality. We developed a GIS to assess the effects of landscape factors on invertebrate communities.

Overall, we collected 177 and 216 invertebrate taxa in 2009 and 2010, respectively. During 2009, landuse composition within 1 and 2 km, proximity to nearest wetland, wetland density within 1 and 2 km, density of semipermanent wetlands within 1 and 2 km, wetland area within 1 km, and hydroperiod diversity within 1 and 2 km were important predictors of invertebrate taxa richness at the landscape level. At the wetland level, landuse composition within 15 m, wetland hydroperiod, wetland size, coefficient of variation of water depth, coefficient of variation of vegetation complexity, wetland plant richness, turbidity, and ammonia-nitrogen were important predictors of invertebrate taxa richness. Conductivity, plant richness, vegetation complexity, emergent cover, and submergent cover were important predictors of invertebrate taxa richness at the sample site. Adjusted R^2 of the three proceeding models were 36.3, 40.9, and 59.9, respectively. The best combined model, consisting of variables at the landscape, wetland, and sample site level, included 15 predictors with an adjusted R^2 of 65.0, indicating a majority of the variation in taxa richness can be explained by variables at the sample site.

These wetlands are extremely dynamic with the amount of available habitat for invertebrates varying considerably from year to year. Therefore, understanding the drivers of invertebrate populations can lead to more efficient monitoring and can also provide us better knowledge on how to protect and conserve these wetland systems in Oklahoma.

Contact Information: Micah D. Meyer, Department of Natural Resource Ecology and Management Oklahoma State University, 008C Ag Hall, Stillwater, OK 74078, USA, Phone: 218-639-8808, Fax: 405-744-3530, Email: micah.meyer@okstate.edu

AMAZING PATTERN: SELF-ORGANIZATION IN NORTHERN PEATLAND ECOSYSTEMS

Maarten B. Eppinga, *Stefan C. Dekker, Hugo J. De Boer, Max Rietkerk* and *Martin J. Wassen*
Utrecht University, Utrecht, The Netherlands

The surface of northern peatland ecosystems frequently exhibits self-organized patterning of densely vegetated hummocks and more sparsely vegetated hollows. Theoretical studies so far suggest multiple alternative mechanisms that could be driving this pattern formation. The long time span associated with peatland surface pattern formation, however, limits possibilities for empirically testing cause-effect relationships through field manipulations. We present a model that describes spatial interactions between vegetation, nutrients, hydrology, and peat. We use this model to study pattern formation as driven by three different mechanisms: peat accumulation, water ponding, and nutrient accumulation. By on-and-off switching of each mechanism, we created a full-factorial design to see how these mechanisms affected surface patterning (pattern of vegetation and peat height) and underlying patterns in nutrients and hydrology.

Results revealed that different combinations of structuring mechanisms lead to similar types of peatland surface patterning but contrasting underlying patterns in nutrients and hydrology. More specifically, in patterns driven by evapotranspiration (ET) differences, hummocks are characterized by high nutrient availability and low hydraulic head. In contrast, in patterns driven by drainage differences, hummocks are characterized by low nutrient availability and high hydraulic head. These contrasting underlying patterns suggested that the presence or absence of the structuring mechanisms can be identified by relatively simple short-term field measurements of nutrients and hydrology, meaning that longer-term field manipulations could be circumvented.

We test these predictions by comparing nutrient distributions among patterned peatlands in maritime (Scotland), humid temperate (Sweden), and humid continental (Siberia) climates. The areas comprise a climatic gradient from very wet and drainage-dominated (Scotland) to less wet and ET dominated (Siberia) peatlands. Nutrient distribution was quantified as resource contrast, a measure for hummock–hollow difference in nutrient availability. We tested the previous model prediction that there is a trend in the resource contrast along the climatic gradient; from negative (highest nutrient availability in hollows) in Scotland to positive (highest nutrient availability in hummocks) in Siberia. The resource contrasts as measured in vegetation indeed showed a trend along the climatic gradient, corroborating the main prediction of previous models.

Our approach is that we explore multiple peat forming mechanisms in a model environment, and subsequently confront these predictions to empirical data. Although we focused on northern peatlands in previous work, this approach may be useful for (sub)tropical peatlands as well. This notion will be illustrated with current work in progress, in which we use a peat accumulation model to explore to what extent multiple climatic drivers can explain regional differences in the onset of peatland development in the Florida Everglades.

Contact Information: Maarten B. Eppinga, Department of Environmental Science, Utrecht University, 3508 TC Utrecht, The Netherlands, Phone: +31-(0)302533147, Fax: +31-(0)302533147, Email: m.b.eppinga@uu.nl

RESTORING WETLANDS AT HAZARDOUS WASTE SITES

Anthony Esposito
ARCADIS-US, Syracuse, New York, USA

Remediation of hazardous waste sites often results in the exposure of sterile subsurface soils where functioning habitats previously existed. While the removal of contamination from environmental media is an environmental benefit, restoration or enhancement of the previously existing habitats can often be economically accomplished by incorporating post-remedial conditions into restoration designs. Restoration typically requires importing clean topsoil, grading, seeding, and woody plantings. The challenge to achieving successful restoration is selecting the appropriate soils, ground elevations, seed mixes, and plant communities to support the desired habitat functions. This paper summarizes the physical and biological factors to be considered when designing the restoration or enhancement of disturbed wetland habitats. Opportunities often arise for the reduction in backfill quantities if altering the hydrology of a wetland by reducing ground elevations will enhance the previous functions of the wetland. Consideration must also be given to the physical and chemical properties of imported soils to maintain hydrologic interactions and to support the desired plant community. In addition, soil contamination can alter the native plant community, so the removal of non-desirable vegetation, soil, and the associated seed bank or remnant rhizomes provides an opportunity to establish a higher quality plant community. The paper also discusses the importance of assembling a team of engineers, scientists, and biologists during the remedial design process to incorporate the restoration design into the remedial design to enable the economic and environmental benefits of habitat enhancements that take advantage of post-remediation conditions on a hazardous waste site.

Contact Information: Anthony Esposito, ARCADIS-US, Syracuse, NY 13214, USA, Phone: 315-671-9268, Fax: 315-449-0017, Email: Anthony.esposito@arcadis-us.com

LAND COVER CLASSIFICATION AND SEASONAL INUNDATION OF THE PANTANAL OF SOUTH AMERICA USING MULTI-SAR IMAGERY AND AN OBJECT BASED IMAGE ANALYSIS APPROACH

Teresa Evans and *Maycira Costa*
University of Victoria, Victoria BC, Canada

The Brazilian Pantanal is a large continuous tropical wetland with a great biodiversity of flora and fauna species and numerous threatened habitats. The interplay between the distribution of vegetation, the hydrology, the climate and the geomorphology sustains the large diversity of this region, but it is poorly understood at the scale of the entire Pantanal. This study uses multi-temporal L-band ALOS/PALSAR imagery (50m and 100m spatial resolution) and C-band RADARSAT-2 imagery (50m spatial resolution) to map the various habitats and create spatial-temporal maps of seasonal flood dynamics in the Brazilian Pantanal. Initially, the entire Pantanal imagery mosaic was evaluated for radiometric and geometric inconsistencies, and then divided into hydrological sub-regions for subsequent classification. A Level 1 land cover classification was achieved using a novel object-based image analysis (OBIA) classification approach combined with ground truth data and expert knowledge. A Level 2 classification separating Flooded from Non-Flooded regions for eight quasi-continuous temporal periods throughout the year was also accomplished, showing the interannual variability among sub-regions in the Pantanal. The generated maps are a valuable asset for defining habitats required to conserve the Pantanal biodiversity and to mitigate the impacts of human development in the region.

Contact Information: T. Evans, Department of Geography, University of Victoria, PO Box 3060 STN CSC Victoria, BC, Canada V8W 3R4, Phone: 1-250-472-5223, Email: tevans@uvic.ca

DEVELOPMENT OF A NEW HIGH-RESOLUTION GLOBAL INUNDATION MAP

***Etienne Fluet*-Chouinard** and *Bernhard Lehner*
Department of Geography, McGill University, Montreal, Canada

Although their importance for biodiversity, flow regulation and ecosystem service provision is widely recognized, wetlands and temporarily inundated landscapes remain poorly mapped globally because of their inherent elusive nature. Despite recent advances in remote sensing surface water monitoring, current inventories of surface water variations remain incomplete at the global scale due to methodological limitations restricting truly global application. Remote sensing wetland applications such as SAR L-band are constrained by image availability and heterogeneity of acquisition dates, while multi-sensor methods based on passive microwave's coarse spatial resolution cannot discriminate distinct surface water bodies. As a result, the most popular global wetland dataset remains to this day the *Global Lake & Wetland Database* (Lehner and Doll, 2004) a spatially inconsistent database assembled from various existing data sources.

The approach proposed circumvents the limitations of current global wetland monitoring methods by combining globally available hydrogeomorphic data with global multi-satellite inundation data (Prigent et al., 2007) to produce an inundation extent map superior to those currently available. The developed procedure down-scales multi-satellite inundation extent data from its coarse resolution (~27km) of passive microwaves by redistributing the inundated area to the finer spatial resolution (~500m) of *HydroSHEDS* data (Lehner et al., 2006). The down-scaled product map retains the high temporal resolution of the multi-sensor inundation dataset, and from the process emerges new Information on inundation frequency and duration.

A decision tree learner based on various hydro-geomorphic variables is employed to generate inundation class membership probability forthe subsequent redistribution of the inundated area. The decision tree learner is trained and validated usingregional remote sensing inundation maps and is used as a predictive model outside those areas. Redistribution of the inundated area is then predictedwith a seeded region growing process, considering connectivity to river networks. Current test regions at the continental scale exhibit remarkable levels of accuracy (Kappa ~ 70%). As more reference data is included in the model training, results can be expected to improve and will become more globally robust.

Upon completion, this project will offer a globally seamless inundation map at an unprecedented spatial and temporal resolution, and provide a baseline inventory which will open the door to a wide array of possible assessments and applications which were until now data-restricted.

Literature
Lehner, B., K. Verdin, and A. Jarvis. 2008. New global hydrography derived from spaceborne elevation data. Eos 89, no. 10.
Lehner, B, and P Doll. 2004. Development and validation of a global database of lakes, reservoirs and wetlands. Journal of Hydrology 296, no. 1-4: 1-22.
Prigent, C., F. Papa, F. Aires, W. B. Rossow, and E. Matthews. 2007. Global inundation dynamics inferred from multiple satellite observations, 1993–2000. Journal of Geophysical Research 112, no. D12: 1-13.

Contact Information: Etienne Fluet-Chouinard, Department of Geography, McGill University, 805 Sherbrooke Street West, H3A 2K6, Montreal (QC), Canada, Email: etienne.fluet-chouinard@mail.mcgill.ca

DISCHARGE COMPETENCE AS A MECHANISM FOR PEATLAND PATTERN FORMATION

***James B. Heffernan*[1,2,*]*, *Danielle L. Watts*[4], *Matthew J. Cohen*[5]

[1]Department of Biological Sciences, Florida International University, Miami FL 33199
[2]Southeast Environmental Research Center, Florida International University, Miami, FL 33199
[3]School of Natural Resources and Environment, University of Florida, Gainesville, FL 32601
[4]School of Forest Resources and Conservation, University of Florida, Gainesville, FL 32601
[*]Present Address: Nicholas School of the Environment, Duke University, Durham, NC 27701

Regular landscape patterning arises from the operation of spatially-dependent feedbacks, which can undergo catastrophic pattern loss in response to changing landscape drivers. The Florida Everglades historically exhibited regular, linear, flow-parallel orientation of high-elevation sawgrass ridges and low-elevation sloughs of emergence and floating plants; however, this ridge-slough mosaic has degraded through much of its prior extent in response to anthropogenic modification of historic sheetflow. In this study, I use a meta-ecosystem approach to model one proposed mechanism for the establishment, persistence, and loss of this landscape, which we term the discharge competence or self-organizing canal hypothesis. The model assumes non-linear relationships between peat accretion and water depth, and describes microtopographic feedbacks on water depth at varying volumes of flow. Closed-form solutions of this ecohydrologic model demonstrate 1) that this mechanism can produce spontaneous divergence of local elevation, 2) that divergent and homogenous states can exhibit global bi-stability, and 3) that feedbacks that produce this divergence act anisotropically. Predictions that follow from this mechanism, including bi-modality of ridge-slough elevation differences, and increasing elevation divergence with hydroperiod, are supported by an extensive survey of microtopography and vegetation community structure along gradients of anthropogenic hydrologic modification. Thus, discharge competence, when coupled to non-linear peat accretion dynamics, may be sufficient to explain the establishment, persistence, and loss of the ridge-slough landscape, even in the absence of other spatial feedbacks such as sediment or nutrient re-distribution. The potential for global bi-stability suggests that hydrologic restoration may prove insufficient to re-initiate spontaneous pattern establishment, particularly where significant landscape degradation has already occurred. Restoration efforts should focus on preserving relict patterned landscapes via maintenance of historic hydroperiods. More generally, this study illustrates the importance of water flow in wetland pattern formation and the value of simple models, including meta-ecosystem approaches, for investigation of spatial processes.

Contact Information: James B. Heffernan, Nicholas School of the Environment, Duke University, Box 90328, Durham, NC 27708, USA, Phone: 919-613-8004; Email: jim.heffernan@duke.edu

FISH USE OF CANALS AS DRY-SEASON REFUGES IN A SEASONALLY VARIABLE FRESHWATER WETLAND

Ann C. Hijuelos and *Joel C. Trexler*
Florida International University, Miami, FL, USA

Freshwater wetlands are dynamic environments that experience pulses of flow across temporal and spatial scales. The variability of these events leads to periodic drying and flooding and shape unique communities adapted to these abiotic processes. In the freshwater wetlands of the Everglades, Florida, USA, seasonal fluctuation in water levels plays an essential role in the movement of fauna through the landscape. During the wet season, water levels rise as a result of local thunderstorms or tropical systems, inundating wetlands and establishing a level of connectivity across the landscape. This connectivity allows small species such as killifish, livebearers, and juvenile sunfishes to inhabit the marsh and exploit new resources. As water levels recede with the onset of the dry season, fish immigrate to aquatic refuges (i.e., ponds and canals) where they reside until connectivity to the marsh surface is restored. During this critical period, biotic interactions may play an important role in structuring fish communities.

Over the last century, the natural hydrology of the Everglades has been severely altered and variation in water management has affected the way seasonality influences fish communities there. As a result, we hypothesized fish response to pulses of flow will vary across a water-permanence gradient. We quantified fish use of canals adjacent to wetlands that vary in frequency of flooding. A Dual-Frequency Identification Sonar (DIDSON) was used in high frequency mode operating at 1.8MHz to measure the density and size of fish and observe their behavior in two canals, one within a short-hydroperiod wetland and the other within a long-hydroperiod wetland. Sampling occurred from December 2010 to October 2011, encompassing a severe dry-down and "re-wetting" period. Fish density was initially greater in the canal near the short-hydroperiod wetland resulting from an earlier onset of dry conditions and lack of connectivity to the marsh surface. Fish dispersed into the canal near the long-hydroperiod wetland several months later and in large densities. Schooling behavior was observed most frequently by fish < 10 cm during months when there was no connectivity to the marsh surface. Schooling may be a response to predation risk by large, piscivorous fish. Larger fish (> 10 cm) were most abundant in the canals when water levels were lowest in the marsh. It is evident that the region's hydrologic regime and exposure to disturbances shape the distribution and abundance of these communities and influence the aquatic organisms that inhabit these areas.

Contact Information: Ann C. Hijuelos, Department of Biological Sciences, Florida International University, 3000 NE 151 St., MSB 310, North Miami, FL 33181, USA, Phone: 305-919-4103, Email: acomm001@fiu.edu

CHEMICAL SEDIMENTATION, PEAT FORMATION AND DEVELOPMENT OF A PALAEOENVIRONMENTAL RECORD FOR THE SUBTROPICAL COASTAL PLAIN OF MAPUTALAND, SOUTH AFRICA

***Marc S. Humphries*[1]*,** *Finch M. Finch*[2]*, Claudia R. Benitez-Nelson*[3] and *Letitia Pillay*[4]

[1]School of Chemistry, University of the Witwatersrand, South Africa
[2]School of Environmental Science, University of KwaZulu-Natal, South Africa
[3]Department of Earth and Ocean Sciences, University of South Carolina, USA
[4]School of Chemistry, University of KwaZulu-Natal, South Africa

Maputaland is situated on a low-lying coastal plain on the east coast of South Africa. Formed as a result of sea level changes that occurred since the last interglacial (125 Ka), modern Maputaland is host to an extensive and diverse range of estuarine wetland systems, freshwater swamps, floodplains and lakes. This region therefore comprises some of Africa's most diverse and valuable, yet scarce and fragile ecosystems. We have investigated the important role floodplain wetlands play as chemical sinks within the landscape. As a result of variable inflow and high evapotranspiration rates, these seasonally dry systems are often associated with solute accumulation and groundwater salinization. The relationship between vegetation, sediment chemistry and groundwater movement suggests that deep-rooted trees on the floodplain act as evapotranspirational pumps, selectively removing water and causing the subsurface concentration of solutes. Transpiration results not only in the development of saline groundwater, which influences vegetation distribution, but also initiates the precipitation of minerals, such as calcium carbonate and silica. While floodplains act as sites for chemical accumulation, organic deposition occurs in the surrounding lakes and groundwater-fed interdune valleys. Maputaland thus holds great potential for palaeoecological studies within a region characterised by high seasonal climatic variability. A major goal of this study is to understand how spatial variations in these interactions and feedbacks occur, their potential effects on wetland diversity and landscape heterogeneity, and how such interactions contrast with characteristics of more well-studied wetlands from humid and temperate regions. Several vibracores were collected in the peatlands of Maputaland in order to reconstruct late Quaternary vegetation and climate change. Included in our measurements are high-resolution analyses of pollen, charcoal, and diatom assemblages coupled with radiocarbon, lead-210 and other geochemical and isotopic data. Preliminary results reveal the presence of a continuous palaeoenvironmental record that spans the modern day to ~45 000 ^{14}C years ago, the longest record recovered from the south-east coast of Africa. Coring activities within some of the coastal lakes reveal inter-layering between organic-rich sediment, ash, and carbonate dominated sediments, suggesting environmental events that have perhaps had wide significance in the evolution of the Maputaland landscape. The analysis of these deposits is ongoing. As the project continues, we expect to develop a better understanding of the evolution not only of the east coast of South Africa, but the whole south-east African coastal plain.

Contact Information: Marc S. Humphries, School of Chemistry, University of the Witwatersrand, 1 Jan Smuts Avenue, Braamfontein, 2000, Johannesburg, South Africa, Phone: 27-11-71776739, Email: marchump@gmail.com

MECHANISM FOR SOIL STABLE NITROGEN ISOTOPE RATIO AND PHOSPHORUS ENRICHMENT IN TREE ISLANDS

Daniel L. Irick[1], *Binhe Gu*[2], *Yuncong Li*[1], *Patrick W. Inglett*[1], *Michael Ross*[3] and *Alan Wright*[1]

[1]University of Florida, Gainesville, FL, USA
[2]South Florida Water Management District, West Palm Beach, FL, USA
[3]Florida International University, Miami, FL, USA

The concentration of soil phosphorus (P) in tree islands from the Florida Everglades has been reported to exceed soil P concentration of the surrounding marsh. Additionally, soil P concentration appears to vary at the inter-island scale. Heterogeneity of soil P concentration among islands likely suggests the magnitude of P sources to islands may differ. Spatial variability in the deposition of high P content animal waste may explain accumulation of P in tree island soil. Soil P source studies can exhibit challenges in multiple input systems, however investigation of nutrient characteristics which are present in potential P source material may indirectly indicate P source. Bird guano is an example of high P and nitrogen (N) content animal waste which may be differentially deposited at tree islands throughout the Everglades. Investigation of tree island soil and guano nutrient content, and stable nitrogen isotope ratios were conducted to determine if soil stable isotopic analyses can be a useful indicator of P source to tree island soil.

Total elemental analysis and determination of stable nitrogen isotope ratio was conducted on soil (n= 40) and guano samples collected from tree islands in the Everglades. Freshly deposited and aged guano samples were also collected and temporal changes in total C and N, extractable ammonium (NH_4^+), $\delta^{15}N$, $\delta^{13}C$, and P forms were evaluated over a 35 day period. A positive relationship between soil P content and $\delta^{15}N$ in tree island soil suggests deposition of material enriched in P and ^{15}N may explain this pattern. Phosphorus content of guano ranged from 2.1 - 5.7 %, with an average $\delta^{15}N$ of 8.4 ‰. Extractable NH_4^+ increased in fresh guano within 7 days by 0.93 ± 0.06 % (mean ± SE). An increase in $\delta^{15}N$ of 1.31 ± 0.06 ‰ was measured over the same 7 day period. Enrichment of guano $\delta^{15}N$, coupled with an increase in extractable NH_4^+ suggests that ammonia volatilization may play a role in post depositional enrichment of soil $\delta^{15}N$. Additional soil N isotopic fractionation processes should also be evaluated in considerations regarding soil N isotope signature as an indicator of nutrient source. These data provide a direct approach to explain a landscape-scale and biogeochemical mechanism that leads to P and $\delta^{15}N$ enrichment in tree island soil.

<u>Contact Information</u>: Daniel L. Irick, Soil and Water Science Department, Tropical Research and Education Center, University of Florida, 18905 SW 280th Street, Homestead, FL 33031, USA, Phone: 305-246-7001, Email: dirick@ufl.edu

MONITORING PARANÁ RIVER WETLAND DYNAMICS USING MODIS NDVI TIME SERIES

M Salvia[1], ***P. Kandus***[2], *F. Grings*[1] and *H. Karszenbaum*[1]

[1] Grupo de Teledetección, Institute of Astronomy and Space Physics, Buenos Aires, Argentina

[2]Laboratorio de Ecología Teledetección y Ecoinformática, Instituto de Investigaciones e Ingeniería Ambiental (3iA), Universidad Nacional General San Martín, San Martin, Argentina

The largest wetlands in South America are associated with the floodplains of the big rivers. Most of them belong to tropical and subtropical humid climate (Amazonas, Orinoco) but some extend to the subtropical-temperate zone, like those associated to the Paraná River. These wetlands have subregional extension mostly covered by herbaceous vegetation and showing a high spatial and temporal variability of the water table that constrains biogeochemical cycles and fluxes, and supports a very rich and particular biota well adapted to a wide range of water availability and hydroperiods. Paraná River wetlands are important habitat sustaining commercial fisheries, cattle ranching and apiculture providing also roughness surfaces for flood regulation.

Multitemporal satellite images are now of standard use in land cover classification and monitoring of large areas and NDVI (Normalized Difference Vegetation Index) temporal series have been used for monitoring, by means of constructing seasonal activity profiles, obtaining critical Information on phenology and seasonality of vegetation (Paruelo et al, 2001, Orshan, 1989). Even when there is a vast bibliography on the analysis of low or medium resolution NDVI temporal series, most of them were developed for terrestrial environments. Although there are only a few examples for wetland areas, we consider that time series of NDVI could be of great interest to assess processes and functions of the large wetlands of the Paraná floodplain.

Therefore, at regional scale, we used a 8-year of MOD13Q1 product in order to analyze TERRA-MODIS NDVI signal over the large wetland ecosystems of the Paraná River Delta. Our objective was to identify spatial and temporal change patterns based on the hydrologic and plant phenology behavior and to gain insight on the impact of extreme hydrological events (EHE) on the river floodplain. For this, to assess the effect of EHE on wetland NDVI patterns, first we begin by studying vegetation patterns as seen by MODIS in years when no EHE took place (undisturbed). Second, we propose simple models to explain NDVI year-long variation due to phenology. Then using robust statistical tools, we investigate anomalies in NDVI patterns for different types of vegetation in different conditions, usually related to EHE. These anomalies were analyzed using its resilient time and temporal behavior to associate them to extreme environmental disturbances. We have found that marsh vegetation is both the more sensitive to floodplain forcing (flooding, drought, fire) and the one with less resilient time. The effect of these disturbances in marsh vegetation in future wetland dynamics is considered. In particular, the effect of the reduction of the vegetation drag coefficient due to the destruction of marsh overall biomass. We are currently working in mapping and classifying the parameters of the model used for the sample analysis, in order to compose a map that considers both the land cover type and its annual and interannual dynamics.

Contact Information: Mercedes Salvia, Remote Sensing Group, Institute of Astronomy and Space Physics, Pabellón IAFE, Ciudad Universitaria, Casilla de Correo 67 - Suc. 28 (C1428ZAA), Ciudad Autonoma de Buenos Aires - Argentina, Phone: +5411-47890179 ext 226, Fax: +5411-47868114, Email: msalvia@iafe.uba.ar

MONITORING *SPARTINA* MARSHES IN THE ARGENTINE COAST: INTEGRATING BIOPHYSICAL PARAMETERS, HYPERSPECTRAL FIELD DATA AND SATELLITE OBSERVATIONS

Gabriela González-Trilla[1,2], ***Patricia Kandus***[1] and *Jorge Marcovecchio*[2,3]
[1]Universidad Nacional de San Martín (UNSAM), Argentina
[2]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina
[3]Instituto Argentino de Oceanografía (IADO), Argentina

In South America, coastal marshes have their great expression along the humid temperate northern coasts of Argentina, providing recognized ecosystem services. Because functions and values depend on the ecological integrity, there is a growing interest in using environmental indicators to quantitatively determine changes in health of coastal ecosystems. Commonly used and accepted parameters for ecosystem assessment are biomass (Bio) and leaf area index (LAI). However, a deeper understanding is needed about the interactions between biophysical field parameters and the electromagnetic signal from remote sensing.

In this paper we attempt to integrate LAI and Bio acquired at local field scale with satellite remote sensing data from Landsat TM sensor. We calibrate FieldSpec® field radiometer observations with LAI and Bio field data (Bio_{field} and LAI_{field}) of S. *alterniflora* stands at Bahia Blanca Estuary,(Argentina). Bio_{field} and LAI_{field} were estimated by a nondestructive method using permanent sample plots. performed during a two years period (TYP).

Field spectral profiles at different biomass levels was recorded under natural conditions and manipulating standing biomass by means of successive harvestings. We performed regression equations relating Bio and LAI (Eq_{LAI} and Eq_{BIO}) to vegetation indices (VI) derived from field hyperspectral data. The Normalized Difference VI (NDVI) showed logaritmic adjustemts (Eq_{LAI} $R^2 = 0.77$ and Eq_{BIO} $R^2 = 0.72$) whereas the modified soil-adjusted vegetation index (MSAVI) had significant linear regressions (Eq_{LAI} $R^2 = 0.85$ and Eq_{BIO} $R^2 = 0.82$).

Samples of pixels were extracted from 16 Landsat TM scenes callibrated to surface reflectance of the same TYP and the same sites where Bio_{field} and LAI_{field} measurements were performed. TM surface reflectance were transformed into MSAVI ($MSAVI_{sat}$). Bio and LAI were estimated applying Eq_{LAI} and Eq_{BIO} on the $MSAVI_{sat}$ .As a result, Bio and LAI derived from satellite data (Bio_{sat} and LAI_{sat}) were estimated and were compared to Bio_{field} and LAI_{field}.

$MSAVI_{sat}$ seems to followed Bio_{field} and LAI_{field} temporal behaviour of *S. alterniflora*, showing its seasonal pattern. In addition, Bio_{sat} and LAI_{sat} derived from $MSAVI_{sat}$ data correlated positively with Bio_{field} and LAI_{field}, but LAI has better adjustment ($R^2 = 0.79$ and $R^2 = 0.43$ respectively). LAI_{field} and LAI estimated from satellite obsevations (LAI_{sat}) did not significantly differ ($\alpha = 0.05$) for none of the 16 dates analized, showing best fits during summer.

Results obtained in this work indicate that LAI patterns of *Spartina alterniflora* could be monitored by satellite remote sensing data.

Contact Information: Gabriela González Trilla, Laboratorio de Ecología, Teledetección y Ecoinformática (LETyE) Instituto de Investigación e Ingeniería Ambiental (3IA), Universidad Nacional de San Martín (UNSAM) Peatonal Belgrano 3563, piso 1, San Martín Pcia. de Buenos Aires, Argentina, Phone: (54 11) 4580-7264/7300 ext. 106, Email: gabriela.trilla@unsam.edu.ar gabrielatrilla@hotmail.com

REPORTING ON ECOLOGICAL CONDITION AND ECOSYSTEM SERVICES FOR THE 2011 NATIONAL WETLAND CONDITION ASSESSMENT

***Mary E. Kentula**, Teresa K. Magee* and *Amanda M. Nahlik*
U.S. Environmental Protection Agency, National Health and Environmental Effects Laboratory, Western Ecology Division, Corvallis, OR, USA

The first-ever National Wetland Condition Assessment (NWCA) was conducted by the U.S. Environmental Protection Agency (USEPA) in 2011. Vegetation, algae, soil, water chemistry, and hydrologic data were collected at ~900 wetland points across the contiguous United States. The NWCA is the fifth in a series of National Aquatic Resources Surveys (NARS) completed by USEPA and other federal and state partners to improve understanding of the quality of the Nation's waters. A report describing results from the 2011 NWCA is scheduled for completion in 2013. Here, we will discuss the frameworks for reporting on the NWCA. The NWCA report will, at minimum, include the major categories of results describing ecological condition that are found in other NARS reports (e.g., the USEPA Wadeable Stream and Lake Assessments), and has the potential to include new reporting categories as well. Probable result categories for the NWCA are: extent and description of the wetland resource, status of wetland ecological condition (e.g., Index of Wetland Condition, Vegetation Index of Biotic Integrity, or other metrics), extent of wetland area with detectable levels of toxic algae, extent of stressors (e.g., buffer degradation, hydrologic alteration, nutrient loading, etc.), and relationships between stressors and ecological condition. Consideration of the delivery of ecosystem services is a new component of the USEPA NARS assessments. NWCA research will allow USEPA to begin to assess some key wetland ecosystem services. These initial efforts and available research methods support reporting on two major ecosystem services: 1) maintenance of a habitable climate through assessment of the role of wetlands in carbon dynamics, and 2) provision of water for consumption through the use of $\delta^{15}N$ to determine the role of wetlands in denitrification. The results of the 2011 NWCA will provide valuable knowledge that can better inform decision-making for the use, management, and protection of our wetland resources. Subsequent NWCA studies are scheduled on a five year rotation and will give insights into changes over time.

Contact Information: Mary E. Kentula, USEPA, NHEERL-WED, 200 SW 35th Street, Corvallis, OR 97333, USA, Phone: 541-754-4478, Fax: 541-754-4671, Email: kentula.mary@epa.gov

A TEST OF THE NUTRIENT REDISTRIBUTION HYPOTHESIS IN THE EVERGLADES RIDGE AND SLOUGH LANDSCAPE

*Morgan Maglio, **Laurel Larsen**, Gregory Noe* and *Judson Harvey*
U.S. Geological Survey, National Research Program, Reston, VA USA

The Everglades ridge and slough patterned landscape results from spatial variation in rates of peat accretion and organic sediment redistribution. Oligotrophic wetland peat accretion rates are strongly controlled by water level and local nutrient concentrations, which are affected by regional flow patterns, evapotranspiration (ET), and other surface-subsurface hydrologic and biological exchange processes. Feedback between macrophyte distribution, ET, and nutrient accumulation is known to produce regular patterning of boreal bogs. Porewater nutrient measurements suggest that phosphorus accumulation also occurs in Everglades tree islands (Ross et al., 2006), but the extent to which a nutrient accumulation mechanism controls the patterning of Everglades ridges and sloughs has not been well quantified. An alternative hypothesis posits that nutrient exchange is primarily vertical and nutrient dynamics in distinct vegetation communities are independent. In this study, controls on nutrient cycling in ridge and slough vegetation communities were tested to predict how altered flow and nutrient concentrations will impact landscape pattern and ecological function in order to inform future restoration efforts.

A combined sampling/modeling strategy was used to study seasonal variations in the biogeochemistry of adjacent ridge and slough vegetation communities in central Everglades Water Conservation Area 3A. Vertical profiles of surface and subsurface chloride and nutrients were sampled on a monthly basis for 1.5 years within a ridge vegetation community and adjacent flowing slough. The measured chloride profiles were modeled with a one-dimensional advection-dispersion algorithm to optimize conservative transport parameters. Using those parameters, nutrient profiles were modeled to solve for the best-fit source/sink terms within multiple zones, resulting in a matrix of spatial and temporal solute reactivity data.

Results indicate that efficient vertical exchange ensures that ridge and slough biogeochemistry is well mixed during the wet season, although spatial differences in nutrient transformation rates arise from different redox chemistry. During dry periods, when ridges are exposed, ridges and sloughs evolve distinct biogeochemistry due to poor horizontal mixing. Because of their longer exposure, ridges experience greater evapoconcentration of solutes during this period and greater aerobic decomposition. During rewetting, high concentrations of phosphorus (up to about 0.75 µM total dissolved phosphorus) are transported from the ridge subsurface to sloughs, which is opposite of the hypothesized exchange direction in a nutrient accumulation model. Overall, these results suggest that evapotranspiration-driven subsurface nutrient accumulation may be a less important driver of differentiation of Everglades' ridges and sloughs than particulate redistribution of nutrients by flowing water. Restoration efforts should focus on hydraulics and resulting sediment transport as drivers of landscape pattern and ecological function.

Contact Information: Morgan Maglio, U.S. Geological Survey, 430 National Center, Reston, VA, 20192, USA,Phone: 703-648-5877, Fax: 703-648-5484, Email: mmaglio@usgs.gov

SEDIMENT REDISTRIBUTION AND ACCRETION FEEDBACKS: DRIVERS OF LANDSCAPE PATTERN, PROCESS, AND RESTORATION POTENTIAL IN WETLANDS WORLDWIDE

Laurel G. Larsen and *Judson W. Harvey*
U.S. Geological Survey, Reston, VA, USA

Feedback between vegetation and flow can influence landscape pattern at multiple spatial scales. Vegetation can slow flow, inducing sediment deposition locally while routing high, scouring flows to less vegetated regions. In regularly inundated environments, vegetation can also induce in-place peat accretion. However, the mechanisms responsible for the development and stability of different landscape patterns in vegetated flows have remained poorly understood. Recent advances have made possible large-scale models of flow through vegetated environments that can be run over a range of environmental variables and over timescales of millennia (Larsen et al., 2010, 2011). Our quasi-3D cellular automata model couples simulations of shallow-water flow, bed shear stresses, sediment transport, and vegetation dynamics in an efficient manner. That efficiency allowed us to apply the model widely in order to determine how sediment redistribution and accretion feedbacks control landscape pattern and process in general.

The model produced a wide variety of floodplain and wetland landscape patterns found in environments worldwide. Regular, anisotropically patterned wetlands were dominated by allogenic processes (i.e., processes driven by periodic high water levels and flow velocities that redistribute sediment) and were particularly sensitive to hydrologic disturbance. In general, the stability of different wetland pattern types was most strongly related to factors controlling erosion and deposition of sediment at vegetation patch edges, the magnitude of sediment redistribution by flow, patch elevation relative to water level, and the variability of erosion rates in vegetation patches with low flow resistance. In the Everglades ridge and slough landscape, our case study, stable ridges and sloughs parallel to flow arose when bed shear stresses were just sufficient to entrain sediment from sloughs and water levels were deep enough to prevent rapid sawgrass growth. Here we report on new hydrologic connectivity metrics that to compare model-generated landscapes to actual well-preserved portions of the ridge and slough landscape. We find that decreased mean water level, decreased flow velocity, and increased vegetative resistance in sloughs caused rapid degradation of landscape pattern structure, with losses in the hydrologic connectivity of sloughs occurring over a much shorter time than losses in slough area. As exemplified by this case study, feedback between flow and vegetation also causes hysteresis in landscape evolution trajectories that will affect the potential for landscape restoration. Our modeling suggests that flood pulse releases for weeks per year have the potential to halt landscape degradation, preserving well-connected sloughs. As wetlands and floodplains worldwide become increasingly threatened by climate change and land use, the greater mechanistic understanding of landscape pattern and process that our analysis provides will improve our ability to forecast and manage the behavior of these ecosystems.

Contact Information: Laurel Larsen, National Research Program, U.S. Geological Survey, MS430, National Center, Reston, VA 20192 USA, Phone: 703-648-5891, Fax: 703-648-5484,
Email: lglarsen@usgs.gov

CONNECTIVITY OF WETLANDS TO DOWNSTREAM WATERS: CONCEPTUAL FRAMEWORK AND REVIEW

***Scott G. Leibowitz*[1]**, *Laurie C. Alexander*[2], *Bradley Autrey*[3], *Julie DeMeester*[4], *Charles R. Lane*[3], *Stephen D. LeDuc*[2] and *Caroline E. Ridley*[2]

[1]U.S. EPA, NHEERL, Corvallis, OR, USA
[2]U.S. EPA, NCEA, Washington, DC, USA
[3]U.S. EPA, NERL, Cincinnati, OH, USA
[4]AAAS Fellow, U.S. EPA, NCEA, Washington, DC, USA

A river represents the time-integrated combination of all waters contributing to it. Understanding the factors that influence river health and sustainability, as well as its degradation, requires consideration of all the components of the river system and their spatiotemporal interactions. However, wetland effects on rivers have received little attention. Such Information could address science needs regarding the relationship between wetlands and navigable waters arising from the 2006 U.S. Supreme Court's Rapanos case.

We describe a conceptual framework for understanding wetland effects on rivers. Wetlands affect rivers by altering material fluxes, thereby affecting river structure and function. This requires functions that alter material fluxes and connectivity between system components. Wetlands affect material fluxes by serving as sources, sinks, refuges, lags, and/or transformers. Movement of water is the primary mechanism for connectivity between wetlands and rivers, but biological movement also is important. In some cases, lack of connectivity (isolation) is important, as in limiting sediment inputs. Connectivity varies over space and time through expansion and contraction of the river network and transient connection with wetlands and other components. Wetland impacts can increase or decrease connectivity.

We present results of a literature review we conducted to evaluate the physical, chemical, and biological connections between wetlands and rivers. The effects of riparian and floodplain wetlands (RFWs) were considered separately from those of non-riparian and channel origin wetlands (NRCWs), due to fundamental differences in hydrologic connectivity. RFWs are connected with rivers via export of channel-forming sediment and woody debris, storage of groundwater, and transport of organic matter. They remove and transform nutrients and provide habitat for breeding fish and colonization opportunities for stream invertebrates. RFWs act as sinks for floodwaters, sediment, nutrients, and contaminants. Even RFWs that rarely flood can have important, long-lasting effects on streams and rivers.

NRCWs provide numerous benefits to downstream waters, including storage of floodwater; retention of nutrients, metals, and pesticides; and recharge of groundwater sources of river baseflow. NRCWs clearly affect downstream waters if the wetland is connected to the river network through a stream. When a direct surface connection is lacking, connectivity varies within a watershed and over time, making generalizations difficult. However, we conclude that: (1) many NRCWs interact with groundwater, which can travel long distances and affect downstream waters; (2) even isolated wetlands can influence rivers by preventing water from entering the river network; and (3) wetlands that are closer to rivers and streams have a higher probability of being connected than more distant areas, assuming similar conditions.

Contact Information: Scott G. Leibowitz, US EPA National Health and Environmental Effects Research Laboratory, Western Ecology Division, 200 SW 35th St, Corvallis, OR 97333 USA, Phone: 541-754-4508, Fax: 541-754-4799, Email: leibowitz.scott@epa.gov

USE OF ALOS PALSAR FOR REGIONAL MAPPING AND MONITORING OF MANGROVES

Richard M. Lucas
Institute of Geography and Earth Sciences, Aberystwyth, Ceredigion, Wales, UK

As part of the Japanese Space Exploration Agency's(JAXA) Kyoto and Carbon (K&C) Initiative, Advanced Land Observing Satellite (ALOS) Phased Arrayed L-band Synthetic Aperture Radar (PALSAR) dual polarization (L-band HH and HV) mosaics have been generated for several regions, including insular and mainland Southeast Asia, Australia and South/Central America. This research aimed to evaluate and demonstrate the use of these mosaics for mapping, characterizing and monitoring mangroves within these regions.

Whilst the extent of mangroves could be discerned in some cases (e.g., when interfacing with estuarine areas), ALOS PALSAR data were generally limited for mapping. For this reason, existing regional (e.g., Queensland Herbarium Regional Ecosystem Mapping) or global data (e.g., those available through the USGS/NASA) were used to define the extent of mangroves. Within this defined area, three classes of mangrove (low biomass and high biomass, with and without prop root systems) could be differentiated by integrating estimates of canopy height derived from Shuttle Radar Topography Mission (SRTM) data with L-band HH data. Maps of these structural classes were generated for several regions (northern Queensland, Australia, and Belize) where sufficient validation (ground or airborne) data were available.

Throughout the tropics and subtropics, mangroves are subject to change in response to natural or anthropogenic drivers. By using existing datasets (namely the USGS/NASA global mangrove dataset) as a baseline of mangrove extent, changes in mangroves were mapped for the Atlantic coast of South America, southeast and mainland Asia, northern Australia and Belize. Significant changes in the extent of mangroves were identified in northern Queensland (Gulf of Carpentaria, French Guiana and Sumatra), with these attributed to increased accretion or erosion of sediments and sea level fluctuation. Hotspots of mangrove loss were identified in southeast Asia, with these primarily associated with human disturbance. The study highlights the benefits of using ALOS PALSAR for detecting change, particularly given the prevalence of cloud-cover in many coastal regions and concludes by conveying the utility of and requirements for the inclusion of these data within a global mangrove mapping and monitoring system.

Contact Information: Richard M. Lucas, Institute of Geography and Earth Sciences, Aberystwyth University, Aberystwyth, Ceredigion, SY23 3DB, Wales, UK, Phone 00 44-1970-622612, Fax: 00-44-1970-622659, Email: rml@aber.ac.uk

AUTOGENOUS DEVELOPMENT OF HABITAT HETEROGENEITY IN THE OKAVANGO DELTA, NORTHERN BOTSWANA

Terence S McCarthy[1] and *William N Ellery*[2]
[1]University of the Witwatersrand, Johannesburg, South Africa
[2]Rhodes University, Grahamstown, South Africa

The Okavango Delta, a large alluvial fan, represents the near terminus of the Okavango River which discharges ca. 10 km^3/yr of water onto the fan (gradient 1:3400). A further 6 km^3/yr is added by local rainfall of 530 mm/yr. Base flow sustains 5000 km^2 of permanent swamp, which can expand to 12000 km^2 at the peak of the seasonal flood. Whilst channels form an arterial water supply network to the upper, permanent swamps, water in the seasonal swamps is distributed mostly by shallow sheet flow. Evaporation is 2200 mm/yr and 97 % of inflow plus rainfall is lost by evapotranspiration. The sediment load discharged onto the fan (ca. 5.7×10^5 t/yr) is 30% fine-grained sand, 7% silt and clay and 63% solutes (mainly silica and $Ca(HCO_3)_2$, minor $NaHCO_3$). The fan surface is gently undulating, elevated portions forming islands about 1 m above the surrounding swamp. They support much of the habitat diversity. Islands are initiated by either: (a) Topographic inversion following channel failure: bedload is deposited in the leaky channels, causing aggradation. Channel failure shifts water distribution such that peat flanking the former channel burns. The bed remains as an elevated, sinuous island chain when re-flooding eventually occurs; (b) Mound-building termites (*Macrotermes michaelseni*) invade areas that are dry, producing circular mounds several metres in diameter. Termites forage radially and transport material back to a central mound housing the queen and fungus garden. When colonies die the mounds degrade but remain permanent features of the landscape, becoming circular islands when the surrounding areas re-flood. Few local tree species can grow in flooded soils and elevated terrain creates suitable habitat for trees. Trees provide nesting and perching sites for birds, food for browsers and shelter for animals, which import nutrients to the islands, causing them to become hotspots in this hyperoligotrophic environment. Transpiration by trees lowers the water table beneath islands, resulting in centripetal flow of groundwater. Trees selectively remove water and the salinity of groundwater rises, ultimately becoming saturated in silica and calcite which precipitate in the root zones, causing islands to grow. Highly soluble $NaHCO_3$ accumulates in the groundwater beneath the island centres and ultimately inhibits plant growth. The vegetation on islands becomes concentrically zoned, reflecting differing salt tolerances of plants. Over time islands amalgamate. Large islands may impede surface water flow, resulting in differences in swamp water level. Then saline water accumulates beneath the down-slope side and precipitation of silica and calcite occur preferentially on the up-slope side, causing asymmetrical growth upslope.

Contact Information: School of Geosciences, University of the Witwatersrand, Box, 3, WITS2050, South Africa; Phone: +27-11-717-6558; Email: terence.mccarthy@wits.ac.za

EVERGLADES PATTERNING: ALTERED WATER, ALTERED LANDSCAPE

Martha K. Nungesser
South Florida Water Management District, West Palm Beach, FL, USA

Patterned landscapes are particularly well suited to remote observation through aerial photography because the patterning often responds to changes in environmental drivers. The Everglades of south Florida is a patterned peatland originally characterized by regularly spaced, elongated ridges and tree islands oriented parallel to each other and to water flow through shallow, interconnected sloughs. The ridge and slough landscape has undergone major hydrologic modification over the last century, including both drainage and impoundment, and its patterns have changed significantly since the 1880s. Much of this landscape has been lost to development and to water management practices. Nearly all water in the natural systems is managed. Everglades restoration targets include improving the patterning of the ridge and slough landscape.

Simple metrics were developed to quantify the nature, extent, and direction of changes in the ridge and slough landscape to quantify responses to past water management and to establish a baseline for future restoration efforts. Fifteen 24 km2 study plots were located along three flow-ways in Water Conservation Area 3, and historic aerial photography for five decades since 1940 provided source data. Manual digitization, required because of highly variable source photographs, produced consistent maps of ridges, tree islands, and sloughs for each plot and year. These maps allowed for analyses for each year across the landscape and each plot over the six decades.

Pattern metrics characterizing elongation, smoothness, and abundance of ridges and tree islands were used to characterize details and trajectories of pattern changes from 1940 through 2004. Hierarchical agglomerative cluster analysis was used to classify all 75 maps (5 maps for each of the15 plots) into categories based on a suite of metrics relating to pattern quality. Nonmetric multidimensional scaling, an ordination technique, confirmed that these categories were distinct; the primary axis was distinguished by the abundance of elongated ridges. Patterns corresponding to those described by early explorers were characterized by numerous long ridges and classified as strong patterning, while degraded patterns contained few large, irregularly shaped patches. Trajectories within the study plots included loss (ridges fusing into fewer, less linear patches of emergent vegetation), stability, and for a few sites, improvement (ridges and sloughs regaining linearity and abundance).

Analyses of responses since 1940 indicate that ridge and slough patterns can degrade or improve over time scales of a decade or less. Aerial imagery reveals that ridge and slough patterns 1) can be lost quickly following severe peat dryout, yet 2) appear resilient at least over multi-decadal time periods; 3) patterns can be maintained and possibly strengthened with deeper water levels; and 4) the sub-decadal response time of pattern changes allows aerial imagery to be used for change detection within the landscape. This analysis suggests that restoration of some aspects of these unique peatland patterns may be possible within relatively short planning time frames and that aerial photography can facilitate Everglades restoration and adaptive management by revealing pattern changes that respond to altered hydrology.

Contact Information: Martha K. Nungesser, Water Resources Division, South Florida Water Management District, 3301 Gun Club Rd., West Palm Beach, FL 33406 USA, Phone: 561-682-6614, Email: mnunges@sfwmd.gov

WETLANDS AND THE KYOTO AND CARBON INITATIVE

***Lisa-Maria Rebelo*[1]**, *Ake Rosenqvist*[2], *Maycira Costa*
[1]International Water Management Institute, Addis Ababa, Ethiopia
[2]SoloEO, Tokyo, Japan

The Wetlands Theme of the Kyoto and Carbon (K&C) Initiative, undertaken by the Japanese Aerospace and Exploration Agency (JAXA) is focused on the provision of remote sensing datasets that can be used to assist the global mapping and monitoring of wetlands, and in identifying and quantifying the threats to which these are exposed. Specifically, it aims to develop a suite of products which may be used to improve the understanding of carbon cycle science, assist the implementation of conservation and management strategies and support national and international obligations to multi-national conventions. Wetlands contain and cycle a significant amount of carbon and play a key role in the global carbon cycle, not least because of the large turnover of methane within these systems; it is estimated that natural wetland sources emit about 20% of the methane entering the atmosphere each year and they are responsible for a significant proportion of biogeochemical fluxes between the land surface, the atmosphere, and hydrologic systems (Sahagian and Melack 1996). A basic requirement for modelling regional to global methane or carbon dioxide emissions from wetlands is Information on their type and distribution.

The Ramsar Convention on wetlands of International Importance promotes the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world (Ramsar COP8, 2002). The Convention aims to halt and reverse the global trends of wetland degradation and destruction through the dissemination of Information, involvement of local communities and establishment of sustainable management plans. While Contracting Parties to the Convention have been encouraged to undertake better and more efficient wetland inventory, and to establish and maintain national inventories, many countries lack the resources to achieve this. Remote sensing technologies are essential in providing up-to-date spatial and temporal Information about wetlands and their catchment basins, and should be seen as a fundamental component in the development of wetland management plans for conservation and sustainable utilisation. While mapping of wetlands has proved difficult in many areas because of the lack of temporally and spatially consistent datasets, the systematic data acquisition strategy of ALOS PALSAR seeks to redress this (Rosenqvist et al 2008).

Long-term preservation and sustainable use of these resources is therefore critical for the economic and social well being of current and future generations. Key requirements include the establishment of regional and temporal datasets of wetland extent and condition which incorporate an understanding of the inundation dynamics of an area and spatially quantifiable measures of both anthropogenic and natural pressures and threats to wetland communities. This paper reports on the latest developments within the JAXA K&C Initiative, and presents some of the key findings across global prototype sites to date.

Contact Information: Lisa-Maria Rebelo , International Water Management Institute, ILRI Campus, CMC Road, Addis Ababa, Ethiopia, Phone: 00251913547, Email: l.rebelo@cgiar.org

QUANTIFYING HABITAT USE BY CENTRARCHIDS IN RESPONSE TO SEASONAL HYDROLOGICAL VARIATION IN THE EVERGLADES

J. Rehage[1]*, A. Saha, A. Narducci*[1]*, M. Anderson*[1]*, M. Cook*[2] and *T. Dreschel*[2]

[1]Florida International University, Miami, FL

[2]South Florida Water Management District, West Palm Beach, FL

Animal habitat selection and inter-habitat movements are determined by environmental, physiological and behavioral factors. Obtaining a sufficiently high spatiotemporal resolution of the movement paths of organisms remains a major challenge in movement ecology. In this study, we use a combination of tagging and enclosure techniques to gain this high spatiotemporal resolution to interpret the movement and habitat use of piscivorous centrarchids native to the Everglades in relation to seasonal variation in environmental conditions, notably hydrology. Low frequency Radio Frequency Identification (RFID) technology is used to track the movement and habitat use of fishes individually tagged with 21 mm Passive Integrated Transponder (PIT) tags. To overcome the sparse recapture rate inherent in tagging studies, we use six replicate 12m by 4 m field ex-situ enclosures that have RFID tag detection antenna installed. Each enclosure spans the three main habitat types present in the Northern Everglades ie: ridge, slough and alligator holes along an increasing water depth gradient. The enclosures are located in the experimental wetland facility (Loxahatchee Impounded Assessment Landscape, LILA) at Loxahatchee National Wildlife Refuge in the Everglades. Preliminary data in this ongoing study indicates smallmouth bass (Micropterus salmoides) are active in shallow areas from dusk to dawn presumably to forage while they prefer deep water during the day to avoid predation by wading birds. Using RFID technology inside enclosures in wetlands presents unique constructional, design and operational challenges that are also described in this study, the first of its type in a subtropical wetland.

Contact Information: Amy Narducci Department of Environmental Studies, Florida International University, 11200 S.W. 8th Street Miami, FL 33199 USA, Phone: 305 348 0181, Email: anarducc@fiu.edu

DEFORESTATION EVOLUTION IN THE AMAZON FLOODPLAIN

***F. Vivian Renó*[1]**; *Evlyn L. Novo*[1]; *Chieno Suemitsu*[2]; *Thiago S. F. Silva*[1]
1International Institute of Space Research, São José dos Campos, SP, Brazil
2Federal University of Pará, Santarém, PA, Brazil

The floodplain forests bordering the Amazon River have outstanding ecological, economic, and social importance for the region. However, the original distribution of these forests is not well known, as they have suffered severe degradation since the 16th century.

The previously published vegetation map of the entire Amazon River floodplain, based on data acquired in 1996, shows enormous difference in vegetation cover classes between the regions upstream and downstream of the city of Manaus. The upper floodplain is mostly covered by forests, while the lower floodplain is predominantly occupied by grasses and shrubs.

The present study aims to assess deforestation evolution in the Amazon floodplain over a ~40 years period by producing and comparing time-series vegetation maps based on MSS/TM/ETM Landsat images acquired since the late 1970s. To do so, the region was divided into eight sites of interest: 1) Lower Amazon; 2) Belém; 3) Piagaçu; 4) Mamirauá; 5) Xingu; 6) Madeira; 7) Badajós; and 8) Tabatinga. The maps were generated through the following steps: 1) georeferencing and co-registering of the scenes; 2) application of a linear mixing model transformation to produce vegetation, soil and shade fraction-images; and 3) object-oriented image analysis and classification. The following classes were mapped: floodplain forest, non-forest floodplain vegetation, bare soil and open water. The maps were combined using object-level Boolean operations to identify time transitions among the mapped classes, resulting in maps of the forest cover changes occurred over ~40 years.

Preliminary results for the Lower Amazon indicate a value of 3457 km2 ±1062 km2 (95 % CI) of floodplain deforestation over the last 40 years. This value implies that 52% of the forest cover was removed between the studied periods, but the forest removal process was already in course well before the 1970s. In fact, the major phase in the expansion of jute cultivation occurred from 1950 and 1975, suggesting that losses of forest cover between these periods were even greater. Together with field Information, these results indicate that floodplain deforestation in the Lower Amazon was mainly caused by agricultural and livestock activities, which have been progressively replacing the commercial and subsistence fishing practiced by the local people.

Contact Information: Vivian F. Renó, Remote Sensing Division, National Institute of Space Research (INPE), Av. dos Astronautas, 1758. Jd. da Granja, São José dos Campos, SP, Brazil, CEP 12227-010, Phone: +55 (12) 3208-6486,.E-mail: vivianfr@dsr.inpe.br.

BIOGEOGRAPHY OF TROPICAL HARDWOOD FORESTS IN SOUTH FLORIDA: EVIDENCE FOR SELF-ORGANIZATION?

Michael S. Ross, *Jay P. Sah, Pablo L. Ruiz* and *Adam A. Spitzig*
Florida International University, Miami, FL

The concept of self-organization in wetlands is most commonly applied to processes by which landscape pattern emerges from interactions among water, sediment and the biota. However, wetland landscapes may also serve as the template for another sort of self-organization, i.e., the spatial arrangement of biotic assemblages that arises from interchange of individuals among similar habitat patches. In this paper, we examine the biogeography and metacommunity structure of tropical forests embedded in south Florida wetlands and other matrices hostile to trees. Tropical hardwood forests in south Florida are found in conditions where flooding and fire are rare. The absence of these two stressors results from a favorable physical setting, but autogenic processes (e.g., soil accretion, maintenance of a humid microclimate) may also contribute. These forests are naturally distributed in fragments of variable size, separated from one another by marine waters, wetlands, or pine forests. A century or so of urban development has further isolated forest patches along the mainland coast, but forests in the Everglades, the islands of Biscayne National Park, and portions of the Florida Keys are mostly intact. While the matrix in which they are embedded and the processes that connect them have changed over time, south Florida forests fragments still comprise a great regional unit, connected by dispersal processes and a common history. We used spatial and metacommunity analyses to examine the tree species composition of 145 south Florida forests, focusing on the effects of patch size, winter temperature, water relations, and proximity to seed sources. We found strong spatial autocorrelation structure in the species data, and distinct sub-regional groupings suggestive of highly integrated local networks. Notably, the species-by-site matrix was highly nested, with tree species common to small upland fragments in the interior of the Everglades representing a small but distinct subset of the richer assemblages found in mesic sites closer to the coast. Patch size was the strongest single correlate with composition and species richness, but several of the other variables contributed to regression models. Our analyses suggest that patchiness in wetland landscapes ultimately results in further structuring through metacommunity processes.

Contact Information: Michael S. Ross, FIU/SERC, University Park/OE148, Miami, FL 33199. Phone: 305-348-1420, Fax: 305-348-4096, Email: rossm@fiu.edu

MAPS OF CANOPY HEIGHT AND BIOMASS OF ALL MANGROVE FORESTS OF THE AMERICAS

Marc Simard[1], *Naiara Pinto*[2], *Lola Fatoyinbo*[3], *Victor H. Rivera-Monroy*[4], *Chandra Giri*[5] and *Rinku Roy Chowdhury*[6]

[1]California Institute of Technology/Jet Propulsion Laboratory, MS300-319D, Pasadena, California, USA
[2]Department of Geography, University of Maryland, Greenbelt, Maryland, USA
[3]Biospheric Science Lab, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA
[4]Louisiana State University, Baton Rouge, Louisiana, USA
[5]United States Geological Survey (USGS), Earth Resources Observation and Science (EROS) Center, Sioux Falls, USA
[6]Department of Geography, Indiana University, Bloomington, Indiana, USA

Mangrove forests are coastal wetlands that contribute to regional, continental and global biodiversity and act as major biogeochemical links between upland and coastal regions. But as a result of their location and economic value they are among the most rapidly changing landscapes in the Americas. The greatest current threats to mangroves derive from human activities such as aquaculture, freshwater diversions, overharvesting and urban and industrial development. The effects of climate change, such as sea-level rise and increased extreme climatic events, may also increase the vulnerability of this ecosystem. Thus, it is imperative to assess the current status of mangrove forests. In this presentation, we present baseline maps of canopy height and biomass for all mangrove forests of the Americas derived from field and remote sensing data.

The maps were built using a combination of remote sensing products depicting the extent and height of mangrove forests and were validated with field data. Published maps of mangrove extent produce with Landsat were used to extract first estimates of canopy height from the Shuttle Radar Topography Mission elevation dataset and were calibrated with spaceborne ICESat/Geoscience Laser Altimeter data. The maps were then validated using field data.

The field measurements were collected between 2006 and 2010 in the Everglades National Park (Florida), Cienaga Grande de Santa Marta (Colombia), San Juan Estuary (Venezuela), Gulf of Fonseca (Honduras) and Terraba-Sierpe (Costa Rica). The field data included measurements of individual tree height, diameter at breast height (DBH), crown size, root extent, and species identification. We derived a set of allometric equations between these various parameters. At the plot level, we computed maximum height, Lorey's and mean height, and basal area. Finally, we used published allometric equations to estimate biomass. These allometric equations were applied to the remote sensing-derived canopy height product to obtain biomass estimates at the continental scale. The resulting maps are presented.

The resulting data products and models are of direct interest and applicability to international discussions about the social and ecological value of mangrove forests, part of the RAMSAR convention, the UN Blue Carbon Initiative and the ALOS Kyoto and Carbon Initiative. However, it is critical to assess their accuracy if such products are to be used in a large scale decision making process. We discuss errors related to the scale and spatial resolution of remote sensing observations as well as field sampling methodology, scale and allometry.

Contact Information: Marc Simard, California Institute of Technology/Jet Propulsion Laboratory, MS300-319D, Pasadena, California, USA, Fax: 818-354-6972, Email: marc.simard@jpl.nasa.gov

MAPPING MANGROVES AT GENUS LEVEL FROM OBJECT-BASED CLASSIFICATION OF IKONOS IMAGE

Cesar G. Diniz, ***Pedro W.M. Souza-Filho*** and *Marcelo C.L. Cohen*
Universidade Federal do Pará, Belem, PA, Brazil

The use of remote sensing is one of the most efficient techniques for evaluating biomass and distribution of mangroves. However, there still a big problem for identifying species or genus composition within the same vegetal unit. This difficulty is linked to the mixture of spectral patterns resulting from the coexistence of a diverse number of vegetal species and therefore similar spectral responses in the same unit of area. The study area, 64 km2 of the Bragança peninsula, north of Brazil, is densely colonized by mangrove vegetation and dominated by three different mangrove species; Rhizophora mangle, Avicennia germinas and Laguncularia racemosa. R. mangle and A. germinans are the most abundant species, whereas R. mangle is the prevailing mangrove tree specie in the peninsula.

Working towards the individualization and quantification of the mangrove genus Rhizophora, Avicennia and Laguncularia, this study analyzed the subtle differences in the mangrove reflectance signatures obtained directly on the leaves of the mangrove vegetation and from a set of pan sharpened IKONOS images. Supported by the following image parameters; mean of the spectral bands, normalized difference vegetation index (NDVI), soil brightness index (SBI), brightness index (BI) and Harlick texture features, an object oriented approach was used to acquire the distribution and quantification of each one of the mangrove genus. Thus, on September 22nd of 2003, date of image acquisition, the mangrove forests occupied an area of approximately 43,02 km2 of the Bragança Peninsula portion and is mainly represented by Rhizophora (27.64 km2), Avicennia (5.56 km2), Laguncularia (1.15 km2) and shaded vegetation (1.614 km2). The highland classes and others occupied 0.59 and 20.38 km2, respectively.

The results obtained allows better location and quantification of all the mangrove genus in the peninsula of Bragança-PA. The individualization of Avicennia, Rhizophora and Laguncularia confirms the use of high spatial resolution orbital sensors, associated with field reflectance measurements, as an appropriate approach for the effective mapping of mangrove genus. This work will subsidize future studies on relative density of mangrove forests, estimation of biomass, dynamics of mangrove development, environmental analysis and resilience of mangrove forests.

Contact Information: P.W.M. Souza-Filho, Laboratório de Análise de Imagens do Trópico Úmido, Instituto de Geociências, Universidade Federal do Pará, Av. Augusto Correa 1, Cidade Universitária, PO BOX 8608, 66075-110, Belém, Pará, Brazil. Phone: 55-91-32018009, Fax: 55-91-32017478, E-mail: walfir@ufpa.br

MULTI-TEMPORAL MAPPING OF THE LARGEST CONTINUOUS AMAZONIAN MANGROVE BELT USING OBJECT-BASED CLASSIFICATION OF MULTISENSOR IMAGES

Wilson da Rocha Nascimento Junior[1], ***Pedro Walfir M. Souza-Filho***[1], *Christophe Proisy*[2] and *Richard M. Lucas*[3]

[1]Laboratório de Análise of images do Trópico Úmido, Instituto de Geociências, Universidade Federal do Pará,Cidade Universitária 1, , Belém, Pará, Brazil

[2]Institut de Recherche pour le Développement (IRD), UMR AMAP, Boulevard de la Lironde, , Montpellier Cedex 5, France

[3]Institute of Geography and Earth Sciences, Aberystwyth University, Llandinum Building, Aberystwyth, Ceredigion, UK

Globally, mangroves are important for ecosystem services, particularly as these represent a significant store of carbon and act as habitat and nursery grounds for marine fauna. For this reason, generating maps of mangroves at a global level has been the focus of many regional to global studies, although detecting change has proved more difficult because of differences in data sources and interpretation of these. Hence, remote sensing from spaceborne platforms provides the best opportunity to map and routinely monitor the changing extent of mangroves. In response to constant cloud cover over equatorial tropical forests, this study had the objective of quantifying the mangrove area and performing object-orientated classification of 1996 JERS-1 SAR and 2008 ALOS PALSAR data, supplemented by Landsat TM image and SRTM data from east of the Amazon River mouth.

Definiens eCognition software was used for the classification of mangroves areas. This software uses object-based logic, where a segmentation algorithm is a technique for agglutinating the regions that fuse the objects. The scale of segmentation was defined taking into consideration the smallest objects resulting from remote sensing data all together, highlighting 90% for brightness, 10% for segment form and 50% for smoothness and compacity in objects. Following the multi-resolution segmentation stage, equations were utilized to aid in classification with a view to extracting objects with Information about the mangrove areas. As access to the study area is limited, particularly given that the coastline extended for over 7,500 km2, 215 ground control points were collected with 62 used to validate the classification of mangroves and 153 to validate other classes that demonstrated confusion with mangrove vegetation, and other classes in the interface with mangroves.

Comparing object-orientated classification with available ground truth data indicated a global exactness index (GEI) of 96 % (kappa = 90.6 %, tau = 92.6 %) in the classification of major land covers (mangrove, terra firme forest, secondary vegetation, agriculture and lakes) The area of mangrove increased by 718.6 km2 from 6,705 m2 in 1996 to 7,423.60 km2 in 2008. Mangroves had extended by 1,931 km2, whilst 1,213 km2 had eroded, with 5,493 km2 remaining unchanged. The GEI relating to changes in mangroves was 83.3 % (Kappa 66.1 %; tau 66.7 %). The mapping confirms that the Amazon mangroves constitute the largest continuous mangrove belt globally and are experiencing significant change because of the dynamic coastal environment and the influence of the Amazon but also anthropogenic pressures. Continued observations are recommended to establish trends in mangrove distributions and the implications for provision of ecosystem services (e.g., carbon storage, fish/invertebrate nurseries), with combinations of optical and L-band SAR data providing good discrimination of mangrove extent and, in the case of SAR, observation regardless of viewing conditions.

<u>Contact Information</u>: Pedro Souza-Filho, Universidade Federal do Pará, Av. Augusto Correa 1, Cidade Universitária, Belem, Brazil, Phone: 559132018009, Email: pedropwm@gmail.com

TRANSPIRATION AS A HYDROLOGIC DRIVER OF ION AND MINERAL ACCUMULATION ON TREE ISLANDS

***Pamela L. Sullivan*[1]**, *René M. Price*[1&2], *Vic Engel*[3], *Michael S. Ross*[1&2]

[1] Department of Earth and the Environment, Florida International University, Miami FL
[2] Southeastern Environmental Research Center, Florida International University, Miami FL
[3] National Park Service, Everglades National Park, Homestead FL

Groundwater-surface water interactions strongly influence the chemistry of shallow groundwater and the location and patterns of vegetation in wetlands. Recently, the regular landscape patterning of many wetlands has been attributed to variations in groundwater evapotranspiration rates that influence groundwater-surface water interactions and accumulation of nutrients locally. The Everglades is one ecosystem where this process has been hypothesized to contribute to the formation of nutrient-rich tree islands surrounded by an otherwise oligotrophic marsh. This study presents both hydrologic and geochemical data indicating that transpiration processes drives groundwater-surface water interactions and leads to ion accumulation in the groundwater of a tree island in Everglades National Park. Sap flow, soil moisture, water level, water chemistry, and rainfall were monitored to identify the relationships between climate, transpiration and groundwater uptake by phreatophytes, and their effects on groundwater ionic strength as well as potential mineral formation. The results suggested that during the dry season, trees relied more on groundwater for transpiration, which led to a depressed water table and the advective movement of groundwater and associated ions from the surrounding marsh toward the center of the island. The loss of groundwater through transpiration led to the elevated concentration of all major dissolved ions in the tree island groundwater compared to the adjacent marsh. Groundwater on the islands was supersaturated with respect to the minerals aragonite and calcite indicating the potential for mineral formation to enhance soil development.

Contact Information: Pamela Sullivan, Department of Earth and Environment, Florida International University, ECS 347, 11200 SW 8th Street, Miami FL, 33199, Phone: (305) 766-2291, Email: psull001@fiu.edu.

WETLAND BELTS AND WET TO DRY GRASSLAND AREAS ON DUNES AT LAKE SHORES

K. Siegmar Thomas
Institute of Landscape Architecture, Dresden University of Technology, Germany, Saxony

Growth and species combinations of aquatic and terrestrial plant communities follow the terrain surface height. This is valid for submerse flora belts and wet to dry terrestrial plant community belts. The plant growth below the lake water level depends mainly on water deepness above lake ground. Main basics for terrestrial plant belts are floods during springtime and increasingly deeper ground water level. The submerse flora belts follow the water deepness along the depressions and elevations of the lake bottom. The terrestrial plant community belts follow the surface depressions and elevations (strata in the direction of slope curves, the orthogonal trajectories of contour lines). These layers are not parallel to contour lines, but they mediate between the elevated terrain surface and depression deep lines. This kind of spatial ecological order may be resilient against – moderate – permanent change of the lake water level (decrease of water level artificially by water constructions or by climate change). The aquatic and terrestrial plant belts will then be moved and redeveloping in deeper positions parallel to the new shore line. These processes will need a certain time of decades, if no other disturbing processes exist. Also the site conditions will be changed into new balance, like soil stratification into oxidation and reduction horizons.

An example shows species-rich wetland areas at Müritz lake shore, the largest German inland lake, near to a lagoon. Brief descriptions of ecology, hydrology, pedology and management practices will be given. It was a nature reserve, and is now part of the larger National Park Müritz. The areas harbor a large variety of wetland-specific plant species, on lower sites flooded in springtime, and also terrestrial species of the juniper heath (with bushes of Juniperus communis). The areas contribute substantially to the species diversity of the landscape. Protection and sustainable management was done with cattle at pasture, since 1969. Some common pasture grasses and herbs, not found within the sample plots by author in 1977, now occur in nearly comparable sample plots (research work and dissertation from the Oldenburg University 2004). This may indicate an intensified use of the areas and enrichment with fertilizers. (And could in future endanger some rare species?) Long term ecological studies, related to wetland and adjacent areas should be done to protect the biodiversity e.g. under cattle management.

Contact Information: K. Siegmar Thomas, Institute of Landscape Architecture, Dresden University of Technology, Germany, Saxony, D-01062 Dresden, Phone +49 351 8362253, Email: siegmar.thomas@mailbox.tu-dresden.de

LINKING WETLAND HYDROLOGY TO ECOSYSTEM SERVICES USING A GRAPH THEORETICAL APPROACH

Abbey A. Tyrna and *Robert P. Brooks*
Pennsylvania State University, University Park, PA, USA

Hydrology, both within a wetland and across the riparian landscape, is the most critical variable regulating the biogeochemical processes that cycle nutrients and store containments flowing from terrestrial uplands. Equally important, hydrology governs the presence of organisms as water connects discrete patches enabling organisms to disperse across the landscape. Hydrologic connectivity is defined as the frequency of surface and subsurface waters entering the root zone of riparian wetlands. The variation in hydrologic connectivity across the floodplain is tightly coupled with the variation in the ability of wetlands to produce many ecosystem services from nutrient cycling to habitat provisions. As a result, an analysis of floodplain hydrologic connectivity specifically among streams and riparian wetlands will identify areas within a watershed that are particularly important for the production of ecosystem services and therefore should be prioritized for preservation.

Wetland ecosystem services are wetland functions that benefit human-beings. Examples include water quality enhancement, carbon sequestration, and habitat provisions. A goal of the U.S. Environmental Protection Agency is to map the abundance, distribution, and condition of wetland ecosystem services across the watershed. One method for doing so is to use hydrologic connectivity as a surrogate for ecosystem services and graph models to map the landscape. A graph model is a simplified version of a system where nodes represent discrete landscape patches and vertices signify the structural or functional connections between them.

Shaver's Creek subwatershed in central Pennsylvania, USA was used as a case study. General trends in hydrologic connectivity were extrapolated based on hydrogeomorphic classification from long-term water level data collected for over 40 riparian wetlands across Pennsylvania. In an effort to achieve a nearly complete wetland inventory, 75 acres of riparian wetlands, 32% of all wetlands identified, was added to the Shaver's Creek wetland inventory during the 2011 field season. A graph model of the stream and wetland network within Shaver's Creek was created using hydrologic connectivity and terrain analysis. Wetlands and streams served as the nodes, which were connected by vertices if the systems were hydrologically connected. By using a method embedded in graph theory, this investigation will add to the ecological comprehension of the riparian ecosystem by answering the questions: 1) How large is the wetland-riparian-stream network and how does its connectivity change seasonally and annually, and, 2) how do seasonal and annual changes in connectivity influence the structure of the network to support the production of ecosystem services? The results of this project will reveal the dynamics and hierarchy of spatially explicit hydrologic connections across the subwatershed offering insight into areas of the network that should be prioritized for preservation.

Contact Information: Abbey A. Tyrna, 304 Walker Building, Department of Geography, Pennsylvania State University, University Park, 16801, Phone: 814-865-5786, Email: aat145@psu.edu

DO LOCAL INTERACTIONS OR THE LANDSCAPE DETERMINE SPATIAL SELF-ORGANIZATION IN WETLAND ECOSYSTEMS?

Johan van de Koppel
Royal Netherlands Institute for Sea Research, Yerseke, The Netherlands

Complexity theory proposes that spatial self-organization, the process where small-scale, localized interactions among the components of a system generate complex spatial structures at large spatial scales, explains the formation of autogenic spatial patterns in many wetland ecosystems. I question this premise by reviewing a number of wetland ecosystems where self-organization has been put forward to explain spatial patterns. I will use the contributions presented in this special session to address this question, and assess the hypothesis that self-organized wetlands are shaped by the combination of small-scale interactions between ecological and physical processes on the one hand, and large-scale physical forcing on the other. More specifically, local interactions generate patchiness at small spatial scales, whereas landscape forcing determines the shape and orientation of these patches in the landscape. Finally, I will address the question whether spatial self-organization has emergent effects on the functioning of wetlands, and what evidence actually exists that supports hypothesized emergent effects.

Contact Information: Johan van de Koppel. Royal Netherlands Institute for Sea Research, Korringaweg 7, 4401 NT Yerseke, The Netherlands. Telephone: +31 113 577455. Email: johan.van.de.koppel@nioz.nl (only valid after jan 1st 2012)

ANALYSIS OF PATCH GEOMETRY CHARACTERISTICS IN THE RIDGE-SLOUGH PATTERNED LANDSCAPE IN THE EVERGLADES

***Jing Yuan*[1]**, *Joseph Delesantro*[2], *Stephen Casey*[3], *Sergio Padilla Paz*[4], *Danielle Watts*[1], *Matthew J. Cohen*[2],

[1] chool of Natural Resources and Environment, University of Florida, Gainesville, FL, USA
[2]School of Forest Resources and Conservation, University of Florida, Gainesville, FL, USA
[3]Environmental Engineering, University of Florida, Gainesville, FL, USA
[4]Wildlife Ecology and Conservation, University of Florida, Gainesville, FL, USA

Research on the ridge-slough patterned peatland in the Everglades has focused on mechanisms of pattern genesis and trajectories of degradation and restoration. Patterning in the best conserved remnants have several salient attributes: 1) patches are oriented parallel to historical flow, with elongated ridges (ca. 400 m long, 50-150 m wide) embedded within a matrix of sloughs, and 2) ridges occupy higher elevation sites than sloughs (ca. 25 cm). While these attributes describe general landscape properties, they fail to effectively capture the apparent fractal nature of extant patch geometry, where ridges vary widely in size, and possess substantially convoluted margins. Our objective was to investigate pattern geometry, with a focus on ridge patches because ridges evidently emerged (ca. 2700 ybp) as a landscape feature in a uniform prairie/slough landscape, and because ridge prevalence and geometry may regulate landscape discharge. We investigated three attributes of ridges as a function size. First, we evaluated the relationship between ridge size and soil elevation. Our point-scale conceptual model suggests the presence of two alternative ecological configurations to achieve the same peat accretion rate (higher ridges, lower sloughs) wherein surface elevations are independent of bedrock elevations. If true, ridge elevations should be independent of mechanisms controlling patch shape and size. Second, we evaluated the relationship between ridge size and patch elongation, measured as the patch length-to-width ratio. Enumerating metrics of elongation are important because, while the landscape pattern is thought to emerge from bi-directional interactions between biota and hydrology, the specific mechanisms that lead to patterning remain unclear; attributes of the pattern may help discriminate among competing explanations. One hypothesis posits localized effects of differential velocity that sculpt ridges into elongated forms, while another invokes a diffuse landscape feedback between lateral ridge prevalence and hydroperiod. The former would generally result in elongation of all ridges, regardless of size, while the latter would principally act to elongate larger ridges which have greater potential to affect landscape discharge competence. Finally, we evaluated scaling relationships for ridge length and width. Previous work suggests that ridge sizes follow power-law scaling, suggestive of spatial self-organization and facilitation. However, this runs counter to regular patterning, where a fixed wavelength orthogonal to flow would preclude power-law scaling. One possibility for reconciling these two observations is that ridge <u>lengths</u> are power-law distributed, while ridge <u>widths</u> are scaled otherwise (e.g., exponentially, normally).

Our results suggest ridges are of uniform height regardless of size, supporting the point-scale conceptual model, and suggesting that elevation is independent of spatial organization. We found a statistically significant positive association between ridge anisotropy and size, but the fit was poor. This provides tentative support for scale dependent anisotropy, but further work is needed. Finally, preliminary evidence supports the conclusion that ridge lengths follow power-law scaling, while ridge widths are distributed exponentially. We note, however, that power or truncated power functions may better explain both, albeit with significantly different slopes. Together, these results provide landscape geometric properties that can be used to evaluate simulation model performance of landscape pattern genesis.

<u>Contact Information</u>: Jing Yuan, School of Natural Resources and Environment, University of Florida, 327 Newins-Ziegler Hall, Gainesville, FL 32611, USA, Phone: 352-283-1417, Fax: 352-846-1277, Email: yj@ufl.edu

WETLAND ECOSYSTEMS PROCESSES & FUNCTIONS - RIVERINE AND FLOODPLAIN WETLANDS

MULTI-ELEMENT FINGERPRINTING OF RIPARIANWETLANDS

***Aida. Asgary*[1]**, *Donna L. Jacob*[2] and *Marinus L. Otte*[3]
[1]U.S. Environmental Protection Agency. USA
[2]North Dakota State University, Fargo, ND, USA

Riparian wetlands are important ecosystems in many ways, they stabilize stream banks, improve water quality, trap sediment, and are habitat for many species. Riparian wetlands are impacted by land use and geography through interactions between water and soil. As a result of these interactions, and the influx of new material via particle movement in the rivers, they can show great variability in flora and fauna, even over short distances. Riparian ecosystems in East of North Dakota with the flat landscape and narrow range of elevation show different properties from the ecosystems in the semi-arid West of North Dakota with mountainous landscape. The question is how significant is the role of sediment in these differences and perhaps the similarities?

Fine sediment transfers nutrients, heavy metals and contaminants from both terrestrial and aquatic system and will deposit whenever the flow rate of water is slow. Previous studies have shown the role and importance of sediment on the water quality and ecosystems adjacent to the river. Sediment can give us valuable Information regarding to the possible sources within a catchment, and support the design and implementation of sediment control strategies. Few studies have compared and evaluated the links between elements in the sediment and the conditions in riparian wetlands. The purpose of this project is to investigate the use of concentrations of multiple elements in riparian sediments to develop multi-element fingerprints for condition assessment of riparian wetlands in North Dakota. Sediment samples from Red, James, Sheyenne, Missouri and Little Missouri rivers are being collected and the samples will be analyzed for more than 60 elements with Inductively Coupled Plasma Mass Spectrometry (ICP-MS). We expect the fingerprints to reflect characteristics specific to each river, based on the geology, climate and land use at the study area. For example, the Little Missouri is known to cut through uranium-rich lignite, and so would be expected to be elevated in uranium, while the runoff waters entering the Red River basin, composed mostly of clay, are loaded with elements such as phosphorus, sulfur and nitrogen. We also expect that the variation in element composition will reflect variation in plant communities and productivity. This is the first time multi-element fingerprinting is being used for monitoring and assessment of wetlands on a large (state-wide) scale. This method also could be a complementary to existing wetland assessment techniques, such as the three-tiered wetland assessment approach tested in ND, and the methods used in the NWCA.

Contact Information: Aida. Asgary, Wet Ecosystem Research Group, Department of Biological Sciences, North Dakota State University, Fargo,ND 58108 USA, Phone:701-552-6135 Email: aida.asgary@ndsu.edu.

ZOOPLANKTON BODY-SIZE STRUCTURE AND BIOMASS AND PLANKTIVOROUS FISHES IN TROPICAL FLOODPLAIN LAKES

Claudia Costa Bonecker[1], *Fábio de Azevedo*[2], *Horácio Ferreira Júlio Junior*[1] and *Nadson Ressye Simões*[1]
[1]Universidade Estadual de Maringá/Nupélia/PEA, PR, Brazil
[2]Faculdade Estadual de Educação, Ciências e Letras de Paranavaí, PR, Brazil

This study evaluated whether the size structure of the zooplankton community, as analyzed from density and biomass, would be influenced by bottom-up and/or top-down mechanisms in isolated lakes from the Upper Paraná River floodplain during dry and rainy periods.

Zooplankton individuals were classified as: smaller-sized (<300 µm), intermediate-sized (301 to 600 µm) and larger-sized (greater than 601 µm). Fish abundance was indexed by the capture per unit effort (CPUE; number of individuals.100m-2). Productivity was measured as chlorophyll a.

The size structure of the community did not show significant relationship with chlorophyll a concentration ($p > 0.05$), but it was associated to the increase in fish density during the dry season. The percentage of individuals with intermediate sizes (301 to 600 µm), in both biomass and density, was positively related to the fish density ($R2=0.78$ for biomass, $p<0.001$; $R2=0.58$ for density, $p=0.02$), indicating an increase numerical and mass of this size class with fish density. The percentage of larger-sized individuals (> 600 µm), in both biomass ($R2=0.86$, $p<0.001$) and density ($R2=0.69$, $p=0.02$) was negatively associated to the fish density, reflecting a decrease of this size class with the increase of fish in the environment.

This can implicate a direct and negative effect of the predation on larger-sized individuals, as well as indirect and positive effect on the intermediate-sized individuals, but it occurred only on dry season. Thus, different mechanisms act on the size structure of the zooplankton community between dry and rainy season.

Contact Information: C C Bonecker Universidade Estadual de Maringá/Nupélia/PEA, Paraná, Brazil, Av. Colombo, 5790 – Bl. H-90. 87020-900. Phone (55) 44 3011 4663, Email: bonecker@nupelia.uem.br

RESOURCE PARTITIONING AMONG THREE MESOCONSUMERS AT A MARSH MANGROVE ECOTONE: A RESPONSE TO A SEASONAL RESOURCE PULSE SUBSIDY

R. Boucek and *J. Rehage*
Department of Environmental Studies, Florida International University, Miami, Florida , USA

Pulse subsidies account for a substantial proportion of resource availability in many systems, having persistent and cascading effects on consumer population dynamics, and the routing of energy within and across ecosystem boundaries. Although the importance of resource pulses is well-established, consumer responses and the extent of resource partitioning is not well understood. In the southwest Everglades, annual variation in rainfall drives patterns of marsh inundation, and thus habitat availability for fishes. In response to seasonal drydown, marsh fishes move into deep water habitats such as ecotonal mangrove creeks, resulting in a significant prey subsidy into estuarine habitats. In this study, I continuously sampled the abundance of prey and predators at a marsh-mangrove ecotone, as well as the diets of three dominant consumers (largemouth bass, bowfin, and snook). I identified a pulse of marsh cyprinodontoid, invertebrate, and sunfish prey, which was met by an influx of both marsh and estuarine predators. In response to the pulse, consumers showed heavy segregation among their diets. Bass consumed significantly more cyprinodontoids, bowfin consumed significantly more invertebrates, and snook almost exclusively targeted sunfishes. The diversity of the resource pulse subsidizes multiple consumers, routing pulsed production through various trophic pathways and across ecosystem boundaries. Preserving these complex trophic linkages can be important to maintaining ecosystem function and the provisioning of services (e.g., recreational fisheries).

Contact Information: Ross Boucek Department of Environmental Studies, Florida International University, 11200 S.W. 8th Street Miami, FL 33199 USA, Phone: 239-272-2771, Email: rbouc003@fiu.edu

ECOLOGICAL IMPLICATIONS OF ERRATIC FLOODS IN LARGE RIVER FLOODPLAINS OF THE ANDEAN AMAZON REGION

Jorge E. Celi and *Stephen K. Hamilton*
Department of Zoology & Kellogg Biological Station, East Lansing MI, USA

Scientific understanding of neotropical floodplains comes mainly from work on large rivers with predictable seasonal flooding regimes. Less studied rivers and floodplains on the Andean-Amazon interface are distinct in their hydrology, with more erratic flow regimes, and thus ecological roles of floodplain inundation differ in those ecosystems. Multiple and unpredictable flooding events control inundation of floodplains, with important implications for fish and wildlife, plant communities, and human activities. Wetlands along the river corridor exist across a continuum from strong river influence to influence only by local waters, with the latter often lying on floodplain paleoterraces.

This study seeks to understand the hydrological interactions and habitat diversity of the Napo River, a major Amazon tributary that originates in the Andes and drains exceptionally biodiverse Andean foreland plains. This river system is envisioned by developers as an industrial waterway (hidrovia), but that would require hydrological alterations that would affect floodplain ecosystems. Water level regimes of the Napo River and its associated environments were assessed using networks of data loggers that record time under water across transects extending inland from the river. These networks also included rising stage samplers that collect flood water samples for determination of their origin (i.e., Andean rivers vs. local waters) based on hydrochemical composition. In addition, this work entails a classification of aquatic environments of the Napo Basin using an object-oriented remote sensing approach to simultaneously analyze optical and radar satellite imagery and digital elevation models to better assess the extent and diversity of flooded environments. This research will improve the understanding of floodplain-river interactions in Andean Amazon rivers.

Contact Information: Jorge E. Celi, Department of Zoology & Kellogg Biological Station, 203 Natural Sciences, Michigan State University, East Lansing MI 48824 USA, Phone: 517-614-2357, Email: celijorg@msu.edu

VEGETATION PERSISTENCE IN EXTREME RIVERINE WETLANDS: HYDROLOGY-MEDIATED REPRODUCTIVE STRATEGIES DRIVE ECOLOGICAL SUCCESS IN *MELALEUCA*

C. Chong[1,2]
[1]Centre for Tropical Environmental and Sustainability Science, James Cook University, Cairns, QLD, Australia
[2]Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, QLD, Australia

The prediction and management of biological responses to changing hydrologic regimes is critical to improved global riverine wetland restoration. Climate-driven fluctuations in hydrologic and fluvial processes including drought, erosion, deposition and flooding directly impact the structure and composition of biotic communities that occur in riverine wetlands. Importantly, hydrology impacts vegetation communities by imposing periodic physiological stresses (moisture stress to flood scouring and stem kill), as well as acting as an agent for seed transport and gene flow.

In large unregulated riverine wetland ecosystems in northern Australia, hydrologic disturbances are considered extreme both statistically and ecologically: drought conditions prevail for c. 9 months of every year and are punctuated by erratic, monsoon-driven and geomorphically effective floods occurring at 1-in-8 year return intervals and at orders of magnitude spanning 10-100,000 m^3s^{-1}. In this environment, the paperbark tree *Melaleuca* thrives and dominates the riverine channels to the exclusion of other woody vegetation, despite the severe physiological stresses imposed by periodic drought, flood damage and stem-kill. Moreover, *Melaleuca* persists as the dominant woody vegetation type despite significant variation in the frequency and magnitude of disturbance distributions between river reaches, indicating generalized species ecological tolerance. Plant species that thrive in dynamic riverine wetlands are excellent candidates to examine the interaction between environmental disturbances and biological traits driving persistence, and the effects of these processes on vegetation community structure and change.

This study synthesizes research findings on the ecology and evolution of riverine *Melaleuca* to enhance quantitative understanding of plant traits promoting generalized ecological tolerance. Spatial and genetic structure were assessed at individual, population and species scales, respectively clonality, connectivity, and functional diversity. This research found that under hydrologic disturbances, *Melaleuca* displays versatility in its reproductive strategies and utilizes both clonal and seed propagation. The distribution of clonal growth (“sprouting”) corresponds to the extent and nature of changes to the hydrologic regime. This analysis of the ecology and genetic diversity of riverine *Melaleuca* in relation to prevailing and predicted hydrologic regimes contributes knowledge towards future targeted restoration, management and control strategies for riverine *Melaleuca* in its native and invasive ranges under hydrologic changes.

Contact Information: C. Chong, Australian Tropical Science and Innovation Precinct, James Cook University, Townsville, Queensland, Australia, 4811, Telephone: +61-421-497-873, E-mail: yfcaroline@gmail.com

RELATIONSHIPS BETWEEN RESIDENCE TIME AND CYANOBACTERIAL BLOOMS IN A NUTRIENT-RICH RIVER SYSTEM

Michael F. Coveney[1], *John C. Hendrickson*[1], *Erich R. Marzolf*[1], *Rolland S. Fulton*[1], *Jian J. Di*[1], *Clifford P. Neubauer*[1], *Dean R. Dobberfuhl*[1], *Greeneville B. Hall*[1], *Hans W. Paerl*[2] and *Edward J. Phlips*[3]

[1]St. Johns River Water Management District, Palatka, FL, USA

[2]University of North Carolina Chapel Hill, Institute of Marine Sciences, Morehead City, NC, USA

[3]University of Florida, Gainesville, FL, USA

The St. Johns River Water Management District's Water Supply Impact Study evaluated potential effects of water withdrawals from the St. Johns River (SJR) on biological and water resources, including plankton communities. Phytoplankton blooms, primarily cyanobacteria in fresh water and dinoflagellates in brackish water, were a primary focus.

Important steps were to 1) determine the potential effects of water withdrawals on plankton communities, 2) determine ecological metrics to measure effects and set thresholds for adverse effects, 3) develop hydroecological models to link changes in hydrology to changes in plankton metrics, and 4) use these models to assess the effects of various scenarios for water withdrawal. We aggregated the effects of algal blooms into four algal bloom metrics: marine algal blooms (dinoflagellate biovolume), increase in nitrogen (N) load due to N_2-fixation, magnitude of freshwater algal blooms (maximum chlorophyll-a concentration), and duration of freshwater algal blooms.

We developed empirical multiple linear or multiple logistic regression models to predict bloom metrics from independent variables based on water age, a simulated measure of residence time. This step required nine regression models to cover the four algal bloom metrics in five river segments. Models included two to seven independent variables, and adjusted R^2 values for linear regressions varied from 0.74 to 0.97. We also used the mechanistic water quality model CE-QUAL-ICM as an independent check on the empirical models. We set thresholds for adverse effects for each bloom metric using analyses of SJR data and literature Information. For example, we set two thresholds for maximum chlorophyll-a concentration (chl-a) in freshwater blooms: a lower threshold at 50 µg chl-a L^{-1} based on dominance by cyanobacteria and risk for cyanotoxins and a higher threshold at 138 µg chl-a L^{-1} based on measured depletion of dissolved oxygen from collapsing blooms. We derived a threshold for duration of freshwater blooms, 50 days continuous chl-a above 40 µg L^{-1}, based on a finding of reduced abundance of cladocera (but not other zooplankton) in the SJR during long-duration blooms.

All reaches of the middle and lower SJR that we assessed were impaired based on our algal bloom metrics and long-term monitoring data. Simulated water withdrawals had negligible worsening effects on bloom metrics. CE-QUAL-ICM results confirmed the small effects of withdrawals on bloom magnitude. We judged the uncertainty associated with these assessments of effects to be low or very low.

Contact Information: Michael F. Coveney, Bureau of Environmental Sciences, St. Johns River Water Management District, PO Box 1429, Palatka, FL 32178 USA, Phone: 386-329-4366, Email: mcoveney@sjrwmd.com

THE ROLE OF THE ATCHAFALAYA BASIN FLOODWAY IN THE SEDIMENT BUDGET OF COASTAL LOUISIANA

Richard H Day[1], *Daniel E. Kroes*[2]

[1]U.S. Geological Survey, Lafayette, LA, USA

[2] U.S. Geological Survey, Baton Rouge, LA, USA

The Atchafalaya Basin Floodway is a major distributary of the Mississippi River designed to divert 30% of the combined flow of the Mississippi and Red Rivers under normal condituions and up to 50% of the Mississippi River flow during epic floods. The emerging Atchafalaya River / Wax Lake Outlet delta complex accounts for almost 30% of total persistent land gain in Coastal Louisiana from 1932 to 2010. The Atchafalaya system is the only coastal basin with a net land gain during that period, using basin boundaries defined by the Louisiana Coastal Wetlands Planning, Protection and Restoration Act Program. The Atchafalaya Basin Floodway, immediately upstream of the delta complex, sequesters an enormous amount of sediment that otherwise could be deposited in the delta.

Flow patterns within the Atchafalaya River Basin's vast swamps vary with water level. These flow patterns and sediment loads have been unmeasured and largely unknown. The flood of 2011 in the Lower Mississippi resulted in the highest levels since 1927. Beginning in the spring of 2010 flow patterns were measured and sediment concentrations were collected from over 130 major channel locations within the floodplain at a variety of stages ranging from minimum flows to spring floods, and historic levels. The 2011 historic flood provided the opportunity to examine and compare water exchanges between the river and floodplain in grand scale. During this flood 60% of the 23,000 m^3/s flow passing through the Atchafalaya Basin left the main channel and passed into the swamps. In comparison during normal spring floods 10-20% of the flow leaves the main channel. Measurements of deposition on top of feldspar clay pads give site specific estimates of sedimentation and high resolution lidar provides Information on the widespread distribution of sediments within the Atchafalaya Basin.

The 2011 flood provided valuable insight into the function of the Atchafalaya floodplain, the largest remaining river swamp in the United States. Management of the Atchafalaya Basin involves decisions based on transportation needs, flood protection, and commercial and recreational use, all of which affect the amount of sediment available for land-building in the Atchafalaya Delta.

Contact Information: Richard H. Day, National Wetlands Research Center, U.S. Geological Survey, 700 Cajundome Blvd., Lafayette, LA 70506 USA, Phone: 337-266-8557, Fax: 337-266-8586,
Email: dayr@usgs.gov

THE EFFECTS OF HYDROLOGIC MEAN CONDITION AND VARIATION ON WETLAND STRUCTURE AND FUNCTION

Joseph M. Delesantro and *Matthew J. Cohen*
School of Forest Resources and Conservation, University of Florida, Gainesville, FL, USA

An important debate in ecology considers the relative importance of mean condition vs. variation around that mean for controlling ecosystem structure and function. Wetlands provide a useful setting for examining this question because hydrology acts as the primary exogenous ecosystem driver and may exhibit large variation or fluctuate only slightly around the mean. Most previous studies have compared wetland study sites which vary greatly in mean condition but also in water chemistry, morphology, timing of flooding and dispersal characteristics, limiting independent evaluation of variation. Floodplain wetlands along the Silver River in north Florida provide an ideal hydrologic setting for a controlled natural experiment; stage variation near the spring boil is small so hydrologic conditions deviate only slightly from the mean condition, whereas downstream conditions, which are controlled by the flood regime in the Ocklawaha, are highly variable, deviating from the mean with great amplitude and frequency. Where water level variation changes longitudinally, hydroperiod varies laterally across the floodplain creating two orthogonal gradients, which offer the opportunity to isolate their effects independently.

Our objective is to evaluate the hypothesis that variation around the mean is as important as the mean condition in controlling ecosystem structure and function. This is accomplished by contrasting the effect of hydrologic mean condition and variation on attributes of long-term ecosystem self-organization, including net primary productivity, surface morphology/microtopography, organic matter accumulation, and forest community structure. We selected 10 study sites, pairing a short hydroperiod (10-30% inundation) and long hydroperiod (40-60% inundation) located at each of 5 transects along the Silver River gradient in water level variation. We are in the preliminary stages of analyzing our results, and seek to separate responses of ecosystem attributes to hydroperiod and water level variation.

<u>Contact Information</u>: Joseph Delesantro, University of Florida, 327 Newins-Ziegler Hall, Gainesville, FL, USA, Phone: 956-463-1068, Email: sci525@ufl.edu

IMPACTS TO SUBMERGED AQUATIC VEGETATION ASSOCIATED WITH HYDROLOGIC CHANGES IN THE ST. JOHNS RIVER ESTUARY, FLORIDA

D. R. Dobberfuhl[1] and *K. Moore*[2]

[1]St. Johns River Water Management District, Palatka, FL, USA

[2]Virginia Institute of Marine Sciences, College of William and Mary, Gloucester Point, VA, USA

A number of environmental and anthropogenic factors including weather fronts, tropical storms, climate change, and consumptive water use can potentially affect submerged aquatic vegetation (SAV) in the St. Johns River, Florida. SAV is particularly vulnerable in the estuarine portion of the river where large and frequent salinity changes regularly occur. We constructed a salinity-exposure model for *Vallisneria americana*, the dominant species in the estuarine reach, to predict the relative threat to SAV from elevated salinity related to channel deepening, sea level rise, and surface water withdrawals. The model was initially developed using literature data for *V. americana* salinity tolerance. We subsequently refined the model with novel, stress enzyme biomarker data, high frequency monitoring, and reciprocal transplant experiments. An EFDC hydrodynamic model of the middle and lower basins of the river generated spatially explicit, salinity time-series data for a variety of model scenarios based on possible water management actions, climate change, and physical alterations to the river channel. We used the salinity-exposure model in conjunction with the modeled salinity time series to identify periods of time with elevated stress. Stress was categorized as None, Low Stress, Moderate Stress, and Extreme Stress. The risk to the SAV community was evaluated as differences in relative frequencies of stress conditions between model scenarios. The model scenarios considered did not generally change the dynamical patterns of salinity events; however, salinity peaks were elevated and event durations increased by varying amounts among scenarios. The upper range for predicted sea level increase posed the greatest risk to the SAV community while water withdrawals appeared to pose the least amount of risk. The overall approach proved useful for identifying changes in the frequency and spatial extent of relative risk to the SAV resulting from environmental changes.

Contact Information: Dean Dobberfuhl, Bureau of Environmental Sciences, St. Johns River Water Management District, P.O. Box 1429, Palatka, FL 32178-1429, Phone: 386-227-0643, Fax: 386-329-4585, Email: ddobberfuhl@sjrwmd.com

GROUNDWATER AND STRATIGRAPHY IN TOE-SLOPE/VALLEY BOTTOM WETLANDS, CENTRAL PIEDMONT, VIRGINIA, USA

Kerby M. Dobbs and *G. Richard Whittecar*
Old Dominion University, Norfolk, Virginia USA

In landscapes surrounding urban zones, exploration continues for large sites that can be converted successfully to mitigation wetlands. The weathered crystalline Piedmont uplands west of many U.S. cities normally support wetlands only in valley bottoms, so the sites most appropriate for efficient conversion lie on low terraces and floodplains. Along stream valleys in the central Virginia Piedmont, both the geological history and historical land usage generated valley-bottom deposits that strongly influence the groundwater and overbank flow available to wetlands. The expected stratigraphic package in a Piedmont valley bottom is a fining-upwards (gravel-sand-mud) point-bar/flood basin sequence deposited by a stream channel migrating laterally. Floodplains underlain by this sedimentary sequence often contain numerous riparian wetlands fed by rain, groundwater and overbank flow. Unfortunately this classic stratigraphic scenario may be less common than expected because of valley damming during the 18th and 19th centuries. Extensive and unexpectedly thick mud beds deposited in historic, abandoned millponds carpet those valley bottoms and produce markedly altered subsurface hydrologic conditions. Surface flow often changes, too, because many streams have incised mini-canyons 1-3 m deep into those deposits. Such incised streams are now hydraulically disconnected from their old floodplains.

Groundwater discharge may contribute significantly to wetland water budgets at toe-slopes along floodplain edges. Out on the valley bottom, though, wetland water on floodplain surfaces near incised streams drains downward into soil pipes and other megapores that form in the silty millpond sediments. This complex history of deposition, incision and piping create terrace surfaces with water levels too low to support wetlands that are not in the proximity of toe-slope seeps. In such settings, successful hydrologic designs for mitigation wetlands might rely upon the groundwater that emerges at toe-slope seeps and is spread across regraded sloping surfaces carved from the historic milldam sediments.

Contact Information: Kerby M. Dobbs, Ocean, Earth and Atmospheric Sciences, Old Dominion University, Norfolk, Virginia 23529 USA. Phone: (757)-647-7021, Fax: 757-683-5303, Email: kdobbs@odu.edu

ECOPHYSIOLOGICAL PROFICIENCY OF MATURE BALDCYPRESS ON HUMMOCKS AND IN HOLLOWS WITHIN A FRESHWATER TIDAL SWAMP

Jamie A. Duberstein[1], *Ken W. Krauss*[2] and *William H. Conner*[1]
[1]Clemson University, Georgetown, SC USA
[2]U.S. Geological Survey, Lafayette, LA USA

Hummock and hollow microtopography exists in most tidal freshwater swamps in the southeastern United States. Situated above normal flood levels, hummocks are often aerated significantly longer than normal soil surfaces (hollows). Many tree species grow atop hummocks significantly more than in hollows, leading to the hypothesis that hummocks provide preferred locations for maximizing physiological proficiency for a range of tree species. Recent studies have used thermal dissipation probes to measure sap flow and assess mature tree ecophysiological proficiency under different environmental conditions. This study investigated sap flow rates in 22 mature baldcypress (*Taxodium distichum* [L.] L.C. Rich.) trees in a tidal freshwater swamp; 11 were positioned on hummocks and 11 in hollows in order to make use of a natural flood disparity and to understand more about the consequences of life on hummocks versus hollows. Most probes measured sap flow at 15 mm into the sapwood, but a limited number of probes measured at a depth of 25 mm. Water levels generally stayed below the tops of hummocks (17 cm) for most of the study, but selection of days for which flood waters exceeded this height were analyzed to determine whether excessive flooding served as a stress. Results show that sap flow increased in trees on both microsites during flooded conditions, counter to our expectations that hummocks provide a physiological escape from flood stress. Microtopographic position was not found to be a significant factor related to sap flow in mature baldcypress. Though most previous studies have found that the shallow sapwood depths (*e.g.*, 15 mm) are most active, this study found higher rates at 25 mm into the sapwood, which actually mirrors patterns from a nearby non-tidal swamp. Sap flow rates at 25 mm into the sapwood suggest greater differences in sap flow between trees on hummocks versus in hollows than rates at 15 mm, but limited statistical power failed to identify differences.

Contact Information: Jamie A. Duberstein, Baruch Institute of Coastal Ecology and Forest Science, Clemson University, Georgetown, SC 29440. Phone: (706) 410-6722, Email: jaduber@clemson.edu

A PROPOSAL FOR DEVELOPING AN INTEGRATED MASTER PLAN IN THE THREE GORGES RESERVOIR ECO-REGION

Kevin L. Erwin
Kevin Erwin Consulting Ecologist, Inc., Fort Myers, Florida, USA

The Three Gorges Project may be the largest water impoundment project in the world, creating perhaps the largest novel wetland ecosystem with the Three Gorges Reservoir averaging over 660 km long and 1.1 km wide with a surface area of approximately 1,045 km^2 during high water conditions. The 30m water level fluctuation within the reservoir affects an area exceeding 350km^2 thus having significant environmental implications on the ecosystem.

There currently exists a great potential for actions that would enhance and protect the vast natural and human resources within the Three Gorges Reservoir Ecoregion (TGRE) with many cost-effective opportunities to restore and sustainably develop both natural and man-made features on a vast landscape that is also home to more than 32 million people. Issues such as flood and erosion control, abatement of landslides, impacts on fish and wildlife, loss and transformation of agricultural lands and pollution control all of which are effected by a changing climate require attention. These issues are of great concern to the Chinese government as evidenced by recent collaborative efforts between scientists and government officials. In October 2011 two international meetings were held in Chongqing and Kaixian County, PRC to discuss the eco-friendly utilization of wetlands within the Three Gorges Reservoir. The meetings were hosted by the Ministry of Science and Technology of China, Chongqing and Kaixian municipal governments and Chongqing University. During these meetings and the discussions that followed it became apparent that there is a need to develop new Information through coordinated research coupled with a sound, integrated planning process.

The proposal is to develop an Integrated Master Plan (IMP) for the TGRE that reflects responsible governance between agencies, municipalities and universities. A coordinated research effort can provide the guidance necessary to make the TGRE more sustainable by properly directing future development, wetland restoration, re-forestation and fish and wildlife enhancement projects. Development of an IMP will require the collection of baseline ecological and hydrological data and the application of an integrated, three-dimensional hydrological model. Water is now the main driver of the TGRE and understanding the operational details of the TGRE's hydro-patterns is fundamental to conducting sound ecological research and appropriate future land-use planning. This type of model is the best, science-based, landscape planning tool for developing a successful Master Plan for the TGRE because it will integrate data collected from a wide variety of sources to provide a more realistic description of historic conditions, an accurate reflection of existing conditions and a reliable prediction of future conditions taking into consideration planned and unplanned modifications to the landscape and factors such as climate change.

Contact Information: Kevin L. Erwin, Kevin Erwin Consulting Ecologist, Inc., 2077 Bayside Parkway, Fort Myers, FL 33901 USA, Phone: 239-337-1505 Fax: 239-337-5983, Email: klerwin@environment.com

CONTROLS OF DENITRIFICATION IN PAPYRUS WETLANDS OF THE NYANDO AND MARA RIVERS, EAST AFRICA

Gretchen M. Gettel[1]*, Kuenzang Tshering*[1,2]*, Hawa Nakitende*[1,3]

[1]UNESCO-IHE Institute of Water Education, Delft, The Netherlands
[2]Royal University of Bhutan, Thimphu, Bhutan
[3]National Water and Sewerage Corporation, Kampala, Uganda

Papyrus wetlands in East Africa are important to the livelihoods of millions of people, and may also be important for nutrient retention, which protects sensitive downstream ecosystems from eutrophication. The Nyando and Mara wetlands border Lake Victoria in Kenya and Tanzania, respectively. In dry periods, parts of these wetlands are converted to grazing and local crop production of rice, maize and sugarcane, among others. Denitrification -- the production of gaseous nitrogen (N) from the microbial reduction of nitrate (NO_3) in anaerobic environments -- is likely an important mechanism for nitrogen retention in these systems. However, few measurements have been made, and the effect of land use change on denitrification has not yet been determined.

Using acetylene block technique to measure potential denitrification (denitrification enzyme assay), we measured potential denitrification rates in natural papyrus vegetation and in grazing, rice, maize, and sugarcane fields in the Nyando and Mara wetlands in November - December 2010. We also determined whether denitrification was limited by soil organic carbon or by NO_3 in different land uses, and further assessed controls using multivariate analysis relating soil characteristics to potential denitrification rates.

Potential denitrification in papyrus vegetation were the highest of all measured sites ($p<0.05$; ranging from 128 to 601 μg N_20 g soil dry weight^{-1} hour^{-1}) and the lowest in grazing sites (0.1 to 0.5 μg N_20 g soil dry weight^{-1} hour^{-1}). Rates were second highest in rice fields (2.3 - 303 μg N_20 g soil dry weight^{-1} hour^{-1}), and intermediate in maize and sugarcane (6.5 - 75 μg N_20 g soil dry weight^{-1} hour^{-1} and 5 - 30 μg N_20 g soil dry weight^{-1} hour^{-1} respectively). Controls of denitrification in different land uses were similar in the Nyando and Mara sites, and showed that NO_3 limited denitrification in papyrus vegetation, whereas organic carbon was limiting in all agricultural sites. Multivariate analysis showed that this pattern also corresponded significantly with low soil organic matter in the agricultural sites and low soil NO_3 (by KCl extraction) in papyrus vegetation ($p<0.05$).

These results were confounded by soil moisture, which was also higher in papyrus vegetation than in the agricultural sites, and likely resulted in a greater availability of anaerobic microzones. On an areal basis, papyrus vegetation may provide hotspots for denitrification (up to 0.2 kg N-N_20 m^{-2} day^{-1}) whereas agricultural lands show considerably lower rates (0.005 - 0.02 kg N-N_20 m^{-2} day^{-1}). We conclude that the reduction of potential denitrification in agricultural soils due to lower soil organic carbon and lower soil moisture results in tradeoffs in provisioning and nutrient retention functions of these wetlands.

Contact Information: Gretchen M. Gettel, Water Science and Engineering Department, UNESCO-IHE Institute of Water Education, Westvest 7, 2611 AX Delft, The Netherlands, Phone: +31 (0)15 215 1715 Fax: +31 (0)15 212 2921, Email: g.gettel@unesco-ihe.org

TROPICAL FLOODPLAIN ECOLOGY: AUSTRALIA COMPARED TO SOUTH AMERICA

Stephen K. Hamilton
Kellogg Biological Station, Michigan State University, Hickory Corners, MI, USA

Much tropical floodplain research on comes from the largest rivers of South America, including the Amazon, Orinoco, and Paraguay (Pantanal). These lowland systems have very large catchments with humid climates and distinct wet/dry seasonality, and consequently inundation tends to be prolonged, predictable, and monomodal. Most are located inland from the sea, either fringing large rivers (e.g., central Amazon, lower Orinoco) or as complexes of internal deltas (Pantanal). The Flood Pulse Concept embodies the idea of flood regimes that promote biotic adaptations to cope with and benefit from the flooding. Examples include prolific growth of floating aquatic macrophytes and food webs dependent on aquatic production during the inundation phase. South American floodplains along smaller rivers, and along rivers emanating from Andean mountain watersheds, tend to have more unpredictable flood regimes, and hence many of the ecological features documented in the largest lowland floodplains are less applicable to these ecosystems.

Floodplains in dryland regions also are globally important, but differ markedly in their ecology. Australia's tropical north provides an instructive example. Although annual rainfall may be similar, the monsoonal rainfall is highly episodic and variable in timing, and the dry season is longer and more severe. The relatively sparse vegetation in much of the catchments results in high runoff with even modest rainfall. Large expanses of land are subject to inundation, but because of the proximity to the sea, flood waters tend to run off readily. Many rivers flow little or not at all during the dry season, which allows seawater to penetrate up connected channels, and there may be little freshwater during the dry season.

Australia's tropical rivers drain geologically old terrain compared to the Andes of South America, but soil erosion and sediment transport can still be intense, possibly influenced by land use. Major solute and nutrient chemistry are not greatly different from South American floodplains and reflect the long history of weathering of these landscapes.

Aquatic macrophytes are less abundant in most Australian floodplains, probably reflecting the short inundation, severe dry season, and heavy grazing pressure during the dry season. A seasonal pulse of plant growth may occur as flood waters recede, but usually proves to be ephemeral. Dissolved oxygen depletion has been shown to be an important feature of South American floodplains, but is evidently less common in Australian floodplains.

Biodiversity is greater in South American floodplains than in Australian ones, reflecting biogeography as well as abiotic stresses faced by freshwater life in dryland climates. However, aquatic food webs seem remarkably similar (see talk by Jardine in this session). Invasive aquatic and terrestrial species strongly affect Australian floodplains. The dryland climate of the Australian floodplains presents more severe dry-season stress to terrestrial animals, including livestock, which consequently are more dependent on floodplains.

Contact Information: S.K. Hamilton, Kellogg Biological Station, Michigan State University, Hickory Corners, MI 49060 USA, Phone: 269-671-2231; Fax: 269-671-2104, Email: hamilton@kbs.msu.edu

ENVIRONMENTAL COMPLIANCE AND ECOLOGICAL RESTORATION WITH FLOATING WETLAND ISLANDS

Kevin Hedge and *Ted Gattino*
Managing Partner, BlueWing Environmental Solutions & Technologies, LLC

Floating Wetland Islands are man-made replicas of natural peat based systems found around the world. They are an example of Biomimicry, which is the use of nature's models to address anthropocentric problems. In our context, we use nature to improve and restore aquatic habitats and water quality. This presentation is intended to give the attendee a basic understanding of Biomimicry and why it is important. Give a basic understanding of floating wetlands and how they work to process nutrients and provide critical riparian wildlife habitats. Demonstrate how the floating wetlands function and provide numerous ecosystem services, as well as provide a glimpse into where the floating wetlands have been used and potential applications for the future.

The floating wetlands are manufactured using a fibrous recycled material (matrix) and are installed in all types of water. The interstitial spacing of the recycled materials allows naturally occurring microbes to colonize the fibrous surfaces creating a diverse wetland ecosystem where waterborne pollutants and contaminants are bio-processed into and out of the food chain. We will examine the key processes present in the floating wetland system and details of system dynamics that are optimized with the current island design. The massive potential of this habitat and nutrient processing tool will also be examined, along with explanation of existing and proposed projects, as well as the potential for future embodiments that can be utilized to reduce dead zones in all impaired waterways.

There are many applications that have been identified to date and people are thinking up creative ways to use the floating islands all the time. A partial listing includes: sewage treatment, storm water, drinking water reservoirs, polluted rivers and streams, erosion control in urban environments; treating effluent water from aqua and agri-culture operations; treating cleansing water and settling out heavy metals from mining applications; habitat enhancement and wave dampening projects related to climate change adaptation and lake restoration, dead zone mediation.

The floating wetlands can be applied to wet ponds and wetland applications and are a variation of infiltration and filtration practices. They can be used in stream and abandoned mine restoration projects, monitored drinking water projects as well as wastewater landfill leachate treatment projects.

By combining the best of wetland science, ecosystem design and processing, along with proven wastewater treatment technologies, this system has been effectively shown to reduce temperature and oxygen (DO) stratification in deep water ponds. The system is designed to easily allow removal of pollutants from the aquatic environment for proper storage, disposal and processing.

Participants will learn about the Biomimicry, concentrated wetland effect, biofilm, and ecosystem services.

Contact Information: Kevin Hedge, Managing Partner, BlueWing Environmental Solutions & Technologies, LLC, 4309 English Morning Lane, Ellicott City, Maryland 21043; Phone: 410-203-2270; Email: Kevin@bluewing-env.com

EFFECT OF VEGETATION HARVESTING ON NITROGEN AND PHOSPHOROUS CYCLING IN ROOTED PAPYRUS WETLANDS

***Edwin M.A. Hes*[1]**, *Anne A. van Dam*[1], *Ren Niu*[2] and *Kenneth Irvine*[1]
[1]UNESCO-IHE Institute for Water Education, Delft, The Netherlands
[2] Beijing Public Utility Science Research Institute, China P.R.

East African papyrus (*Cyperus papyrus*) wetlands support the livelihoods of millions of people through agriculture and harvesting of vegetation, and protect downstream ecosystems from eutrophication. To balance these ecosystem services, an understanding of the trade-off between vegetation harvesting and nutrient retention is needed. We studied this trade-off by constructing a simulation model for nitrogen and phosphorous cycling in papyrus wetlands. The model consists of sub-models for hydrology, carbon (C), nitrogen (N) and phosphorous (P) under permanently and seasonally flooded conditions. State variables included above and below-ground C, N and P pools in living and dead papyrus plants; total organic C, N and P; inorganic N and P species; and water volume. Modelled processes included: net primary production; C, N and P translocation and uptake; settling; mineralization; nitrification; and denitrification. Hydrologic parameters included precipitation; evapotranspiration; inflow; outflow; and drainage.

The model was parameterized using field data from the Nyando wetland (Kenya) and the Mara wetland (Tanzania) and literature. Data on papyrus growth from Nyando and Mara wetlands were used to calibrate papyrus growth and N and P distribution within the above ground and below ground biomass at different growth stages. The model was implemented in Stella 9.1.3 for a period of 1825 days with rectangular integration and a time step of 0.0625 days.

The model simulated the standing biomass, C, N and P fluxes for Nyando and Mara wetland well. The permanent wetland retained nutrients better than the seasonal wetland. Nutrient retention increased with vegetation harvesting (at a harvesting rate of 30% of the aboveground biomass per year at maximum biomass density). Differences in nutrient retention between seasonal and permanent wetlands were attributed to drought and variations in soil oxygen. Drought resulted in lower primary production and therefore less nutrient uptake in the seasonal wetland. The positive effect of harvesting on nutrient retention was less pronounced for P than for N, as adsorption to the soil particles is the main mechanism for P retention and the P-content of papyrus biomass is lower than the N-content. Further improvements of the model include the incorporation of new data on denitrification, biological N fixation and N adsorption to the soil in the Nyando and Mara wetlands.

Contact Information: Edwin M.A. Hes, UNESCO-IHE Institute for Water Education, Department of Water Science and Engineering, P.O. Box 3015, 2601 DA Delft, The Netherlands, Phone: +31-15-2151796, Email: e.hes@unesco-ihe.org

FOOD WEBS OF THE WET-DRY TROPICS: MULTIPLE SOURCES OF PRIMARY PRODUCTION FUEL ANIMAL BIOMASS

Timothy D. Jardine[1]*, Stephen K. Hamilton*[2] and *Stuart E. Bunn*[1]
[1]Australian Rivers Institute, Griffith University, Nathan, QLD, Australia
[2]Kellogg Biological Station, Michigan State University, Hickory Corners, MI, USA

The sources of carbon that support aquatic food webs regulate animal biomass and production. In the wet-dry tropics several potential sources of food exist, including phytoplankton, periphyton, decaying terrestrial leaves, submerged and emergent macrophytes and riparian grasses. This talk will review past research on sources of production sustaining food webs and search for commonalities and disparities among regions of the wet-dry tropics with a focus on the neotropics and northern Australia. Early work from South American rivers that used observational and stomach content data together with flux measurements found that fish yields were driven by highly visible sources such as detritus from higher plants. However, more recent stable isotope investigations have revealed that inconspicuous sources such as phytoplankton and periphyton form the bulk of the assimilated portion of fish diets. These contrasting insights may be reconciled by differences in light availability and subsequent algal production across systems that differ greatly in canopy cover and turbidity. Knowledge of these patterns of resource availability and use by animals will help guide conservation and management of these important ecosystems.

Contact Information: Timothy D. Jardine, Australian Rivers Institute, Griffith University, 170 Kessels Road, Nathan, QLD, Australia, 4111, Phone: 07 3735 5359, Fax: 07 3735 7615, Email: t.jardine@griffith.edu.au

LONG-TERM EFFECTS OF CREEK CHANNELIZATION ON RIPARIAN SWAMPS IN CENTRAL FLORIDA, US

***Michael J. Jerauld*[1], *Craig V. Duxbury*[2], *Peter M. Wallace*[3], *Thomas A. DeBusk*[1]**

[1]Azurea, Inc., Rockledge, FL, USA
[2]WDI, Orlando, FL, USA
[3]Ecosystem Research Corp., Gainesville, FL, USA

In 1969, a small, tannic stream in central Florida was channelized and impounded to provide control over upstream runoff. Downstream of the impoundment, the straightened, incised creek and associated spoil levee reduced or eliminated overbank flooding in the adjacent forested wetlands. The disconnection of the floodplain from the creek allowed oxidation of the organic wetland soils, resulting in severe soil subsidence in some areas. Several permanent transects were established approximately 20 years after channelization in three wetland areas along the creek. The trees in each transect were surveyed for species and diameter at breast height five to eight times in the period from plot installation to 2008. The wetlands were dominated by *Acer rubrum, Taxodium spp., Nyssa sylvatica* var *biflora,* and *Magnolia virginiana.* Over the period of record, the density of trees in each wetland declined by 40% to 50%, though there was high spatial variability; individual transects ranged from a loss of 78% of stems to an 8% increase in density, across all three wetlands. In later tree surveys, individual trees were tagged with numbered markers so that mortality and recruitment rates could be calculated. Average annual mortality (4%-24%) markedly outpaced average annual recruitment (0%-2%) in most transects. In 2011, depth of soil loss was measured in each transect and ranged from 10 to 83 cm. Across transects in all sites, mortality was well correlated with the depth of soil loss. Average annual mortality was nearly 10% per year in transects with the most severe subsidence, which is 2.5 to 10 times the rate of tree loss reported for similar systems. Additionally, average annual mortality was elevated in most transects (4%-52%) following the multiple tropical cyclones that impacted the region in late 2004. The major tree species displayed statistically significant differential mortality, with *Taxodium spp.* being the most resilient and *M. virginiana* losing the highest proportion of individuals. A small group of transects in one of the wetlands experienced extraordinarily high tree mortality (92-99% over the period of record), disproportionate to the depth of soil lost. The high density of woody vines observed during a 2011 field visit suggests that a positive feedback cycle of tree fall and vine growth may have been active in this area. Additional field work is needed to determine the current rate of subsidence and to evaluate the potential for slowing the rate of soil and tree loss by hydrologically restoring these wetlands.

<u>Contact Information</u>: Michael J. Jerauld, Azurea, Inc., 16112 East Duran Blvd., Loxahatchee, FL 33470 USA, Phone: 561-801-2899, Fax: 561-784-7890, Email: mike@dbenv.com

THE EFFECTS OF WASTEWATER DISCHARGE, AGRICULTURE AND PAPYRUS HARVESTING ON THE NUTRIENT REGULATION FUNCTION OF NAMATALA WETLAND, UGANDA

Susan Namaalwa[1], *Anne A. van Dam*[2], *Ajie Guruh*[2], ***Rose C. Kaggwa***[1] and *Andrew Sekayizzi*[1]
[1]National Water and Sewerage Corporation, Kampala, Uganda
[2]UNESCO-IHE Institute for Water Education, Delft, The Netherlands

Despite the important services they provide, wetlands in Uganda are facing severe degradation caused by a range of pressures like agricultural development and urbanization. An example is the Namatala wetland (size 260 km^2, altitude 1082-1128m) near the town of Mbale in East Uganda. The wetland is fed by Namatala river and other streams arising from the Mbale plain and the Mount Elgon highland zone and drains into the Mpologoma river system and ultimately Lake Kyoga. Two waste stabilization ponds (WSP) systems receiving wastewater from Mbale town, and untreated wastewater from Budaka and Nashibisho streams discharge into the wetland. A large part of the wetland is used for agriculture (mostly rice) and for papyrus harvesting. A balance between the provisioning and regulating services is necessary to achieve sustainable management.

The overall objective of this study was to compare total nitrogen (TN) and phosphorous (TP) input into Namatala wetland from the main river, from other tributaries, and from the wastewater treatment systems with the export of these nutrients through rice and vegetation harvesting. Specifically, we (1) estimated the main inflows into the wetland; (2) measured TN and TP concentrations in the inflows; (3) estimated the rice and papyrus harvests and determined their nutrient content.

Results showed that on average about 90% of the inflow into the wetland came from Namatala river and other tributaries. The remaining inflow was from Mbale town and the WSP systems. TN concentrations were low in the river (0.1-0.5 mg/l) whereas they were much higher in the urban streams (up to 30 mg/l in the discharge from the WSPs). Similarly, TP concentrations were low (0.09-1.0 mg/l) in the river but higher (up to 14 mg/l) in the urban streams. The rice area in Namatala wetland was 11624 ha with annual production of 24000 tonnes of grain. The papyrus area was 1200 ha with dry weight biomass between 1865 and 3050 g/m^2 of which 360 tonnes per year is harvested.

Based on these measurements, we estimate that nitrogen and phosphorous export from Namatala wetland through rice and papyrus harvesting are higher than nutrient input into the wetland through wastewater discharge. These findings are confirmed by generally acceptable nutrient concentrations downstream of Namatala wetland. Namatala wetland may be an example of successful integration of regulating (water quality maintenance) and provisioning (rice production) ecosystem services. However, further intensification of agriculture (including fertilizer application and channelization) and population growth (leading to higher waste flows) require careful management of the balance between ecosystem services.

Contact Information: Susan Namaalwa, Water Quality Department, National Water and Sewerage Corporation, P.O. Box 7053, Kampala, Uganda. Phone: +256717315106; Fax: +256414256929; Email: susan.namaalwa@nwsc.co.ug

MULTITEMPORAL REMOTE SENSING APPROACH FOR MAPPING WETLANDS SHALLOW LAKES IN THE PARANÁ RIVER FLOODPLAIN

*M. Marta Borro [1,3], Natalia S. Morandeira[1,3], Gabriela Gonzalez Trilla[1,3], Mercedes Salvia[2,3], Priscilla Minotti[1], **Patricia Kandus** [1]*

[1]LETyE, 3iA, UNSAM, Bs.As., Argentina
[2]Instituto de Astronomía y Física del Espacio. Ciudad Universitaria, CABA, Argentina
[3]Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina

One of the main features of South America floodplains is the presence of shallow lakes (SL) included in the wetland matrix, which are key elements to sustain their high biological diversity. Mapping of SL is critically required to understand wetland dynamics and for ecosystem monitoring. However, problems arise when trying to identify their boundaries, due to the fragmented nature of wetland landcover types, the coverage of macrophytes in the floodplain, and the spatial and temporal variability of the actual area occupied by the SL.

In order to discriminate SLs from the wetland matrix in the Paraná River Delta floodplain, we used 77 NDVI scenes (Path 226, Row 83) derived from Landsat TM, from 1987 to 2010, representing different hydrometric levels. A NDVI threshold of 0.3 was estimated based on pixel samples of different types of SL and surrounding wetlands landscape elements. Individual scenes were segmented into binary SL images and a SL frequency image was calculated for the whole dataset. We applied a mask to exclude the river courses. The same analysis was performed for set of images corresponding to high, medium and low water level. To evaluate the minimum number of images needed to reduce the variability in SL cover we run a sensitivity analysis with stacks composed of different numbers of SL images (5 to 30) taken at random.

We found it requires at least 20 images to obtain a trustful result of SL cover. The resulting coverages were contrasted to an existing map of SL and ground data and all the Kappa indices showed high accordance (> 0,85). SLs represent circa 0,1% of the studied region. For the whole 1987 – 2010 period, the maximum coverage occurred for images with high water levels (205,690.59 ha). The lowest SL coverage (59,227.92 Ha) occurred for low water levels of the dry period between 2000 – 2010.

The use of time series of LANDSAT images helped distinguish the diversity of SL immersed in the floodplain wetland mosaic, for its spatial resolution allowed the detection of SL with an area less than one hectare which are the predominant in the Paraná River Delta region.

Contact Information: M. Marta Borro, Laboratorio de Ecología, Teledetección y Eco-Informática, Instituto de Investigaciones e Ingeniería Ambiental, Universidad Nacional de General San Martín, Peatonal Belgrano 3563, (1650) Gral. San Martín, Buenos Aires, Argentina, Phone: 54 11 4580-7300 ext: 106, Email: marta.borro@gmail.com

HYDROPERIOD EFFECTS ON ANNUAL RELEASE RATES OF N, P, AND DOC IN A FLOODPLAIN WETLAND

***L. Keenan*[1]**, *E. Lowe*[1], *E. Dunne*[1], *A. Bochnak*[1], *J. Di*[1], *K.R. Reddy*[2], *A. Wright*[2],
[1]St. Johns River Water Management District, Palatka, Florida, USA
[2]University of Florida, Gainesville, Florida, USA

This work was part of an interdisciplinary effort to develop methods for system-wide forecasts of the potential environmental consequences of proposed water withdrawals in large river systems. We focused on the biogeochemical effects of reduced hydroperiod in wetlands adjacent to the river and how those changes could affect the river itself.

Carbon, nitrogen, and phosphorus are sequestered and released by wetlands. In warm climates, wetlands sequester organic matter and nutrients in plant biomass, litter, and soil during periods of inundation, owing to suppression of aerobic decomposition. Constituent release rates tend to be highest following periods of exposure when organic matter and nutrients were subject to aerobic decomposition and, consequently, enhanced oxidation rates. Reduction of the hydroperiod, or average annual period of inundation, increases the annual period of enhanced oxidation and therefore the annual mass release of organic matter and nutrients. Because surface water withdrawals can reduce hydroperiods in floodplain wetlands, the annual duration of exposure of organic soils can increase thereby increasing the release of carbon and nutrients from the wetland to the river.

We developed a hydroecological model relating the change in annual mass release of N, P, and DOC to forecasts of the additional hectare-days of exposure of wetland organic soils. Using this model, the effects of the hydrologic forcings, in our case a reduction in hydroperiod, on annual release rates were evaluated. The model was parameterized using in situ measurements of release rates for carbon and nutrients. In the sites that could be affected by withdrawals, we found little potential for an increase in annual mass releases to the river. Three factors were prominent in this finding. First, the organic matter in the soils was highly refractory. Consequently, little additional decomposition was associated with additional exposure. Second, modeled rates of reduction in released nutrients, either through uptake or transformation, were sufficiently high that only a small portion of the released constituents would reach the river. Third, the additional load was a negligible fraction of the total loading to the river. We also examined the potential for reduction of dissolved oxygen (DO) concentrations in the river associated with increased release of P and DOC, but, for the same reasons, this effect also was minimal.

Using data from another site, we will demonstrate that the effects of augmented release rates of nutrients can be significant where organic soils are more labile and could significantly decrease the DO concentrations in the receiving waters.

Overall, the potential for deleterious effects was negligible for the area modeled. However, reduction of hydroperiod in other areas could have important environmental effects.

Contact Information: Lawrence W. Keenan, St. Johns River Water Management District, P. O. Box 1429, Palatka, FL 32178-1429 USA, Phone: 386-329-4425; Fax: 386-329-4585, Email: lkeenan@sjrwmd.com

GROUNDWATER-SURFACE WATER INTERACTIONS IN A PAPYRUS WETLAND

Patrick S. Khisa[1,2]*, Stefan Uhlenbrook*[2,3]*, Jochen Wenninger*[2,4]*, Ann van Griensven*[2,4] and *Margaret Abira*[1]

[1]Water Resources Management Authority, Lake Victoria South Catchment Area, Kisumu, Kenya

[2] UNESCO-IHE Institute for Water Education, Delft, The Netherlands

[3]Delft University of Technology, Delft, The Netherlands

[4]Vrije Universiteit Brussel, Brussels, Belgium

A hydrometric network was established to investigate groundwater-surface water interactions at a 4,000 ha papyrus wetland on the eastern shores of Lake Victoria, Kenya. Nyando wetland supports a fragile ecosystem and community livelihoods in one of the most densely populated parts of East Africa. The main objective of the study was to understand the groundwater-surface water exchange fluxes between the river, lake, and alluvial aquifer in the wetland and surrounding area.

Sampling was carried out along two main transects based on hydrological, ecological and socio-economic gradients. Climate data were collected using a weather station. Pressure sensors (van Essen type) were installed at 5 single and 2 nested piezometers, and stilling wells to log groundwater levels, river and lake stages and temperature data at hourly intervals. The ECHO2 soil moisture sensors were installed 30 cm, 60 cm and 90 cm depths adjacent to the river, lake and wetland periphery to record data at hourly intervals. All data loggers were synchronized to record data at the same time. In addition, manual staff gauges, rain gauges and evaporation pans were installed and read by community observers on a daily basis. Discharge measurements were undertaken during low to high flows using the Acoustic Doppler Velocimeter (ADV) and Acoustic Doppler Current Profiler (ADCP) at river gauging stations and along river reaches. Routine *in-situ* water quality measurements were undertaken at river, lake and groundwater stations. Experimental data analyses were carried out in order to develop a conceptual model for the dominating groundwater-surface interactions conceptual models during flood and low flow events.

Results show that the wetland is connected to the river and lake as one hydrological unit during floods in the rainy season. In the dry season, the river is isolated or decoupled from the wetland but the lake is directly connected to the exposed papyrus wetland following diurnal cycles. In the wet season, the river recharges the alluvial aquifer (influent condition), which reverses to effluent condition in the dry season. The alluvial aquifer recharges the lake most of the time, with the exception of the prolonged dry season, when the lake recharges the aquifer, being influenced by topography. Understanding these groundwater-surface water exchange fluxes provides vital knowledge for papyrus wetland conservation and management.

Contact Information: Patrick S. Khisa, Water Resources Management Authority (WRMA), Lake Victoria South Catchment Area, P.O. Box 666-40100, Kisumu, Kenya. Email: patkhisa@yahoo.com

HYDROLOGY AND THE DISTRIBUTION OF FLOODPLAIN PLANT COMMUNITIES OF THE UPPER ST. JOHNS RIVER, FLORIDA

***Palmer Kinser*[1]**, *Sandra Fox*[1], *Lawrence Keenan*[1], *Aisa Ceric*[1], *Fay Baird*[1], *Peter Sucsy*[1], *William Wise*[2], *Clay Montague*[2]

[1]St. Johns River Water Management District, Palatka, Florida, USA
[2]University of Florida, Gainesville, FL, USA

The extent and other characteristics of freshwater wetlands are driven by hydrology. When hydrological conditions are altered, wetland vegetation communities are likely to change in composition over time to more nearly resemble those communities better adapted to the altered hydrology. With reduced hydration, the range of responses may extend from subtle changes in productivity or species composition to replacement of the community by one characteristic of a dryer environment or an upland type. With diminished hydration, community boundaries would be expected to shift downslope over time as plant species and communities re-establish at elevations best suited to their hydrologic tolerances.

In this presentation, we consider the St. Johns River, Florida as a model system to examine wetland plant community response to hydrologic alteration. Specifically we examine whether changes in inundation depth and duration are likely to change the extent of wetlands in the landscape, shift community boundaries, or alter key aspects of seasonal flooding and drying patterns. Transects across the floodplain of Lake Poinsett in the upper St. Johns River valley were analyzed to determine changes in hydrologic characteristics from baseline and to project potential changes in community boundary locations and width of wetland community types resulting from surface water withdrawals. This analysis made the following simplifying assumptions: 1.) Lake Poinsett water levels adequately represent the hydrology of adjacent wetlands, 2.) With diminished hydration, wetland communities shift downslope and re-establish at elevations with hydrologic exceedences similar to those experienced at their previous landscape positions, 3.) dryer communities displace more hydrophilic communities through competition for moisture and light, 4.) communities are discrete and move as intact units. Given these assumptions, analytical results represent a worse-case outcome. Actual outcomes are modified by additional landscape, soil, and hydrological drivers, which tend to lessen the severity of effects.

<u>Contact Information</u>: Palmer D. Kinser, Bureau of Environmental Sciences, St. Johns River Water Management District, 4049 Reid Street, Palatka, FL, 32178 USA, Phone: 386-328-4369; Fax: 386-329-4329; Email: pkinser@sjrwmd.com

INTEGRATION OF ECOLOGICAL, HYDROLOGICAL AND SOCIO-ECONOMIC DATA INTO A BAYESIAN NETWORK MODEL FOR THE SUSTAINABLE UTILIZATION OF PAPYRUS WETLANDS

Julius Kipkemboi[1] and *Anne A. van Dam*[2]
[1]Egerton University, Njoro, Kenya
[2]UNESCO-IHE Institute for Water Education, Delft, The Netherlands

Wetlands dominated by papyrus (*Cyperus papyrus*) occur widely throughout central and eastern sub-Saharan Africa. They perform important ecosystem functions and services such as maintenance of water quality, habitat provision, and biomass production; and hence have a strong influence on the livelihoods of local and regional human populations. If not regulated, the increasing demands for wetland goods and services to sustain livelihoods constitute a threat to these ecosystems. For a better understanding and effective management of papyrus wetlands, a holistic approach is needed. This paper describes the development and improvement of a transdisciplinary framework for knowledge management and sustainable use of papyrus wetlands.

The study area was the Nyando papyrus wetland on the eastern shores of Lake Victoria in Kenya. The main environmental issues were identified from on-going research on the hydrology, ecology, socio-economics and governance of the Nyando wetland. A Bayesian Network model with 35 nodes, developed earlier (using Netica 4.16) with expert and stakeholder input, was improved with quantitative data collected from on-going research on the hydrology, ecology and socio-economics of the wetland. This resulted in better model descriptions of: the relationships between rainfall, river discharge, lake levels and wetland flood duration and extent; the impact of agriculture on primary productivity, nutrient and sediment retention, and vegetation biodiversity; and of the effects of income and hydrology on resource use and livelihoods activities by wetland households.

Model results confirmed earlier findings showing that dry conditions stimulate cropping, livestock herding and vegetation harvesting but have a negative effect on wetland ecosystem function. Flooded conditions had a strong positive effect on ecosystem function. The overall effect of flooding on livelihoods was limited because communities rapidly adjust to seasonal changes by engaging in a range of different livelihoods activities. The model is adaptive and can be further improved as new knowledge becomes available. Further improvements to the current model can be expected from incorporating knowledge about the effect of wetland policy and economic development on resource use. The model can be customised for other, similar wetland ecosystems. This integrated framework is also a useful tool for communicating research results to diverse groups who have interests in wetlands: scientists, policy makers, implementing agencies and local communities.

Contact Information: Julius Kipkemboi, Department of Biological Sciences, Egerton University, P.O. Box 536-20115, Njoro, Kenya. Email: j_kkipkemboi@yahoo.co.uk

A SUMMARY OF EXISTING WETLAND RESEARCH ON THE THREE GORGES RESERVOIR AREA

Xingzhong Yuan[1] *Qiang Wang*[2] *Kevin L. Erwin*[3] *Ruoxi Li*[4] *Presented by:* ***Yuechen Li***
1,2College of Resources and Environmental Science, Chongqing University, Chongqing,PRC
3Kevin Erwin Consulting Ecologist, Inc., 2077 Bayside Parkway, Fort Myers, Florida, USA
4Chongqing Normal University, 12 Tianchen Road, Shapingba District, Chongqing,PRC

The Three Gorges Reservoir Area (TGRA), which comprises the twenty six counties around the reservoir and covers about 58,000 km^2, is historically one of the richest flora centers in China. There are 6388 taxa of vascular plants (including 155 threatened species listed in the China Protected Species List), 3418 insect species and 500 species of vertebrates in the TGRA. Surveys following the dam completion indicated that 55 % of vascular flora species have disappeared. Some impacted species, such as Myricaria laxiflora, were found downstream of the Three Gorges Dam (TGD). We believe that while the TGD may not have resulted in vascular plant extinctions in China, floral biodiversity within the TGRA has significantly decreased. Little is known about the current condition of approximately 150 species of fish and 1085 species of plankton, benthic invertebrates and aquatic plants within the TGR.

Both central and local governments accord great importance to environmental issues within the TGRA. Many works and plans have been conducted to protect the reservoir area. In 2011, the Wetland Engineering and Technology Research Center was constructed and now operates within the Three Gorges Reservoir Area in order to achieve sustainable use of wetland resources in the Three Gorges Reservoir, to enhance research capabilities in wetland engineering and to strengthen international and domestic academic communication, The Center is used as a platform to carry out cooperation in wetland education and protection, ecological engineering and restoration research and the development of wise-use strategies.

Current research activities include investigating; the physiological responses of plants to flooding, the effects of water stresses on growth, biophysical responses to different soil water regimes, vegetation restoration and utilization techniques within typical water-level fluctuation zones, littoral zone dike-pond system designs, the effects of the impoundment on plant community, diversity and zonation, relationships between standing vegetation and soil seed banks, the effect of flooding on soil properties and release of nutritional elements, the TGR's effects on greenhouse gas emissions, studies on reservoir eutrophication and algal bloom analysis.

Contact Information: Ruoxi Li, Chongqing Normal University, 12 Tianchen Road, Shapingba District, Chongqing 400047 PRC
Phone: 86 023 65363508, Email: cc86@163.com

GENERAL METHOD FOR EVALUATING POTENTIAL ECOLOGICAL EFFECTS OF ALTERED HYDROLOGIC REGIMES

E. Lowe, *L. Battoe, D. Dobberfuhl, M. Cullum, P. Sucsy, T. Cera, J. Higman, M. Coveney, D. Curtis, L. Keenan, P. Kinser, R. Mattson* and *S. Miller*

St. Johns River Water Management District, Palatka, Florida, USA

During a three-year, comprehensive evaluation of potential environmental effects of proposed water withdrawals from the St. Johns River, Florida, we developed a general approach for forecasting the hydroecological (HE) effects of anthropogenic modification of hydrologic regimes. This approach seems suitable for a variety of circumstances where management decisions must consider the potential for environmental effects associated with needs for public water supplies, flood control, or other services that can significantly alter hydrologic regimes.

The general method can be summarized as follows. 1) Define a baseline time period for which the data set is adequate to assess the hydrology, hydrodynamics, and ecological status. 2) Develop hydrologic and hydrodynamic (H&H) models calibrated to the baseline condition. 2) Using H&H models, simulate the hydrologic and hydrodynamic deviation from the baseline condition associated with a proposed action. The deviations in H&H drivers become the forcings for ecological attributes. 3) Develop conceptual models demonstrating a plausible chain of causation linking the status of key ecological attributes to H&H forcings. 4) Develop HE models for key ecological attributes. 5) Use the forcings as input to HE models to simulate the deviations of ecological attributes from the baseline conditions. The deviations in ecological attributes form the suite of potential environmental effects. 6) Examine the longitudinal variation in potential effects. As part of this aspect of the work, we found it useful to divide the river into segments that were relatively uniform in terms of their ecological characteristics. 7) Evaluate the importance of an effect based on its strength (intensity and scale), persistence (recovery time/recurrence interval), and diversity (i.e. range of species and/or functions affected). 8) Assess the level of scientific uncertainty associated with the forecast based on the goodness-of-fit of models, the weight of supporting evidence, and the degree of understanding of the causal mechanisms.

We believe our approach has general application for evaluation of the potential effects of human modifications to the hydrology of rivers and their associated wetlands and estuaries.

<u>Contact Information</u>: Edgar F. Lowe, St. Johns River Water Management District, P. O. Box 1429, Palatka, FL 32178-1429 USA, Phone: 386-329-4398, Fax: 386-329-4585, Email: elowe@sjrwmd.com

VARIABLE RESPONSES OF ECOLOGICAL ATTRIBUTES AND DRIVERS TO HYDROLOGIC ALTERATION IN THE ST. JOHNS RIVER, FLORIDA

E. Lowe, *L. Battoe, D. Dobberfuhl, M. Cullum, P. Sucsy, T. Cera, J. Higman, M. Coveney, D. Curtis, L. Keenan, P. Kinser, R. Mattson* and *S. Miller*

St. Johns River Water Management District, Palatka, Florida, USA

In order to understand the overall potential for ecological effects from hydrologic and hydrodynamic forcings, it is necessary to examine both the longitudinal variation in the sensitivities of ecological attributes and the inter-attribute variation in sensitivity within river segments. To elucidate these sources of complexity in the river's potential response to water withdrawals, we examined the deviation from the baseline condition of hydrologic and hydrodynamic (H&H) drivers (forcings) and of ecological attributes (effects) along the river's length.

Our work indicates that there is considerable longitudinal variation in the hydrologic and ecological sensitivity of the river to water withdrawals. With respect to hydrologic and hydrodynamic (H&H) forcings, water level forcings were negligible from the mouth to about 200 km upstream owing to the overriding influence of sea level. Material salinity forcings were limited to a 43 km stretch (RK 38 – 81) in an area of highly variable salinities. Retention time forcings spanned the length of the river but were not significant upstream of river kilometer 200. As would be expected, flow rate forcings spanned the length of the river downstream of the withdrawal points, but forcings were greatest near the upstream withdrawal points. Scaling of forcings against natural variation showed that natural variation would still be salient.

Our work indicates that ecological attributes can show their greatest responses in areas other than those where the relevant driver showed the strongest forcings. For example, flow rate forcings were strongest for the upper reaches but the effects of flow rate forcings on ecological attributes, in this case the abundances of estuarine fish and benthic macroinvertebrates, were strongest in the lower reach. In most cases, however, the strongest ecological effects were spatially congruent with the spatial variation in the strength of the relevant H&H forcings. In our work, the most responsive of the ecologic attributes evaluated were the relative abundance of fish species in the estuary and the density of fish in the floodplain freshwater wetlands.

Contact Information: Edgar F. Lowe, St. Johns River Water Management District, P. O. Box 1429, Palatka, FL 32178-1429 USA, Phone: 386-329-4398, Fax: 386-329-4585, Email: elowe@sjrwmd.com

BIRDS, PEOPLE AND PAPYRUS SWAMPS: BALANCING LIVELIHOODS AND BIODIVERSITY CONSERVATION

Ilya M. D. Maclean
Centre for Ecology and Conservation, Biosciences, College of Life and Environmental Sciences, University of Exeter, Penryn, UK

Birds are generally considered to be good indicators of ecosystem health and constitute the taxa most often used to designate protected areas. Knowledge of their overall status and an understanding of how birds respond to increasing human pressure could help inform conservation planning and policies designed to balance the needs of people and wildlife.

Using survey data collected across the Lake Victoria basin, I determine the structural characteristics of papyrus swamps that affect avian abundance. Using a time series of satellite images to derive habitat structure remotely, I (1) map the abundance of key indicator species in over 30,000 papyrus swamps across the region, and (2) infer the declines that have occurred as a result of human-induced habitat loss and degradation, in so doing providing the first quantitative assessment of swamp drainage in the region.

I show that (1) a very high proportion of the total population of birds could, in theory, be conserved by protecting a small number of wetlands, (2) wetlands hosting high densities of species are also the most threatened and consequently birds have declined at much higher rates than their habitat, and (3) bird densities are highest in swamps subject to low-intensity disturbance. I argue that papyrus swamp management benefiting wildlife would also benefit people, but that currently papyrus swamps are mismanaged for a number of reasons. I outline what I believe those reasons to be and invite broader debate on the subject.

Contact Information: Ilya M.D. Maclean, Centre for Ecology and Conservation, Biosciences, College of Life and Environmental Sciences, University of Exeter, Cornwall Campus, Penryn TR10 9EZ, UK, Email: i.m.d.maclean@exeter.ac.uk

RESPONSES OF ESTUARINE BENTHIC MACROINVERTEBRATE COMMUNITIES TO CHANGING RIVER FLOWS IN THE ST. JOHNS RIVER ESTUARY, FLORIDA, USA

Robert A. Mattson[1]*, Paul A. Montagna*[2]*, Terry Palmer*[2] and *Jennifer Beseres-Pollack*[2]
[1]St. Johns River Water Management District, Palatka, Florida USA
[2]Harte Research Institute for Gulf of Mexico Studies/Texas A&M University Corpus Christi, Corpus Christi, Texas USA

Benthic macroinvertebrate communities are strongly influenced by altered freshwater inflows to an estuary. Macroinvertebrate communities are affected by factors (including nutrient concentrations, sediment supply and salinity) caused by variation in freshwater inflows to an estuary. The purpose of this study is to identify specific macroinvertebrate bioindicators and their response to salinity change and to speculate on the possible implications of decreasing volumes of freshwater inflows into the St Johns Estuary. The analysis used existing water quality and benthic macroinvertebrate data from seven US Environmental Protection Agency EMAP sites and ten Florida Department of Environmental Protection (FDEP) stations. Analyses were also conducted on blue crab and penaeid shrimp populations using nine years of data collected by the Florida Fish and Wildlife Conservation Commission Fisheries Independent Monitoring Program.

Benthic community structure had the highest correlation with salinity out of all water quality variables measured concurrently with the benthic samples (temperature, dissolved oxygen, pH and salinity). There was a significant correlation between mean invertebrate abundance and salinity using the three-parameter, log normal model. Peak abundance occurred at 0.4 ppt. Bioindicators for salinities less than 2 ppt in the St Johns Estuary include: insects, oligochaetes (*Limnodrilus hoffmeisteri* and *Bratislavia unidentata*),amphipods (*Apocorophium lacustre* and *Corophium* sp.), barnacles (*Balanus* sp.), and bivalves (*Mytilopsis leucophaeta* and *Rangia cuneata*). The bivalve *Mulinia lateralis* is a good indicator for salinities of approximately 15 ppt and the polychaete *Mediomastus* sp. is a reliable indicator for salinities above 10 ppt. The implication of these results is that if a reduction of freshwater inflows to the St. Johns Estuary causes isohalines to shift upstream, associated species and taxa groups will shift upstream also. Populations of juvenile blue crab and penaeid shrimp (principally white shrimp, *Litopenaeus setiferus*) were largely unresponsive to variation in freshwater inflow or exhibited higher abundance at lower river flows.

Contact Information: Mr. Robert Mattson, Bureau of Environmental Sciences, St. Johns River Water Management District, P.O. Box 1429, Palatka, FL 32178-1429 USA, Phone: (386) 329-4582, FAX: (386) 329-4585, email: rmattson@sjrwmd.com

POTENTIAL EFFECTS OF WATER MANAGEMENT PRACTICES ON WETLAND-DEPENDENT SPECIES IN THE ST. JOHNS RIVER, FLORIDA

*D. Curtis, **L. McCloud**, S. Fox, D. Dobberfuhl*
St. Johns River Water Management District, Palatka, FL, USA

Hydrologic changes, whether anthropogenic or climatologic, have the potential to affect wildlife, particularly wetland dependent species. We have created a process loosely based on the US Fish and Wildlife Service Habitat Evaluation Procedure to predict impacts to wildlife potentially resulting from hydrologic changes within the St. Johns River, Florida and its surrounding floodplain. The first step was creating an inventory of all candidate species whose range and habitat requirements intersected the river and its associated floodplains. The second step was identifying forage preferences, reproductive requirements, and hydrologic requirements of each species in the inventory. From this Information, we identified a number of important hydrologic criteria and the optimal habitat criteria for listed species and other focus species. GIS was used to develop a grid-based model that integrated land surface elevation and hydrologic model data to generate a time series of ponded depth. GIS model input included an HSPF hydrologic model and a LiDAR-derived digital elevation model constructed for the upper basin of the St. Johns River. Ponded depth was used to calculate hydrologic statistics for each model cell (e.g., inundation frequency). Each model cell was then scored according to species-specific requirements. This model ultimately allows us to assess potential effects on wetland-dependent wildlife based on predicted water management changes.

Contact Information: Lori McCloud, Bureau of Environmental Sciences, St. Johns River Water Management District, P.O. Box 1429, Palatka, FL 32178-1429 USA, Phone: 386-329-4872, Fax: 386-329-4585, Email: lmccloud@sjrwmd.com

PREDICTING FRESHWATER INFLOW EFFECTS ON ESTUARINE FISHES IN THE ST. JOHNS RIVER, FLORIDA

Steven J. Miller, *Ronald E. Brockmeyer, Jr.* and *Wendy Tweedale*
St. Johns River Water Management District, Palatka, Florida, USA

Potential relationships between freshwater inflow and fish distribution and abundance in the St. Johns River estuary were examined by correlation and regression analysis. Inflow relationships were derived using monthly fisheries catch data collected from 2001 to 2010 by the Florida Fish and Wildlife Conservation Commission's Fisheries Independent Monitoring Program (FIM). The FIM uses a stratified random sampling design and a multi-gear approach to collect data on fishes and invertebrates from a wide range of habitats and life history stages. Three types of sampling gear were used: (1) 21.3-m center-bag seine, (2) 6.1-m otter trawl, and (3) a 183-m seine.

Species-specific ontogenetic changes in habitat, size-specific mortality, and gear avoidance have the potential to confound relationships between inflow and species abundance and distribution. To better control these influences, species were divided into size classes. For individual species, specific size classes, recruitment period of the size-classes, collection gear, and sampling location were use to delineate what were termed "pseudospecies". Spearman's rank correlation (rho) between inflow-distribution and inflow-abundance were assessed for each pseudospecies that had $n > 99$ animals collected and occurred in ≥ 5% of the samples. Inflow effects were investigated at lag periods of 30, 60, and 90 days (distribution and abundance), and 120, 150, 180, 210, 240, 270, 300, 330, and 360 days (abundance only) prior to the designated sampling period (month or annual recruitment period). Linear regression analyses of dependent variable (abundance or distribution) on lagged inflow were conducted for pseudospecies that had a significant response ($p < 0.05$) and a Spearman's rho ≥ 0.4. Four linear regressions corresponding to different transformation scenarios (no transformation, dependent variable transformed, independent variable transformed, and both dependent and independent variables transformed) were conducted on each retained pseudospecies lagged-inflow period combination. In all cases, the transformation applied was a fourth-root transformation. The PRESS coefficient of determination r^2 was calculated for each linear regression model. The pseudospecies inflow combination and transformation regression with a significant slope ($p < 0.05$), the highest PRESS r^2, and an linear regression $r^2 \geq 0.25$ were used for predicting effects of varying inflow.

After regression screening, 61 pseudospecies abundance to inflow regressions representing 34 species, and 20 pseudospecies center-of-abundance to inflow regressions representing 14 species were retained. These regression were used in conjunction with hydrologic modeling data to predict potential effects of surface water withdrawals. Results suggest fishes in the St. Johns River estuary are extremely sensitive to variations in freshwater inflow. In general marine pseudospecies increased in abundance and freshwater pseudospecies declined in abundance with declining inflow. With declining inflow all pseudospecies exhibited a small upstream shift in their center of abundance.

Contact Information: Steven J. Miller, St. Johns River Water Management District, P.O. Box 1429, Palatka, Fla. 32178 USA: Phone 386-329-4387, Fax: 386-329-4585, Email sjmiller@sjrwmd.com

IMPACT OF CLIMATE VARIABILITY ON THE HYDROLOGY OF THE SUDD WETLAND: SIGNALS DERIVED FROM LONG-TERM (1910 TO 2010) WATER BALANCE COMPUTATIONS

Yasir Mohamed[1,2,3]

1Hydraulic Research Station, Ministry of Irrigation and Water Resources, Wad Medani, Sudan
2UNESCO-IHE Institute for Water Education, Department of Management and Institutions, Delft, The Netherlands
3Delft University of Technology, Department of Water Resources, Delft, The Netherlands

The Sudd wetland is a huge swampy area (30,000 to 40,000 km^2) with vegetation composed mainly of papyrus, water hyacinth and grasslands. It is located in South Sudan and is of vital importance for livelihoods, ecosystem services and water resources both locally as well as regionally. Half of the White Nile flow evaporates when passing through the Sudd wetland. Historically, water conservation plans were prepared to divert part of the river inflow through shortcut channels, culminating in the start of the construction of the Jonglei canal in 1978. Recently, interest in finishing construction of the canal has been revived. However, the available Information on the hydrology of the Sudd is limited, and mostly outdated.

This study aims at understanding the long term dynamics of the Sudd hydroclimatology by utilizing water balance computations. The Sudd wetland area is predominantly determined by the regional climate upstream – outflow from Lake Victoria plus torrential flow, and the local climate – precipitation and evapotranspiration over the wetland. An accurate assessment of the long term variability of the wetland area provides insights into the two-way climate feedbacks.

However, the Sudd is characterized by scarce ground measurements because of the harsh conditions and long instability in the area. Remotely sensed data of precipitation, evapotranspiration and water level were found to be very instrumental to augment long missing data gaps. The inflow to the wetland was estimated from Lake Victoria outflow and runoff from catchment up to Mangala (torrents flow). The potential evapotranspiration from the wetland as computed from climate data was adjusted using actual values derived from satellite images during three years (1995, 1999 and 2000). The derived wetland area was verified with the area delineated from high resolution satellite images during the last two decades.

The 100 year long variability of the wetland area and the correlation with key hydroclimatological drivers enabled an accurate assessment of the impact of the regional climate on this important tropical wetland.

<u>Contact Information</u>: Yasir Mohamed, UNESCO-IHE Institute for Water Education, Department of Management and Institutions, PO Box 3015, 2601 DA Delft, The Netherlands, Email1: y.mohamed@unesco-ihe.org; Email2: y.mohamed@hrs-sudan.sd

FIRE, FLOODPLAINS AND FISH: CONSERVATION OF NATIVE FISHES IN THE RIVERINE AND FLOODPLAIN WETLANDS OF THE COSUMNES RIVER, CALIFORNIA

Michelle L. Stevens and ***Joshua L. Moore***
CSU Sacramento Environmental Studies Dept, Sacramento, CA, USA

Traditional Resource Management is an influential supplement to overall restoration policy and management practices. The Cosumnes River is located in the northeastern portion of the Sacramento-San Joaquin Delta of Central California. Prior to European settlement, this area was Plains Miwok territory, supporting an estimated population density of 57 individuals per square mile along riparian areas . Overall floodplain biodiversity and native fish productivity benefited from burning and other traditional management practices utilized by Native Californians. Ethnographic and archaeological data were used to reconstruct pre-European settlement traditional management practices. Ethnographic data was gathered from historical literature and local Miwok informants. Archaeological data from four Cosumnes River sites dating to the Late Period (1200 to 100 B.P.) were analyzed and compared to records of modern fish abundance and floodplain habitat modifications. Three types of fish habitat occur in the Cosumnes River: slow water settings, fast water settings and varied settings; each provide differing habitats for native California fish populations. Archaeological and ethnographic records indicate fish species that exist within the slower water setting of the Cosumnes River include: tule perch (*Hysterocarpus traski),* Sacramento Perch (*Archoplites interruptus),* thicktail chub *(Gila crassicauda),* hitch *(Lavina exillicauda)* and Sacramento blackfish *(Orthodon microlepidotus).* Fast water settings include Pacific lamprey *(Lempertra tidentata),* hardhead *(Mylopharadon conocephalus),* fall run Chinook salmon *(Oncorhynchus tshawytscha),* and white and green sturgeon *(Acipsenser medirostris).* Fish species found in varied settings include: Sacramento sucker *(Catostomus occidentalis),* Sacramento splittail *(Pogonichthys macrolepidotus),* and the Sacramento pikeminnow *(Ptychochelius grandis).* All species exist within the Cosumnes River Preserve except the Sacramento perch and the now extinct thicktail chub. This study synthesizes data from fish ecology, four archaeological ichthyofaunal site remains, ethnographic sources, and traditional knowledge to reconstruct the landscape of the lower Cosumnes River watershed prior to Euro-American settlement. Results indicate that traditional management practices, such as burning and harvesting plant materials in the floodplain, may have increased the productivity of floodplain rearing habitat, thereby increasing fish growth and reducing fish mortality. Loss of traditional tending practices compounded by widespread degradation of habitat, alteration of flows, and introduction of exotic species has resulted in the catastrophic decline of most California native fish species. Minnows and other native fishes that were originally abundant in lowland lakes, tule marshes, sloughs and slow moving sections of the river have diminished significantly or disappeared from pre-European settlement numbers. Just over 50% of the fish species present within the archaeological record for the study area are now either on watch status, threatened, of special concern, or extinct. The Sacramento perch, which composed 42% of the entire archaeological icthyofaunal record presented here, is no longer present within the study area. The thicktail chub, which composed 32% of all the assemblages, is now extinct. Fall run Chinook salmon, commonly referred to in the ethnographic record, are listed as species of special concern. Based on this synthesis of multiple sources of Information, it is likely traditional practices optimized habitat vitality for native fish species, attributing to higher fitness levels towards fluctuating environmental conditions.

Contact Information: Michelle Stevens, CSU Sacramento, Environmental Studies Dept, 6000 J St, Sacramento, CA 95819-6001, USA, Phone: 916-765-7397, Email: stevensm@csus.edu

INSTITUTIONS AND GOVERNANCE: COMMERCIALIZATION OF WETLAND RESOURCES AND ITS EFFECT ON TRADITIONAL INSTITUTIONS IN THE NYANDO PAPYRUS WETLANDS, KENYA

Serena Nasongo[1,5], *Fred Zaal*[1,2], *Ton Dietz*[1,3] and *J.B. Okeyo-Owour*[4,5]

1University of Amsterdam, The Netherlands
2 Royal Tropical Institute, Amsterdam, The Netherlands
3African Studies Centre, Leiden, The Netherlands
4School of Environmental Sciences, Moi University, Eldoret, Kenya
5VIRED International, Kisumu, Kenya

Wetland environments have played an important role in the development and sustenance of cultures throughout human history. Since early civilization, many cultures have lived in harmony with wetlands and developed economies around them due to their functions and services. Wetlands are composed of a number of physical, biological and chemical components which are of direct use value to humans. An example is the Nyando Wetland in Kenya, a wetland dominated by papyrus (*Cyperus papyrus*) vegetation. The communities living around the Nyando Wetland are tightly bound by strong pre-modern socio-cultural ties to the natural resources around them from which they have developed their livelihoods. In most of these communities, the socio-cultural knowledge and beliefs were transmitted by oral traditions and strongly rooted in personal and local experience. However, communities are growing, partly through immigration, becoming more complex, fragmented, and becoming more ethnically and socio-economically diverse. This has brought both positive and negative impacts. The resident communities' own traditions and institutions are changing because of this, either through experience or through Contact, and good and bad aspects of alien traditions and beliefs have been incorporated into a pre-existing culture.

Due to commercialization of wetland resources there have been many changes in the institutions that controlled how the Nyando Wetland resources were used. Institutions are sets of norms and rules and systems of values that control, organize, imprint a pattern on and shape the behavior of actors during their interaction to satisfy their functionally related requirements of life. The different types of institutions (family, economic, political and religious) regulate the meeting of needs, since they rationalize and systematize social interaction for the use of resources (material or non-material) available to a community. Ultimately, there is a need to understand the factors controlling the dynamics of the specific natural resource-related institutions.

The objective of the study was to determine how commercialization of resources has changed traditional institutions that governed wetland resource use in the Nyando papyrus wetland. The study was carried out in four sub-locations within the Nyando Wetland: Ogenya, Kakola Ombaka, Jimmo Middle and West Kabodho, Kisumu County. Quantitative data was collected using a questionnaire from 411 households while qualitative data came from key informant interviews and focus group discussions. The data was analyzed using SPSS and EXCEL for the quantitative data while the qualitative data was analyzed using ATLAS Ti. The results showed that there have been changes in institutions and relations between the local stakeholders interacting in this area and consequently the governance system of wetland resources. Commercialization of wetland resources, imported ideas on other cultures and technology have shaped the ways in which communities have evolved and adapted themselves, through the institutions that they use to govern their resources in the Nyando wetland. Therefore, local stakeholders should decide on the priority problems, control of available resources, and their role in planning and management of the Nyando Wetland.

Contact Information: Serena Nasongo, VIRED International, P.O. Box 6423, Kisumu, Kenya, E-Mail: adedeserena@gmail.com

WETLAND POLICY DEVELOPMENT IN RWANDA: FROM WETLAND INVENTORY TO LEGISLATION FOR SUSTAINABLE USE

***Paul Ouedraogo*[1]** and *Rose Mukankomeje*[2]
[1]Ramsar Convention, Gland, Switzerland
[2]Rwanda Environment Management Authority, Kigali, Rwanda

Rwanda is divided into two major drainage basins: the Nile basin to the east, covering 67% and source of 90% of the national waters; and the Congo basin to the west, which covers 33%. The abundance of water resources is reflected by the existence of a network of wetlands whose main functions include agricultural production, hydrological functions, biodiversity reservoirs, peat reserve, hydroelectricity, mitigation of climate change, leisure and tourism and cultural value. An inventory based on satellite image analysis was conducted in 2008 by the Rwanda Environment Management Authority (REMA) and showed that Rwanda has 860 marshlands and 101 lakes, covering a total surface of 278,536 ha (10.6 % of the country's surface area) and 149,487 ha (5.7%), respectively. The inventory also found 861 rivers totaling 6,462 km in length. Of the inventoried marshlands, 41% are covered by natural vegetation (often including *Cyperus papyrus*), 53% (about 148,344 ha) are under cropping and about 6% are fallow fields. Following Rwanda's signing of the Ramsar Convention, the Convention came into force in Rwanda on April 1, 2006 with REMA being the Administrative Authority for the Convention.

The categorization of Rwandan wetlands in 2008 included 38 wetlands (56,120 ha; 20%) proposed for full protection, 475 wetlands (206,732 ha; 74%) proposed for exploitation under conditions and 347 wetlands (15,689 ha; 6%) proposed for exploitation under a basic Environmental Impact Assessment. In May 2009, the Rwandan government adopted four ministerial orders related to wetlands and dealing with the Organic Law, establishing (1) the list of wetlands and their limits; (2) the list of protected wetlands; (3) the organization, rules of management and use of wetlands in Rwanda; and (4) the list of rivers and lakes. In addition to that, a draft wetlands law is being reviewed by the government and the parliament. These policy developments aim at the maintenance of the ecological character of Rwandan wetlands within the context of sustainable development and promote the "wise use" concept. The Convention emphasizes that human use of wetlands can be compatible with Ramsar principles and wetland conservation in general.

The wetland inventory was a big step towards improving Rwandan government policy and strategy for the wise use of wetlands. The over-exploitation of plant and animal biodiversity in wetlands impacts negatively on the wetlands ecosystem services. The government's response will contribute to improving the wetland functions of sediment retention and flood control, to reduce the gradual erosion of wetland biodiversity and to regulate the exploitation of important vegetation with species such as *Cyperus papyrus*, *Cyperus latifolius*, *Vossia cuspidata* and *Cyperus denudatus*.

Contact Information: Paul Ouedraogo, Senior Regional Adviser for Africa, Ramsar Convention Secretariat, 28 rue Mauverney, CH-1196 Gland, Switzerland, Fax: +41(0)22 999 0169, Email: ouedraogo@ramsar.org

RESPONSE OF PAPYRUS WETLAND ECOSYSTEM TO SEASONAL CHANGES IN HYDROLOGY AND LIVELIHOOD PRESSURES

Priscah J. Rongoei[1], *Julius Kipkemboi*[2] and *Anne A. van Dam*[3]

1Egerton University, Department of Environmental Sciences, Egerton, Kenya
2Egerton University, Department of Biological Sciences, Egerton, Kenya
3UNESCO-IHE Institute for Water Education, Delft, The Netherlands

Papyrus wetlands, dominated by *Cyperus papyrus*, are used widely by communities in sub-Saharan Africa to support their livelihoods. Little is known about the ecological functions of papyrus wetlands in relation to increasing pressure from conversion to agriculture and vegetation harvesting. This study was done in the Nyando wetland in Kenya. The aim was to understand the response of the wetland's emergent macrophyte species abundance and diversity to seasonal changes in hydrology and exploitation pressures.

Data from June 2010 (wet season) and May 2011 (dry season) were used. In three transects in Nyando wetland (Ogenya, Singida and Wasare), plots of 30 x 30 m^2 were demarcated, one in the permanent wetland and one in the seasonal wetland (which during the dry season is converted to agriculture). Within each plot, species composition, abundance and diversity were determined in five quadrats of 1 x 1 m^2.

The number of emergent species was higher in the dry season than in the wet season, with average no. of species 5.8, 5.6 and 2.8 in Wasare, Ogenya and Singida, respectively. In the wet season, this was 4.4, 3.6 and 2.6, respectively. The total no. of individuals was higher in the wet season than in the dry season, with highest mean abundance in Wasare (43.2 ind./m^2 in the wet season, versus 30.4 in the dry season), followed by Ogenya (35.6 versus 32.2) and Singida (21.6 versus 10.6). In the wet season, the relative abundance of *C. papyrus* was highest (42, 57 and 63% in Wasare, Ogenya and Singida, respectively). In the dry season, papyrus abundance was lower (14, 33 and 11%, respectively). In Wasare, papyrus was replaced in the dry season by *Ipomoea aquatica* (44%), in Ogenya by *Commelina* sp. (20%) and *Cucumis* sp. (11%), and in Singida by *Ipomoea wrightii* (43%) and *Ranunculus* sp. (28%).

Species diversity was higher in the dry season in Wasare (Shannon index 1.37, dry versus 1.27, wet season) and Ogenya (1.42 versus 0.93). In Singida, diversity was slightly higher in the wet season (0.71 dry, 0.79 wet season). There was a strong linear relationship between Shannon index (Y) and relative abundance of *C. papyrus* in the wet season ($Y = 1.85 - 1.58 X$, $R2 = 0.796$, $P < 0.001$, $N = 15$, three transects).

In the dry season, relative abundance of *C. papyrus* in the converted seasonal wetland was low with 6%, 7% and 0% relative abundance in Wasare, Ogenya and Singida. In Wasare, *Ranunculus* sp. (38%) and *Leersia hexandra* (25%) were dominant, while in Ogenya *Commelina* sp. (13%) and *Cynodon dactylon* (22%), and in Singida *Ranunculus* sp. (60%) and *Polygonum senegalensis* (17%) were important. In the converted wetland, Shannon index was higher than in the permanent wetland in Wasare (1.53 versus 1.37) and in Singida (0.96 versus 0.71), but lower in Ogenya (1.17 versus 1.42). Differences between transects can be explained partially from differences in hydrology (lake and river influence) and exploitation pressure (agriculture, livestock herding and vegetation harvesting).

Contact Information: Priscah J. Rongoei, Egerton University, Department of Environmental Sciences, P.O. Box 536-20115, Egerton, Kenya. Email: priscah.rongoei@gmail.com

REMOTE SENSING APPROACH FOR MONITORING THE FLOOD EXTENT IN THE AMAZON RIVER FLOODPLAIN

Allan. S. Arnesen[1], ***Thiago S. F. Silva***[1], *Laura L. Hess*[2], *Evlyn . M. L. M. Novo*[1]

[1] Remote Sensing Division, National Institute for Space Research, S. José dos Campos, SP, Brazil.

[2] Earth Research Institute, University of California Santa Barbara, CA, USA

The Lower Amazon River floodplain is subject to large seasonal variations in water level due to the dimensions of the basin. Such amplitude, associated with its flat topography, results in significant variation in flood extent throughout the year.

Remote sensing data, especially Synthetic Aperture Radar (SAR) data, represents a good alternative for mapping the total flood extent of these wetlands, because of its ability to provide timely and continuous Information, since they are less affected by atmospheric conditions than optical data. Nevertheless, mapping the total flood extent is not an easy task, as the Amazon River floodplain is composed of different types of land cover with backscattering properties that change in time and space. Therefore, before the application of techniques for land cover classification, it is necessary to characterize this backscattering on SAR images.

The present study has two objectives: 1) Characterize the backscattering of the main Amazon floodplain cover types in PALSAR/ALOS (ScanSAR mode) images, ands 2) Use the SAR images to map inundated area at multiple dates along the hydrological cycle.

Twelve ScanSAR scenes were acquired between 2006 and 2010, focusing on the Curuai Lake floodplain, situated at the Lower Amazon River, near Óbidos (PA). Water level Information from gauge stations (Curuai and Óbidos), field photographs collected during the rising water period of 2011 and optical images (Landsat-5/TM and MODIS/Terra and Acqua) were also used as complementary data.

Since considerable overlaps were observed between the class distributions in the ScanSAR images, a data mining tool (Weka Data Mining) was used to identify multiple thresholds that could be used as classification rules. A hierarchical, object-oriented classification method was then applied, using the determined rules, to map the flooding variation in the Curuai Lake floodplain. The accuracy of the classification was assessed for two lowest hierarchical levels, the second (for the entire time series) and the third (low and high water stages). Overall accuracy of the second level was 90% (kappa index = 0.86). For the third level, accuracy was of 78% and 80% for low and high water stage respectively (0.7 kappa index in both cases). Based on the mapped estimates of flooded area, a polynomial regression model was fitted to predict flood extent as a function of the water level at the Curuai gauging station using data from 2007, (highest number of images available), with $R^2 = 0.94$ ($p < 0.05$). The model was then validated using image classifications from 2009 and 2010.

Contact Information: Allan Saddi Arnesen, Divisão de Sensoriamento Remoto, Instituto Nacional de Pesquisas Espaciais – INPE. Av. dos Astronautas, 1758. Jd. Da Granja. S. José dos Campos, SP, Brazil. CEP 12227-010. Phone: +55 (12) 3208-6437. E-mail: allansa@dsr.inpe.br.

REMOTE SENSING OF LARGE WETLANDS: CAPTURING THE SPATIAL AND TEMPORAL DYNAMICS OF THE AMAZON FLOODPLAIN

Thiago S. F. Silva[1], *Evlyn M. L. M. Novo*[1], *Tarik S. Araújo*[1], *Eduardo. M. Arraut*[2], *Maycira P. F. Costa*[3], *John M. Melack*[4]

[1]Remote Sensing Division, National Institute for Space Research, S. José dos Campos, SP, Brazil
[2]Earth System Sciences Center, National Institute for Space Research, S. José dos Campos, SP, Brazil
[3]Department of Geography, University of Victoria, Victoria, BC, Canada
[4]Bren School of Environmental Science and Management, University of California Santa Barbara, CA, USA

The Amazon region contains some of the largest wetland areas in the world, totaling almost 1 million square kilometers, and the mainstem Amazon floodplain alone covers over 350,000 km^2. Given its sheer size, remote sensing has played a key role in studying and understanding the hydrological and biogeochemical processes of these ecosystems. Moreover, remote sensing studies are often coupled with field and modeling approaches for the quantification of carbon emissions, development of conservation strategies, and other similar studies.

The fast and often unpredictable dynamics of wetland systems present, however, unique difficulties for the application of remote sensing techniques. Different vegetation types can show seasonal and regional variations at very diverse time and spatial scales, and natural long term variability can have significant effects on observed results. These characteristics often demand the use of multiple image sources, covering a broad range of spectral, spatial and temporal resolutions, and challenge the usual concept of “maps” as static representations of the land. Thus, new methods are needed that allow the integration of multiple image sources, and that are able to properly capture and represent this variability

This presentation will summarize some of the recent advances in remote sensing applications to study the functioning and dynamics of the Amazon floodplain, and how the issues stated above were addressed. Study cases will include 1) the combination of high frequency, high resolution synthetic aperture radar data and high frequency, low resolution optical imagery to properly quantify the effects of macrophyte variability on the carbon cycling of the floodplain, and 2) the use of MODIS EVI time series to quantify the scale and intensity of the effects of extreme flooding and drought events at the landscape level, for the entire Amazon River mainstem. Special attention will be given to the challenges of integrating multiple imagery sources and of representing highly variable ecosystems, and how the solutions found could be applied to remote sensing studies of large wetland systems across the world.

<u>Contact Information</u>: Thiago Sanna Freire Silva, Divisão de Sensoriamento Remoto, Instituto Nacional de Pesquisas Espaciais – INPE. Av. dos Astronautas, 1758. Jd. Da Granja. S. José dos Campos, SP, Brazil. CEP 12227-010. Phone: +55 (12) 3208-6433. E-mail: thiago@dsr.inpe.br.

SUSCEPTIBILITY OF MACROPHYTE PRODUCTIVITY TO VARIATIONS IN FLOOD INTENSITY IN THE AMAZON FLOODPLAIN

Thiago S. F. Silva[1], *Tarik S. Araújo*[1], *Evlyn M. L. M. Novo*[1], *John M. Melack*[2]
[1] Remote Sensing Division, National Institute for Space Research, S. José dos Campos, SP, Brazil.
[2] Bren School of Environmental Science and Management, University of California Santa Barbara, CA, USA.

The aquatic environments of the Amazon region have a higher contribution to the regional carbon balance than would be expected by their size alone. Amazon wetlands are responsible for CO_2 emissions comparable to land-cover associated emissions for all tropical Americas, and for about 20% of the total CH_4 emitted by natural wetlands in the globe. The mainstem Amazon River floodplain alone contributes with a large portion of these totals, but many aspects of its carbon dynamics are still poorly understood.

Primary producers in the floodplain are mainly characterized by woody and herbaceous vegetation (macrophytes), with small contributions from phytoplankton and periphyton due to the high turbidity observed for most of its waters. Productivity is largely modulated by the "flood pulse", a recurring annual pattern of inundation that drives most of the ecological and biogeochemical processes in the floodplain. Macrophyte communities are particularly susceptible to short-term changes in flooding patterns. As these plants present some of the highest productivity rates in the world, alterations in inundation patterns are likely to result in changes to their carbon input contributions.

The present study combined field measurements, Radarsat-1 synthetic aperture radar and MODIS optical images and object-oriented remote sensing techniques to estimate macrophyte cover for multiple inundation stages during the 2003 - 2005 period, at different locations in the mainstem Amazon River floodplain. Preliminary results for the Curuai Lake region, in the eastern portion of the floodplain, indicate that macrophyte cover area was inversely related to flood levels ($r = -0.8$, $p < 0.05$). The extreme drought observed for year 2005 led to an increase in maximum macrophyte cover by a factor of 1.3. At the same time, vertical macrophyte growth (biomass accumulation) was directly related to inundation levels ($r = 0.9$, $p < 0.05$). The observed results suggest that two antagonistic processes can drive macrophyte productivity in the floodplain: higher water levels will result in increased vertical growth, while reduced water levels will increase macrophyte colonization during the early flooding season. Under the predicted scenario of more intense and recurrent extreme climatic events for the Amazon floodplain, significant changes in the macrophyte contribution to the carbon cycle of the region can be then expected.

Ongoing analysis include the quantification of the relationship between macrophyte cover and flooding levels for other regions in the floodplain, and also simulations of macrophyte NPP by estimating monthly coverage and monthly biomass as a function of water level, using historical river stage data.

Contact Information: Thiago Sanna Freire Silva, Divisão de Sensoriamento Remoto, Instituto Nacional de Pesquisas Espaciais – INPE. Av. dos Astronautas, 1758. Jd. da Granja. S. José dos Campos, SP, Brazil. CEP 12227-010. Phone: +55 (12) 3208-6433. E-mail: thiago@dsr.inpe.br.

WILL HYDROLOGICALLY RESTORED MISSISSIPPI RIVER WETLANDS PROMOTE CRITICAL BIOGEOCHEMICAL FUNCTION?

***Jared M. Theriot*[1], *John R. White*[1], *Ronald P. DeLaune*[1], *S. Reza Pezeshki*[2]**

[1]Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, Louisiana

[2]Department of Biological Sciences, University of Memphis, Memphis, Tennessee

Riparian wetlands are essential components of the landscape providing critical functions including buffers for floodwaters, wildlife habitat, and improvement of surface water quality. Many riparian areas have been functionally removed from the landscape by emplacement of levees alongside the Mississippi River and its distributaries. Recent restoration efforts along the Mississippi River, in southern Arkansas, include reconnecting the river with the riparian alluvial fringe. Now that the hydrologic connection has been re-established, we are investigating several microbial-mediated wetland soil biogeochemical processes including ammonification and the important nitrate removal process of denitrification. We established sampling stations at newly restored wetland sites and at an adjacent control wetland that has been continually flooded by river water. Soil and microbial processes measured include bulk density, organic matter, total carbon, nitrogen (N) and phosphorus, microbial biomass, potentially mineralizable N and potential denitrification. Higher soil bulk density and lower soil organic matter, total C, total N, and microbial biomass were observed for the restored site. The mineralizable N rates were 21.4 ± 7.9 and 85.8 ± 22.0 mg N kg^{-1} d^{-1} for the restored and control wetland soils, respectively. The denitrification rate of the restored wetland soils were 7.94±7.44 and 459±60.6 mg N_2O-N kg^{-1} d^{-1} in the control wetland. This result suggests that while the hydrologic function of the riparian wetland has been restored, the biogeochemical function of the wetland is substantially lower than that of the control, ranging from four times lower mineralizable N to 58 times lower potential denitrification at the restored site. One possible remedy for speeding up the rate of "biogeochemical restoration" would be the addition organic matter to the restored site to more quickly restore the microbial-mediated biogeochemical functions.

<u>Contact Information</u>: Jared Theriot, Department of Oceanography & Coastal Sciences, Louisiana State University, 3221 Energy, Coast, & Environment Building, Baton Rouge, LA 70803, Phone: 225-578-1123, Email: Jther12@lsu.edu

THE WALK-A-WAY SYSTEM: A MULTI-BENEFIT PLANTING REGIME FOR REINTRODUCING HARD MAST INTO WETLAND RESTORATION.

Mike Thompson[1] and *Ken Dalrymple*[2]
[1]Wetlands Forever Inc., Bartelso, IL, USA
[2]SoggyBottom LLC, Annada, MO, USA

"Planting trees can be problematic in floodplains and riparian areas because of intense competition from herbaceous and woody plants, animal herbivory and browsing, and flooding and saturated soils. Overall, we found RPM seedlings had greater survival and growth than bare root seedlings. We suspect that this is because the RPM seedlings are larger, have bigger root systems and, thus are more competitive when out-planted. This finding is consistent with other oak plantings in uplands, where larger seedlings with bigger root systems had greater survival and growth than smaller seedlings." [3]

Riverine and floodplain restoration planting site success has many obstacles to overcome. Dynamic site conditions such as hydrology, soil, landscape, plant quality, planting practices and wildlife pressure affect success. The Walk-A-Way System provides restoration professionals with a system to address those difficult and dynamic restoration site conditions.

The "Walk-A-Way" system supports a restoration project fact of "Sites get little or no attention after planting". The Walk-A-Way planting system extends plant growth beyond easy reach of browsing deer, overtopping by floodwater and sunlight competition. The multi-step sequence of the Walk-A-Way Planting System includes ground preparation; cover crop establishment; superior planting stock, proper tree establishment, protection barrier to reduce tree mechanical damage, and first year maintenance.

The Walk-A-Way System using RPM container trees makes good economic sense due to an increase in survival rates, reduced competition, accelerated growth rates, and earlier fruiting. Superior plant stock utilizing only 50-60 RPM trees are needed to canopy and regenerate one acre of land compared with hundreds of bare root seedlings.   Instead of taking 20 years to produce acorns, RPM species like Swamp White Oak (Quercus bicolor) have fruited in the fourth year! Early fruiting equates to increased wildlife food sources and an improved chance for natural regeneration of hard mast tree species.

Using RPM planting stock makes good economic sense due to the high survivability, increased growth rate and reduced number of plants per acre needed to obtain a successful diverse wetland site in half the time of typical successional models for wetland restoration.

The Root Production Method (RPM) is a patented process developed by Forrest Keeling Nursery that creates world class plants for numerous environmental, conservation and agroforestry applications.

[3]Dan Dey, John Kabrick & Michael Gold – Establishing Oaks in Big River Floodplains

<u>Contact Information</u>: Ken Dalrymple, SoggyBottom LLC, Annada, MO 63343 USA, Phone: 636-578-3381, Email: ken_dalrymple@netzero.net

DIVERTED MISSISSIPPI RIVER SEDIMENT AS A POTENTIAL PHOSPHORUS SOURCE TO LOUISIANA COASTAL SYSTEMS

***John R. White*[1], *Wei Zhang*[2], *Ronald D. DeLaune*[1]**

[1]Louisiana State University, Baton Rouge, LA, USA
[2]Chinese Academy of Sciences, Chengdu, Sichuan, China

Mississippi river water and associated suspended sediment are seasonally diverted into Louisiana coastal basins to restore historic hydrologic and salinity regimes in efforts to slow or reverse widespread coastal wetland loss due to high rates of relative sea level rise. Breton Sound receives such seasonal diversions through the Caernarvon diversion structure from the Mississippi River, located just downstream from the city of New Orleans. We examined the effect of soil redox condition on phosphorus (P) release from the newly deposited Mississippi River sediment. Sediment was collected from Big Mar Lake, the receiving water body of the Caernarvon diversion structure, through which river water is diverted into the Breton sound estuary. A sediment suspension was incubated in the laboratory under sequential aerobic and anaerobic conditions and the relation of redox conditions to soluble P release was determined. Soluble reactive P (SRP), dissolved organic P (DOP), dissolved Fe and Mn concentrations increased with decreasing sediment redox potential. The increase in soluble SRP was correlated to an increase in ferrous iron which was associated with reduction of ferric phosphate. The SRP and DOP concentrations increased 32 and 8 fold during 20 days of anaerobic conditions. While the vast majority of studies on nutrients associated with the Mississippi River diversion have focused on excess inorganic nitrogen forms (e.g NO_3) in the river water, this study is one of the first to demonstrate that upon reduction associated with the prolonged flooding associated with the operation of the diversion, the recently deposted diverted Mississippi River sediment, associated with coastal restoration projects, can be a significant source of bioavailable P to the coastal basin.

Contact Information: John R White, Wetland & Aquatic Biogeochemistry Lab, Department of Oceanography, Louisiana State University, Baton Rouge, LA 70803 USA, Phone: 225-578-8792, Fax: 225-578-6423, Email: jrwhite@lsu.edu

ECO-ECONOMIC ASPECTS OF A DIKE-POND PROJECT IN THE DRAWDOWN ZONE OF THE THREE GORGES RESERVOIR

Bo Li[1,2], *XingZhong Yuan*[1,2] and ***J.H. Martin Willison***[3]
[1] College of Resources and Environmental Science, Chongqing University, Chongqing, China
[2] Key Laboratory of Exploitation of Southwest Resources and Environmental Hazards Control Engineering, Ministry of Education, Chongqing University, Chongqing, China
[3] School for Resource and Environmental Studies, Dalhousie University, Halifax, NS, Canada

In contrast with the hydrological condition of natural rivers in the Three Gorges Reservoir (TGR) region, the water level of the TGR is high in winter and low in summer. While this condition is un-natural, it nevertheless provides a summer growth period for plants in the drawdown zone. Eco-friendly methods for using TGR drawdown zone resources are urgently needed because conventional agriculture is widespread throughout the reservoir region and improper land uses will threaten the ecosystem health of the TGR ecosystem.

Based on analysis of characteristics of the TGR drawdown zone, a 4.26 ha experimental dike-pond project was established near the Pengxi River of Kai County, Chongqing, based on ecological engineering principles. For reference purposes, a 4.62 ha conventional agricultural zone near the dike-pond project was also selected. Ecological and economic parameters of the project area and contrast area were investigated and initial results indicate that the dike-pond project provided richer habitat for wetland biodiversity while also providing some economically valuable products. In the dike-pond project area there were 26 species of aquatic insects (1.53 times higher than those in the comparison zone), 4 species of frogs (1.33 times higher), and 16 species of birds (1.45 times higher). The following economically valuable plant species were found to have high productivity in the drawdown zone: *Trapa bispinosa*, *Eleocharis dulcis*, *Zizania latifolia*, *Oryza sativa*, *Nelumbo nucifera* (space-traveled) and *Nelumbo nucifera* (ordinary variety).

In light of the successful implementation of these experimental dike-ponds, survival and productivity of the introduced plants will continue to be monitored. Similar experiments with a wider range of plants species will be conducted, and measurements of biodiversity will be extended and improved.

Contact Information: Bo Li, College of Resources and Environmental Science, Chongqing University, Chongqing 400044, China, Email: wetlandlee@gmail.com

POTENTIAL FOR WETLAND RESTORATION IN THE DRAWDOWN ZONE OF HANFENG LAKE, CHONGQING, CHINA

***J.H. Martin Willison*[1], *Bo Li*[2,3], *Qiang Wang*[2,3] and *XingZhong Yuan*[2,3]**

[1] School for Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia, Canada
[2] College of Resources and Environmental Science, Chongqing University, Chongqing, China
[3] Key Laboratory of Exploitation of Southwest Resources & Environmental Hazards Control Engineering, Ministry of Education, Chongqing University, Chongqing, China

In 2008 Hanfeng Lake was created in Kai County, Chongqing, by the filling of the reservoir associated with the Three Gorges Dam. The reservoir is filled during winter and lowered during summer for flood control purposes. Hanfeng Lake is partially separated from the associated Pengxi River by a water-level regulatory dam and is surrounded by urban development. The drawdown zone of Hanfeng Lake requires special attention because of its urban location and the status of the lake as a nature reserve.

Here we discuss some of the management considerations for the drawdown zone, with special consideration to eco-design principles. Given the unique nature of the lake, we argue that management of the drawdown zone requires an approach that is experimental and therefore adaptive. The nature reserve objectives include a focus on bird abundance and diversity and so we argue that the management approach must be ecosystem-based. Given the urban location of the lake, we argue that community-based processes should be used for the management approach to be socially acceptable. We consider that the effective ecosystem is the watershed of the lake and that both large-scale and local zoning are necessary management tools. Within the drawdown zone itself, we consider that eco-design principles can be applied to achieve the provision of valuable ecosystem services including: bank stabilization, improved water quality, wetland productivity and biodiversity, natural science education, food production, and agricultural education.

Experimentally engineered dike-pond wetlands lying in an urban section of the Hanfeng Lake drawdown zone were created in 2011 and were populated with plant species that survived prolonged flooding in an earlier experiment conducted in a nearby rural region. Based on this and other experiments being conducted in the Three Gorges Reservoir region, further rounds of experiments and wetland restoration projects will be conducted at Hanfeng Lake. We propose that by taking experimental ecosystem-based approaches such as this, backed with appropriate land-use planning and community-support, natural ecosystem services will be delivered and these will promote the sustainable economic and social development of Kai County.

Contact Information: J.H. Martin Willison, School for Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia, Canada B3R 2C6. Phone: 902-477-6102, Fax: 902-494-3728, Email: willison@dal.ca

BOTH SUMMER AND WINTER FLOODING DETERMINE THE BIODIVERSITY AND ABOVE-GROUND BIOMASS PATTERN OF VEGETATION IN THE DRAWDOWN AREA OF CHINA'S THREE GORGES RESERVOIR

Qiang Wang[1,2], ***Xingzhong Yuan***[1,2], *Hong Liu*[1], *J.H.Martin Willison*[3], *Yuewei Zhang*[1,2], *Zhongli Chen*[4] , *Bo Li*[1,2]

[1]College of Resources and Environmental Science, Chongqing University, Chongqing, China
[2]Key Laboratory for the Exploitation of Southwestern Resources and the Environmental Disaster Control Engineering, Ministry of Education, Chongqing University, Chongqing, China
[3]School for Resource and Environmental Studies, Dalhousie University, Halifax, Nova Scotia, Canada
[4]Institute for Environmental Research (Biology V), RWTH Aachen University, Aachen, Germany

It is well known that hydrological alternation can dramatically influence riparian environments and shape riparian vegetation. It has been difficult, however, to predict the extent to which the largest dam in the world (the Three Gorges Dam in China) would influence former riparian vegetation. This is because vegetation at the Three Gorges Reservoir site has historically been submerged by short-term summer flooding of the Yangtze River, which has selected for flood tolerant varieties. In addition, the new hydrological regime created by the dam involves both short periods of summer-time flooding and long-term winter impoundment for half a year due to reservoir regulation. The work reported here targeted the lateral pattern of vegetation biodiversity and above-ground biomass in the drawdown area of the Three Gorges Reservoir and provides a preliminary examination of some effects of environmental factors in the drawdown zone.

Twelve sites distributed widely along the length of the drawdown area were chosen for vegetation sampling using typical plant community survey methods at the ends of growing seasons in 2009 and 2010. Above-ground biomass and soil moisture content were measured conventionally in the laboratory by drying samples. Slope, substratum, and former land uses of the sampling sites were determined *in situ*. The durations of both summer and winter submergence were calculated using data from the daily records of the Three Gorges Dam hydrological station and comparing these with elevation data for the sampling sites.

Our research recorded 175 plant species in the drawdown area in 2009 compared with 392 species before impoundment. In 2010, the number of plant species decreased to 127, indicating that 68 % of vascular plant species had either disappeared or become rare. Almost half of the remnant species were annuals. Species richness, Shannon-Wiener Index and above-ground biomass of vegetation exhibited an increasing pattern along the elevation gradient, being greater at higher elevations subjected to lower submergence stress. Spearman's Rank Correlation Test indicated vegetation biodiversity and above-ground biomass was very significantly influenced by the duration of submergence in both summer and the previous winter, which itself was relative to elevation.

This study suggests that both long-term winter flooding and short periods of summer flooding determine biodiversity and the above-ground biomass pattern of vegetation in the drawdown zone of the Three Gorges Reservoir. Continued monitoring and experimentation will be necessary to determine whether this conclusion holds true over a longer period of time because the reservoir has only recently been filled and the drawdown zone has only recently been affected by prolonged flooding.

Contact Information: Qiang Wang, College of Resources and Environmental Science, Chongqing University, Chongqing 400044, China, Phone: (86)13996481852, Email: wqabso@163.com

THE LITTORAL ZONE OF THE THREE GORGES RESERVOIR: CHALLENGES AND OPPORTUNITIES

Xingzhong Yuan[1,2]*,Hong Liu*[1]*, Rong Sun*[1]*, Qiang Wang*[1] and *Bo Li*[1]

1 College of Resources and Environmental Science, Chongqing University, Chongqing, China

2 Key Laboratory for Exploitation of Southwestern Resources and Environmental Disaster Control Engineering, Ministry of Education, Chongqing University, Chongqing, China

China's Three Gorges Reservoir (TGR) region covers about 58,000 km^2, with a reservoir surface area of about 1,080 km^2. For flood control purposes, the water level of the TGR varies significantly. In October 2009, the water level was raised for the first time to its full height of 175 m and was then lowered during the following summer flood season. The annual reservoir surface elevation amplitude is about 30m at the dam. Filling of the reservoir created about 348 km^2 of newly flooded riparian zone, having a littoral edge total length of about 4,900 km at maximum pool height. The average flooding period lasts for more than six months, mid October to late April. The submergence duration declines somewhat with elevation.

The dam and its associated reservoir provide flood control, power generation, navigation, and other economic benefits, but there are also problems. Water level fluctuation of the TGR in particular creates several large-scale problems with complicated ecological attributes, including: mud-sand deposition, landslides, environmental pollution, and others. An additional complex issue is that plants grow vigorously in the exposed gently sloping belt of the drawdown zone during summer. During the subsequent period of inundation, organic material accumulated in the summer growing season undergoes anaerobic decomposition beneath the water, releasing secondary pollutants. Thus we face a two-edged sword.

During recent summer growing seasons, most parts of the exposed gently sloping banks of the drawdown zone were covered with vegetation. Littoral zones with less than 15^o slopes comprise 204.6 km^2 and account for 66.7% of the total TGR drawdown area. Growth of vegetation in the hydro-fluctuation belt is therefore a valuable resource due to accumulation of carbon and nutrients. The benefits produced during summer are countered, however, by the subsequent winter anaerobic decay; but rather than looking at this from a negative perspective we should consider the ecological opportunity provided. The TGR is uniquely situated and has a large drawdown zone. An ecological approach to the problem is needed.

Water levels are low during the growing season and conventional wetland agriculture can therefore be practiced on riparian slopes. Dike-pond agricultural systems are an important and widely-used heritage in China. In dike-pond systems, economic hydrophytes that are well adapted to controlled water level fluctuation are planted in ponds. It is therefore feasible to avoid anaerobic decay of plant residues by planting hydrophytes after the water recedes and harvesting them before the water rises again. Furthermore, if properly designed, dike-pond systems have the capacity to capture nutrients from uplands and obstruct soil erosion. Ecological engineering approaches can therefore reduce TGR impacts and enhance ecological services by using a pulsing ecological system derived from traditional wetland agriculture that is already practised widely in the TGR region.

Natural regeneration and ecological restoration in the drawdown zone will: decrease soil erosion, reduce pollution, conserve biodiversity, increase the carbon sink, and maintain ecosystem heath. Combining modern and traditional ecological engineering approaches will promote the sustainable development goals of society, both economic and ecological.

Contact Information: Xingzhong Yuan, College of Resources and Environmental Science, Chongqing University, Chongqing 400044, China., Phone (86) 023 65422272, Email: xzyuan63@yahoo.com.cn

RESTORATION OF SAND MINED WETLANDS IN THE WILD DUCK LAKE NATURAL RESERVE, BEIJING: APPROACHES AND EVALUATION

Manyin Zhang[1], *Lijuan Cui*[2], *Yifei Wang*[3], *Xinsheng Zhao*[4]*Kevin L. Erwin*
[1,2,3,4] Wetland Research Institute, Chinese Academy of Forestry, Xiangshan Road, Haidan District, Beijing,PRC
[4] Kevin Erwin Consulting Ecologist, Inc., 2077 Bayside Parkway, Fort Myers, Florida 33901 USA

Human activities are one of the leading causes of wetland degradation and among them, sand mining can directly affect the structure and function of wetlands. In the Wild Duck Lake Natural Reserve, sand mining severely damaged the native vegetation, sandy soils and organic matter content of the wetland. In 2008, wetland restoration that included evaluating the relationship between restored hydrological regimes, micro-topography modeling, soil organic matter recovery, vegetation planting and construction of ecological revetments, was applied in the wetland area degraded by mining. When completed, restoration success was evaluating by monitoring the restored wetlands for four years. Research was conducted on biological diversity, soil organic matter content, wetland dependent wildlife species and soil fauna in the project area. This case study on the post-mining restoration techniques and success can provide a suitable guide for the restoration of other similar degraded wetlands.

Contact Information: Manyin Zhang, Wetland Research Institute, Chinese Academy of Forestry, Xiangshan Road, Haidan District, Beijing 100091 PRC, Phone: 86-13552294641 Fax: 86-10-62824155, Email: cneco@126.com

OVERVIEW OF RESULTS FROM THE EU-WETWIN PROJECT WITH SPECIAL REFERENCE TO UGANDAN PAPYRUS WETLANDS

István Zsuffa[1], *Rose C. Kaggwa*[2] and *Anne A. van Dam*[3]

[1]VITUKI Environmental and Water Management Research Institute Non-profit Ltd., Budapest, Hungary

[2]National Water and Sewerage Corporation, Kampala, Uganda

[3]UNESCO-IHE Institute for Water Education, Delft, the Netherlands

The WETwin project aims at supporting decision makers and stakeholders in improving the community services of wetlands, while conserving their good ecological status. It also endeavours to support adapting wetland management to changing environmental conditions and integrating wetlands into river basin management.

The project worked on case study wetlands from Africa, South America and Europe. Management strategies for these wetlands were elaborated and evaluated using hydrological, water quality, ecological and socio-economic models. Where data availability limited the application of models, qualitative, expert judgement-based evaluation was carried out. Results of the evaluations were input into multi-criteria decision analysis, which helped to identify the strategy that represented a 'best compromise' among the different ecosystem services and stakeholder needs of the wetland. Model-based investigations were extended to the future as well, with the aim to analyze whether the envisaged strategies are capable of counteracting the negative consequences of the changing environmental conditions − in other words: to analyze the vulnerability of the wetland. Implementation of management strategies and adaptation to changing boundary conditions require appropriate institutional capacity. The project explored the current institutional capacity at the study sites and identified the institutional obstacles hampering better management of the wetlands. Involvement of stakeholders played a crucial role in each phase of the project.

Two of the project case studies were papyrus wetlands in Uganda: the Nabajjuzi wetland near the town of Masaka in central Uganda; and the Namatala wetland near the town of Mbale in eastern Uganda. The generic methodology described above was applied to the special conditions of these wetlands. Management strategies were identified for improving water purification and drinking water supply services, without endangering other ecosystem services such as habitat for valuable species, ecotourism and harvesting of raw materials. Vulnerability of these wetlands due to population growth, climate change and inadequate institutional environment was assessed as well, with the aim to support long-term planning and management.

Contact Information: István Zsuffa, VITUKI Environmental and Water Management Research Institute Non-profit Ltd., Kvassay J. u. 1., 1095-Budapest, Hungary, Phone: +36 1 215 6140; Fax: +36 1 216 1514, Email: zsuffa.istvan@vituki.hu

WETLAND ECOSYSTEMS PROCESSES & FUNCTIONS - TROPICAL AND SUBTROPICAL WETLANDS

INTERANNUAL VARIATION IN BULK SOIL PROPERTIES IN THE COASTAL EVERGLADES

Randolph M. Chambers*, Rosemary L. Hatch* and *Timothy M. Russell*
Keck Environmental Field Lab, College of William and Mary, Williamsburg, VA, USA

The organic matter working group of the Florida Coastal Everglades Long-Term Ecological Research program has focused general research efforts on characterizing the pools and identifying the spatial and temporal pathways for exchange of particulate and dissolved organic matter between soils and water in the south Florida landscape. Here, we report on interannual variation in bulk soil properties from freshwater, estuarine, and marine wetland environments occurring along Shark River Slough and Taylor Slough transects. The initial rationale for conducting interannual monitoring was to document soil conditions both prior to and subsequent to enhancement of freshwater flows through the Everglades, as part of the Comprehensive Everglades Restoration Plan. Unfortunately, that flow enhancement action has lagged, and instead our data represents variation associated with other environmental factors.

We documented spatial variation in soil bulk density, percent organic matter, and total carbon, nitrogen, and phosphorus by transect and by wetland type (i.e., freshwater marsh, estuarine mangrove swamp, and marine seagrass meadow). Over the past five years, we also documented variation within each sampling location. The source of interannual differences in soil properties includes natural spatial variability within sites, but also contributions from climate-related drivers of ecosystem structure and change, including rainfall distribution, tropical storms and hurricanes, and sea-level rise.

Contact Information: Randolph M. Chambers, Keck Environmental Field Lab, College of William and Mary, Williamsburg, VA 23187 USA, Phone: 757-221-2331, Fax: 757-221-5076, Email: rmcham@wm.edu

METHANE PRODUCTION PATHWAYS IN SUBTROPICAL (EVERGLADES) AND TROPICAL (PANAMA) WETLANDS

***Beth Huettel*[1]**, *Jeffrey Chanton*[1], *Hee-Sung Bae*[2] and *Andrew Ogram*[2]
[1]Florida State University, Tallahassee, FL USA
[2]University of Florida, Gainesville, FL USA

In recent times the influx of nutrients to the northern Florida Everglades has had a dramatic impact on the ecosystem of this historically oligotrophic wetland. One aspect of these changes is the biogeochemistry of the peat, in particular methane production. Eutrophication leads to increased methanogenesis and also drives the predominant pathway from acetoclastic fermentation toward carbon dioxide reduction. Apparent fractionation factors calculated from the $\delta^{13}C$ of CH_4 and CO_2 in porewater from 3 sites along a transect of increasing phosphorus in Water Conservation Area 2A in the northern Everglades indicated that the production of methane via CO_2 reduction was more important at the site that was most impacted by nutrients than at the oligotrophic site. Incubation of soils from each site with an inhibitor of acetate fermentation revealed that most (around 75%) of the methane produced in the top 10 cm of peat from the least nutrient impacted site and the transition site was from acetate fermentation. In contrast, in peat from the site with highest P concentrations, CO_2 reduction was more important (nearly 50%).

$\delta^{13}C$ of CH_4 in porewater from the Boca del Toro wetland in Panama was more negative (-78‰) than in the Everglades, where values were between -50 and -64‰. Apparent fractionation factors were similar, however, to the nutrient impacted and transition sites in the Everglades, suggesting that the contribution of CO_2 reduction to methane production may be similar in both areas. Incubations of Panama peat gave apparent fractionation factors (1.080 to 1.097) that showed that most of the methane was produced from CO_2. If hydrogenotrophic methanogenesis is more important in Boca del Toro, syntrophic acetate oxidation (SAO) may be a factor. This process, which becomes thermodynamically more favorable with increasing temperature, may remove more acetate in Boca del Toro than the Everglades, leading to acetate limitation for methanogenesis. Ongoing soil incubations may help to clarify the importance of SAO in Everglades and Panama peat.

Contact Information: Beth Huettel, Department of Earth, Ocean, and Atmospheric Science, Florida State University, 112 N. Woodward Ave., Tallahassee, FL 32306 USA, Phone: 850-491-5005; Email: bhuettel@fsu.edu

PHENOLOGY OF THE SPECIES OF TROPICAL FORESTS WETLANDS IN THE COASTAL PLAIN OF VERACRUZ, MEXICO

Dulce Infante Mata[1], *Patricia Moreno-Casasola*[2] and *Carolina Madero-Vega*[2]
[1]El Colegio de la Frontera Sur, Tapachula, CHIAPAS, MEX
[2]Instituto de Ecologia A.C., Xalapa, VER, MEX

We evaluated the phenology of floodplain forest species through the collection of litter in five locations in Veracruz, Mexico from November 2005 to October 2006. Litter was separated by species and structures (leaves, stems, flowers, fruits and seeds), dry weight was obtained per month. We identified 57 species and found that the flood forests produce between 9 and 15 ton ha^{-1} yr^{-1}. The dominant tree species *Pachira aquatica, Annona glabra*, and lianas *Hippocratea celastroides* and *Dalbergia brownei* were the principal litterfall producers. Lianas were found to be extremely productive and represented between 8 and 62% of the total litterfall at the sampled locations.

P. aquatica produces between 1.5 and 10.6 t ha^{-1} yr^{-1}, which can represent up to 73% of the litter (e.g. El Salado). *A. glabra* produces between 1.0 and 3.7 t $ha\text{-}^{1}$ yr^{-1} representing up to 35% in the flooded forest of La Mancha. Lianas *D. brownei* and *H. celastroides* are responsible for 0.8 to 4.7 gives ton ha^{-1} yr^{-1} (30% at some sites) and 1.2 and 3.5 t ha^{-1} yr^{-1} (up to 22% of the litter of Laguna Chica) respectively.

P. aquatica at each site shows a different pattern in the detachment of the structures; however the main presence of seeds occurs during the flooding season in the summer. *A. glabra* completely loses its leaves during one season so it can be considered as a deciduous species, and its fruits and seeds emerge from July to October, which corresponds to the rainy season. Lianas *H. celastroides* produce seeds during the months of August-September, and *D. brownei* from July to October.
Fruit and seed fall coincide mostly with the rainy season, and the accounted for 50 - 90% of the total production and shedding during the flooded season. Species that released seeds during this time had their seeds dispersed by water. Flower production occurred during the dry season (March to June). The litterfall productivity of these forests is similar to that of mangrove ecosystems.

Contact Information: Dulce Infante Mata, El Colegio de la Frontera Sur, Departamento de Aprovechamiento y Manejo de Recursos Acuáticos, Área de Sistemas de Producción Alternativa, Manejo Integral de Zona Costera y Marina. Carretera Antiguo Aeropuerto km 2.5, Tapachula, CHIAPAS, 30700, MEX. Phone +52 (962) 628 9800 Ext. 5000. Fax +52 (962) 628 9806

MULTIPLE TRACER STUDY IN A SMALL, NATURAL WETLAND IN THE HUMID TROPICS OF COSTA RICA

***David A. Kaplan*[1]**, *Manon Bachelin*[1,2], *Congrong Yu*[1], *Rafael Munoz-Carpena*[1]
[1]University of Florida, Gainesville, FL
[2]École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

Hydraulic characterization of wetlands is fundamental to quantifying the diverse set of services provided by these complex ecosystems. While several authors have explored the hydraulic function of constructed wetlands using chemical tracers, hydraulic studies of natural (i.e., not constructed) wetlands are exceedingly scarce. Furthermore, while contaminant reduction in wetlands has been relatively well studied in temperate climates, less is known about the treatment capabilities of tropical wetlands, which have received less attention from the scientific and management communities. An increased focus on the role and function of these imperiled ecosystems is required, particularly as they face widespread degradation due to the increasing appropriation of land and water associated with rapidly increasing populations and food demand in the tropics.

Our hypothesis is that due to their abundance and ubiquitous distribution throughout the landscape, small wetlands in the Central American tropics have a critical and multifaceted role in the environmental quality of the area (water storage, flood control and water quality improvement). The case study of a small Costa Rican wetland presented here aims to quantify the function of these wetlands and generate hydrological Information in support of public decision-making regarding wetland use, conservation, and preservation. Specific objectives were to conduct a multiple tracer field study to explore the hydraulic characteristics of a small natural wetland in the humid tropics and to assess the feasibility of using sulfur hexafluoride (SF_6) as a tracer compared to bromide (Br^-) under humid tropical and slow flow conditions.

Results indicated that Br^- is a useful tracer under shallow, slow-flow conditions in the humid tropics, allowing an analysis of wetland hydraulics and an analysis of potential water quality improvement function based on residence times in the different parts of the wetland. On the other hand, we found SF_6 to be a poor surface water tracer because of its non-conservative behavior caused by strong volatilization; results may be improved by increasing the [SF_6] in the injection water. Wetland water velocities calculated from tracer time-to-peak and distance between monitoring sites ranged between 3.7 and 35.3 m d^{-1}, and calculated wetland residence times suggest high potential pollutant removal over a range of influent concentrations: 80.0 to 99.8% for biological oxygen demand; 60.0 to 99.8% for total suspended solids; 70.0 to 98.4% for total nitrogen; and 76.7 to 95.7% for total phosphorous. In addition to providing site-specific measures of wetland hydraulics, these results may be leveraged to develop hydrodynamic modeling efforts to analyze interactions between vegetation and surface water and to explore the relative importance that small-scale heterogeneity (centimeter to meter) introduces on the effective average predictions.

<u>Contact Information</u>: Congrong Yu, University of Florida, Department of Agricultural and Biological Engineering, 287 Frazier Rogers Hall, PO Box 110570, Gainesville, FL 32611-0570, Phone: 352-392-1864 x.287, Fax: 352-392-4092, Email: yu323@ufl.edu

VEGETATION CHANGES ALONG A GRADIENT OF SALINITY IN THE ORTEGA RIVER OF NORTHEAST FLORIDA

***Palmer Kinser*[1]**, *Clay Montague*[2], *Sandra Fox*[1], *Pete Sucsy*[1], *Ken Riddick*[1]
[1]St. Johns River Water Management District, Palatka, Florida, USA
[2]University of Florida, Gainesville, FL, USA

In Northeast Florida, sea level rise has occurred historically and may be accelerating due to global climate change. Changes in landuse and cover, together with increased ground and surface water use, have simultaneously altered patterns and volumes of freshwater flow and have the potential to affect estuarine systems, such as the Lower St. Johns River in Jacksonville, Florida.

To better understand the nature and dynamics of estuary transition zones and establish a baseline against which changes in salinity can be assessed, we studied an 8 ½ km, fresh to oligohaline section of the Ortega River, a tributary of the Lower St. Johns River. We examined gradients of river and soil salinities to explain observed changes in wetland vegetation communities along the length of the river and created a model to predict the potential movement of community boundaries with rising salinity levels. Break points of soil salinity were determined between wetland community types and related to river salinities. From these relationships, we predicted the future positions of soil salinity break points with increases in river salinity and of potential movement of vegetation community boundaries. The results of this study were subsequently extended to the St. Johns River to predict the potential for changes in vegetation in the larger system from future water withdrawals.

Contact Information: Palmer D. Kinser, Bureau of Environmental Sciences, St. Johns River Water Management District, 4049 Reid Street, Palatka, FL, 32178 USA, Phone: 386-329-4369; Fax: 386-329-4329; Email: pkinser@sjrwmd.com

DROUGHT AND LARGE FISH RE-COLONIZATION HAVE VARIABLE EFFECTS ON MACROINVERTEBRATES IN EXPERIMENTAL WETLANDS.

Natalie Knorp and *Nathan J. Dorn*
Department of Biological Sciences, Florida Atlantic University, Davie, FL

Dry-disturbances alter plant and animal communities in wetlands. Low rainfall or water management practices together or alone can turn an otherwise permanent wetland into a temporary habitat. The permanence of a wetland habitat affects the species found there through direct and/or indirect mechanisms. Dry-disturbances in the Florida Everglades vary spatially and temporally and the net impact of drying on invertebrate communities after re-flooding has been poorly studied. While predatory fishes generally decline in years after strong regional droughts the net effect of drying on invertebrate populations in the ensuing wet season(s) depends on invertebrate life history and taxon-specific sensitivities to predator reduction and habitat changes generated by the drying.

We examined the effects of drought and sunfish re-colonization on macroinvertebrate communities by altering the hydrology and presence of predatory sunfishes (Centrarchidae) in nine replicate 18 m^2 experimental wetlands. All wetlands had a similar hydrological regime and a similar history with fish leading up to May 2011. In late May we simulated a dry-disturbance by drying six wetlands for 15 days. Upon re-flooding we re-colonized three of the dried wetlands with warmouth immediately to simulate the nearby presence of deep water refuge (i.e., fast re-colonization). All nine wetlands were stocked with 11 adult slough crayfish (*Procambarus fallax*) and the previously dried wetlands were inoculated with groups of mosquitofish and grass shrimp and small fragments of *Utricularia* spp. This design created three treatments that varied by hydrological history and sunfish presence: previously dried without sunfish, previously dried with sunfish, and continuously flooded with sunfish. Using 1-m^2 throw traps we quantified the mean densities of grass shrimp, dragonflies (Anisoptera), damselflies (Zygoptera) and crayfish in the wetlands six months after re-flooding. Macroinvertebrate densities (# or g/m^2) were analyzed with ANOVA.

Shrimp, damselfly and slough crayfish densities (#/m^2) were not affected by treatment, but the biomass of recruiting crayfish was more than ten times higher in treatments without sunfish than in treatments with sunfish. Crayfish populations in wetlands with sunfish were dominated by individuals that were <10 mm carapace length, suggesting that the direct consumptive effects of the sunfish were preventing recruitment of crayfish to larger juvenile and adult sizes. When sunfish were present the drying history did not affect crayfish biomass density. In contrast to the crayfish response, total larval dragonfly (mostly *Pachydiplax longipennis*) densities were at least 6 times higher in continuously flooded wetlands than dried wetlands and were unaffected by the presence of fish in wetlands that had previously dried. Habitat structure was also affected by the dry-disturbance. Stem densities of *Eleocharis cellulosa* were similar across all treatments, but the volume of submerged vegetation (*Utricularia* spp.) was higher in the continuously flooded wetlands compared to wetlands that experienced the experimental drying. Considering the vegetation changes in conjunction with dragonfly responses the results suggest severe droughts may exert more influence on dragonfly success indirectly through depression of submerged macrophytes (habitat complexity) than through reduction of predatory sunfishes.

Contact Information: Natalie Knorp, Department of Biological Sciences, Florida Atlantic University, 3200 College Ave., Davie, FL 33314 USA, Phone: 954-236-1539; Fax: 954-236-1099, Email: nknorp@fau.edu

WHAT DRIVES GROWTH AND BIODIVERSITY OF ALGAE IN THE OKAVANGO DELTA?

*Anson W. Mackay, **Luca Marazzi***
Environmental Change Research Centre, UCL, London WC1E 6BT, UK

Algae are at the base of the food webs in many aquatic ecosystems, transferring energy and matter to fish and fish consumers; they are ultimately relevant for food provision to humans. They play a role in other ecosystem services, for example regulating nutrient dynamics, and a high algal biodiversity can improve water quality. Therefore in-depth knowledge of these microorganisms and their distribution patterns is fundamental to understanding ecosystem processes in aquatic environments, particularly in tropical and subtropical wetlands where there is a knowledge gap.

This study is the first systematic assessment of non-siliceous algae in the Okavango Delta (Botswana), a pristine, Ramsar-designated wetland. Its hydrological regime is mainly characterized by the annual slow flood pulse generated by (i) rainfall in the remote Angolan uplands and (ii) local precipitation. Permanently, seasonally and occasionally inundated channels, lagoons and floodplains were investigated in this study. Algal samples were collected in different seasons in 2006-2007 and in 2009-2010 alongside a suite of explanatory physico-chemical variables. Enumeration and identification of algal units (cells, colonies and filaments) have been conducted by means of the Utermohl technique and algal biomass estimated via calculations of biovolumes.

A total of 338 species and 168 genera of algae have been found so far in over 100 samples across four regions with different flooding frequency. Permanently flooded sites have a statistically significantly higher algal biomass while sites with intermediate flooding frequency and duration show higher biodiversity, consistently with the Intermediate Disturbance Hypothesis. Algal biomass is highest in sites with the highest number of total taxa, hence biodiversity seems to drive biomass to a maximum. Permanent swamps show a significantly higher biomass of siliceous algae (diatoms; *Bacillariophyta*) while shallower seasonally inundated floodplains contain a higher biomass of green algae (*Chlorophyta*), with a substantial presence of desmids. The most abundant genera across the Okavango Delta are *Eunotia*, *Synedra*, *Monoraphidium*, *Mougetia*, *Scenedesmus, Gomphonema* and *Cosmarium*. The relative abundance of algae belonging to other phyla – mostly *Cyanophyta*, *Cryptophyta* and *Euglenophyta* – is about 15%.

The data produced are an important baseline for future studies on algae in the Okavango Delta and as a pristine-state benchmark for subtropical wetlands. If upstream hydropower and reservoir plans are implemented, the water discharge in the Delta is likely to be impacted, with climate change representing an additional threat to this ecosystem. Algae can be used as environmental sentinels for early detection of these impacts and are being monitored alongside zooplankton in seven floodplains in collaboration with the Okavango Research Institute to generate new knowledge of food web dynamics. A medium to long term monitoring programme of all the microorganisms supporting the Delta is recommended to gain a systematic understanding of its dynamics and assess its ecosystem health.

Contact Information: Luca Marazzi, Environmental Change Research Centre, Department of Geography, University College London, Phone: 0044 (0)20 7679 0527, Fax: 0044 (0)20 7679 0565. Email: l.marazzi@ucl.ac.uk

CLASSIFYING PALM SWAMP WETLAND ECOSYSTEMS AND ASSESSING THEIR INUNDATION STATE USING HIGH AND LOW RESOLUTION MICROWAVE REMOTE SENSING DATASETS

Erika Podest[1], *Kyle McDonald*[1,2], *Ronny Schroeder*[1,2], *Naiara Pinto*[3], *Reiner Zimmermann*[4], *Viviana Horna*[5]
[1]Jet Propulsion Laboratory, Pasadena, CA, USA
[2]City College of New York, New York City, NY, USA
[3]University of Maryland, College Park, Maryland, USA
[4]University of Hohenheim, Hohenheim, Germany
[5]University of Bayreuth, Bayreuth, Germany

Palm swamp wetland ecosystems are characterized by constant surface inundation and moderate seasonal water level variation. The combination of constantly saturated soils, giving rise to low oxygen conditions, and warm temperatures year-round can lead to considerable methane release to the atmosphere. Because of the widespread occurrence and expected sensitivity of these ecosystems to climate change, knowledge of their spatial extent and inundation state is crucial for assessing the associated land-atmosphere carbon exchange. Precise spatio-temporal Information on palm swamps is difficult to gather because of their remoteness and difficult accessibility. Spaceborne microwave remote sensing is an effective tool for characterizing these ecosystems since it is sensitive to surface water and vegetation structure and allows monitoring large inaccessible areas on a temporal basis regardless of atmospheric conditions or solar illumination.

We are developing a remote sensing methodology using multiple resolution microwave remote sensing data to determine palm swamp distribution and inundation state over focus regions in the Amazon basin in northern Peru. For this purpose, two types of multi-temporal microwave data are used: 1) high-resolution (100 m) data from the Advanced Land Observing Satellite (ALOS) Phased Array L-Band Synthetic Aperture Radar (PALSAR) to derive maps of palm swamp extent and inundation from dual-polarization fine-beam and multi-temporal HH-polarized ScanSAR, and 2) coarse resolution (25 km) combined active and passive microwave data from QuikSCAT and AMSR-E to derive inundated area fraction on a weekly basis. We apply a decision tree classification scheme to derive a palm swamp wetland classification at high resolution, 100m. We compare Information content and accuracy of the coarse resolution products to the PALSAR-derived classifications to ensure Information harmonization. The synergistic combination of high and low resolution datasets will allow for characterization of palm swamps and assessment of their flooding status.

This work has been undertaken partly within the framework of the JAXA ALOS Kyoto & Carbon Initiative. PALSAR data have been provided by JAXA/EORC. Portions of this work were carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

Contact Information: Erika Podest, NASA-Jet Propulsion Laboratory, 4800 Oak Grove Dr., Mail Stop 300-233, Pasadena, CA, USA, Phone: 818-354-6086, Email: erika.podest@jpl.nasa.gov

THE CLIMATE-TREE GROWTH RELATION IN CENTRAL AMAZONIAN BLACK-WATER (IGAPÓ) FLOODPLAIN FORESTS

***Eliane Silva Batista*[2]** and *Jochen Shöngart*[1,2,3]

[1] Max Planck Institute for Chemistry, Biogeochemistry Department, Mainz, Germany
[2] Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus-AM, Brazil
[3] Instituto Nacional de Ciência e Tecnologia em Áreas Úmidas (INAU), Federal University of Mato Grosso, Cuiabá-MT, Brazil

Forest dynamics in the Amazonian floodplains is strongly triggered by the flood-pulse. Trees respond to the unfavorable growth conditions during the flooded period by a cambial dormancy resulting in the formation of annual growth rings. In this study by indexed tree-ring chronologies of the tree species *Macrolobium acaciifolium* were established and compared with hydrological and climatic factors from two different black-water floodplain forests (igapó) in Central Amazonia growing under nutrient-poor conditions (Uatumã Sustainable Development Reserve – RDSU and National Park Anavilhanas - PNA).

We collected the data sampling in the field 20 emergent trees with diameter at breast height (DBH) above 60 cm were chosen at each site. Diameter and inundation height of each tree was measured and a wood sample of the trunk was obtained using an increment borer. Wood samples were sanded and tree rings were identified by marginal parenchyma bands to determine tree age and mean diameter increment rates. Ring width was measured with a digital measuring device (LINTAB) to the nearest 0.01 mm. By cross-dating techniques indexed tree-ring chronologies were constructed for the PNA (1752-2006) and RDSU (1758-2004) using ten trees at each site.The daily fluctuation of water level of the study sites was used to calculate the duration of the earth through the height of water in the trunk (full 2009), and maximum and minimum levels of flooding. To correlate the timelines, annual precipitation, maximum and minimum levels of water and the duration of the ground with the anomalies of SST and SOI were used 24 months of the previous year (indicated by -1) and current year with a series of data 1950 to 2009. To check for statistical difference between the total rainfalls of the two areas of study we used the test t-Student.

Our analyses demonstrated that the maximum tree age at the two sites varied between 418 years at PNA and 443 years at the RDSU. Diameter increment rates were significantly differ between the two studied sites. Ring-width indices were significantly correlated with the duration of the terrestrial phase calculated from nearby hydrological stations for the period 1973-2008. Signals from sea surface temperature (SST) anomalies were more evident in the tree-ring series at the RDSU compared to the PNA. El Niño signals were not detected in the tree-ring chronologies.

Contact Information: Eliane Silva Batista, Instituto Nacional de Pesquisas da Amazônia (INPA), Av. André Araújo 2936, P.O. 478, 69011-970 Manaus-AM, Brazil, Phone: 55+ 92 3643-3136, Email: batista.elianes@gmail.com

FLOOD-INDUCED ENDEMISM IN AMAZONIAN FLOODPLAIN TREES

Florian Wittmann[1], *Ethan Householder*[2], *Jochen Schöngart*[1], *Maria T.F. Piedade*[2], *Pia Parolin*[3] and *Wolfgang J. Junk*[4]
[1]Max Planck Institute for Chemistry, Mainz, Germany
[2]National Institute for Amazon Research - INPA, Manaus, Brazil
[3]University of Hamburg, Germany
[4]National Institute for Wetlands, Cuiabá, Brazil

Besides numbers on species richness and diversity, the amount of endemic species is widely used for the definition of ecosystem, ecoregion and/or biome conservation priorities. However, most Amazonian forested ecosystems lack reliable estimations about the degree of endemism, i.e. by indicating numbers of endemic tree species. Amazonian white-water (várzea) floodplain forests cover an area of approximately 400,000 km^2. Várzea forests are considered the most species-rich floodplain forests worldwide. Its tree species tolerate seasonal inundations of up to 8 m in height resulting in the annual inundation of roots, parts of the aboveground organs, or the entire trees for periods of up to 230 days $year^{-1}$. We reviewed the flora of the Amazonian várzea to check for the amount of its endemic tree species and to test whether endemism is related to geographic and/or flood-induced gradients. Our data consist of 61 forest inventories that cover an area of > 100 ha, and that account on 92,000 individuals belonging to 1014 flood-tolerant tree species. We classified species according to their flood-tolerance in low-várzea species (flood height > 3 m, flooding period > 50 days $year^{-1}$) and high-várzea species (flood height < 3 m, < 50 days $year^{-1}$), and according to their occurrence in western Amazonia, central Amazonia, and eastern Amazonia. Presence or absence of várzea tree species in other, flooded and non-flooded ecosystems and biomes comprising the entire Neotropics were investigated in the most important herbaria, floras and species lists.

Our results indicate that approximately 20% of all Amazonian várzea tree species are restricted to flooded habitats or ecosystems of the Neotropics, and that 11% are endemic to Amazonian várzea. The highest proportion of endemism occurred in the central part of the Amazon basin and in highly flooded low-várzea forests. In contrast to most other tropical floodplains, where past climate change repeatedly interrupted evolutional processes of wetland-specific floras and where endemic tree species are rare or even absent, the comparatively long floristic evolution of the Amazonian floodplains favoured the development of flood-specific adaptations leading to high degrees of endemism. Our results contrast the maps of Amazonian lowland areas of endemism which mostly were developed on ranges of terrestrial organisms, and which consider rivers to be powerful distribution barriers. Instead, we suggest that flooding is an important driver of speciation processes and the development of endemic tree species, and thus of importance for Amazonian biodiversity as a whole.

Contact Information: Florian Wittmann, Department of Biogeochemistry, Max Planck Institute for Chemistry, Johann J. Becherweg 27, 55128 Mainz Germany, Phone: (55) 92 36421503, Email: f.wittmann@mpic.de

LAND-USE HISTORY AND FLOOD REGIME AS DRIVERS FOR WOODY SPECIES DIVERSITY AND BIOMASS ACCUMULATION IN AMAZONIAN FLOODPLAIN FORESTS

Christine M. Lucas[1], *Pervaze Shiekh*[2], *Jochen Schöngart*[3], ***Florian Wittmann***[3], *Paul Gagnon*[4] and *Maria T.F. Piedade*[5]

[1]Department of Wildlife and Conservation, University of Florida, , Gainesville, Florida, U.S.A.
[2]Congressional Research Service, The Library of Congress, 101 Independence Avenue, SE, Washington, DC, USA.
[3]Max Planck Institute for Chemistry, , Mainz, Germany
[4]Murray State University, Department of Biological Sciences, , Murray, KY, USA
[5]Instituto Nacional de Pesquisas da Amazônia, Av. André Araújo Manaus, AM, Brazil

Tropical floodplain forests are renowned for their high productivity and diversity but relatively little forest inventory data is available for these ecosystems. The Amazon River and its adjacent floodplains form the largest and most diverse freshwater system on the globe. Regional carbon budget estimates for the Amazon Basin either exclude or poorly estimate the contribution of floodplain and swamp forests, which comprise over 10% of land area. Over 1000 woody species of variable flood tolerance are found in Amazonian floodplain forests (Wittmann *et al.*, 2006), with estimates of tree diversity ranging from 53 species ha^{-1} (Pires & Koury, 1959) to 149 species ha^{-1} (Balslev *et al.*, 1987, Parolin *et al.*, 2004). Here, we fill a gap in ground-based data for tree species richness and woody biomass accumulation in secondary floodplain forests of the dry corridor of the Eastern Amazon, a region of high risk to carbon loss via drought and deforestation. Most recently, intensification of livestock husbandry is a major land-use change affecting floodplain forests and grasslands in Lower Amazon floodplains.

Species composition and aboveground woody biomass of seasonally flooded forests was monitored over nine years in 43 plots of 0,1 ha across three regional drivers of forest stand dynamics – flood level, forest age, and cattle density. Flood level was the major driver of spatial variation in species richness and net annual biomass accumulation. Temporal change in species richness was negligible, but species lost included two important timber species. Flood level and forest age interacted to affect aboveground woody biomass (AGB), which averaged 212 ± 96 SD Mg ha^{-1}. Net annual biomass accumulation varied widely among forests (mean = 6.4 ± 11.8 SD Mg $ha^{-1} y^{-1}$), due to large differences in stem growth increment and stem mortality. Forests gained 18.5 ± 9.5 Mg $ha^{-1} y^{-1}$, but lost 66 ± 81% of total biomass gained to stem mortality. Net annual biomass accumulation declined with increasing flood levels and tended to be higher in younger forests. Stands with heavy livestock impacts had low ABA, but did not suffer higher mortality or lower recruitment rates, as expected.

Our results suggest that secondary floodplain forests annually sequester substantial amounts of carbon in woody biomass, but have large losses to stem mortality, a potential result of both anthropogenic disturbances (*e.g.,* livestock ranching, deforestation, and fuelwood harvesting) and natural disturbances (*e.g.,* extreme floods, windstorms). Based on these observations, declines in richness of low-flood-tolerant tree species as well as annual C sequestration by AGB are expected with climate-driven increases in extreme flood events as well as land-use intensification in Lower Amazon floodplains.

<u>Contact Information</u>: Christine M. Lucas, Gral. Nariño, 2415, Montevideo, 11500, Uruguay. Phone: (598) 2600.9622, Email: lucas.christine2@gmail.com

WETLAND ECOSYSTEMS PROCESSES & FUNCTIONS - VEGETATION DYNAMICS

CLUMP STRUCTURES OF TWO SEDGE SPECIES INDUCED BY SOIL MOISTURE REGIME IN AN EPHEMERAL WETLAND

Takashi Asaeda[1], *Md Harun Or Rashid*[1], *Lalith Rajapakse*[2] and *Jagath Manatunge*[2]
1Saitama University, Sakura, Saitama, Japan
2University of Moratuwa, Katubedda, Sri Lanka

Inter-specific interactions among aquatic plant species are an important determinant of community structures, composition and dynamics of a particular ecosystem. In ephemeral wetlands with distinct wet and dry seasons, soil moisture often becomes a deficit factor during dry season. It may affect the community structure to produce the positive interaction among species.
A study was conducted to explore the inter-specific plant mutualism driven by moisture deficit at Rowes lagoon in NSW Australia from 2003 through 2004. The lagoon was mostly flat and inundated up to ca. 10 cm depth during winter to spring. Although most of the area was inhabited exclusively by *Eleocharis sphacelata*, the lowest part of the lagoon was occupied mainly with *Baumea arthrophylla*. Between these two areas, there was a wide transitional zone, where both *E. sphacelata* and *B. arthrophylla* grew together. In this zone, clamps of both species grew separately or as mixed clumps where shoots of one species grew around the center of the other's clump. The number of clumps of both florae and their sizes were recorded separately. Aboveground and belowground plant tissues and litters were collected from quadrats and sorted species-wise. Dry weights were obtained for the collected samples. Shoots of *B. arthrophylla* retained moisture by swelling after they died, increasing their diameter, thus shoot diameters were measured with respect to the status of the shoots. Soil samples were taken in between the clumps where soil surface was exposed, around the outer edge and in the center of an individual clump. The moisture content in the soil was also measured.

B. arthrophylla formed clumps composed of densely aggregated shoots around the center, while *E. sphacelata* clumps consisted of widely distributed shoots in the clump area. In the transitional zone, each species formed clumps independently or mixed clumps of both species. The occurrence ratio of mixed clumps was significantly higher than the individual clumps of each species. When shoots of one species grew in the clump of the other, they grew mostly around the center of the clump area rather than along the circumference. Standing shoots inhibited accumulated litters from dislocating, thereby newly produced litters were mostly accumulated inside the clumps. In addition, the shoot diameter of *B. arthrophyll*a enhanced by more than twice in several months after they died. In the mixed clumps, roots also overlapped each other. Towards the end of drought, high mortality of rhizomes was observed, and the contained water was mostly exhausted. *B. arthrophylla* with aggregated shoots contained nearly twice as higher amount of moisture inside the clumps, compared to that of *E. sphacelata.* Therefore, moisture contents in the soil were significantly higher inside the clumps than in the outside in the dry season.

There are negative and positive interactions between plant species when they grow together. At dry condition with low moisture content in the substrate, plant litters on the ground surface and rhizomes and roots below have high potential to maintain moisture. It seems that the formation of mixed rather than individual clumps has more positive effects on two species.

Contact Information: Takashi Asaeda, Institute of Environmental Science, Saitama University, 255 Shimo-okubo, Sakura, Saitama, Japan, Phone: +81-48-858-3563, Email: asaeda@mail.saitama-u.ac.jp

TREE GROWTH RESPONSE ACROSS AN HYDROLOGICAL GRADIENT AT FOUR HOLES SWAMP, SOUTH CAROLINA

William H. Conner[1] and *Dan Tufford*[2]
[1]Baruch Institute of Coastal Ecology and Forest Science, Georgetown, SC, USA
[2]University of South Carolina, Columbia, SC, USA

Forests on the Holcim tract on the edge of the Four Holes Swamp range from very dry upland sites to permanently flooded swamp (except during drought). While many environmental and biological factors influence the structure and dynamics of these forests, hydrology is probably the most important driving force in determining forest structure and productivity. Tree growth, litterfall, and hydrology were measured from 2009 through 2011. Six sets of paired plots (20-m x 25-m) were established in 2009 to cover the different forest types in the area. In each plot, all trees >10 cm diameter at breast height (dbh) were tagged, identified by species, and measured for diameter at the beginning of the study and again at the end of each year. Litterfall was measured in each plot using five 0.5-m x 0.5-m litter traps with a 1 mm mesh fiberglass screen bottom. The traps were elevated using 1-m wooden legs to prevent inundation during flooding events. Litterfall was collected on a monthly basis, dried at 70-80° C for 2 to 3 days, and weighed. Litterfall production for each year was then added to stem production to estimate the annual aboveground net primary production (ANPP) of each wetland. A water table monitoring well and water level data logger was deployed in each set of plots. Logging occurred at one hour intervals.

Stem productivity and litterfall during the year were summed for each site to yield aboveground net primary productivity (ANPP). ANPP was highest on Slope, Depression, and Drain sites (1,091, 1,037, and 1,030 $g/m^2/yr$, respectively) (mean water table depth 1.31 m, 0.25 m, and 0.56 m, respectively) and lowest in the Dry (879 $g/m^2/yr$) and Slough (780 $g/m^2/yr$) sites (mean water table depth 2.12 m and 0.20 m, respectively). The low ANPP values found in the Dry and Slough areas represent the hydrologic extremes for the area. Lower ANPP values could be a result of physiological stress where floods endured and the lack of moisture subsidies in the upper zones. There was significant seasonal variability in water table depth at all sites, with extremes caused by a moderate (2009) and severe (2011) droughts that depressed mean water table depths.

Contact Information: William H. Conner, Baruch Institute of Coastal Ecology and Forest Science, Box 596, Georgetown, SC 29442 USA, Phone: 843-546-6323, Fax: 843-546-6296, Email: wconner@clemson.edu

PROJECTING WETLAND PLANT SPECIES DISTRIBUTION IN A CHANGING CLIMATE

Sylvie de Blois
McGill University, Montreal, QC, Canada

Climate is a powerful determinant of species distribution at regional and continental scales and rapid climate change likely has the potential to lead to novel communities and ecosystems. Although studies have predicted the distribution of a wide selection of plant taxa in response to climate change, they have yet to address explicitly the potential response of wetland plant species. We aimed to develop predictive models that quantify suitable climatic conditions for wetland plant species in northeastern North America, and project the potential geographic shifts of suitable climate-space for these species based upon scenarios of climate change.

Records of occurrences of 57 obligate wetland plant species in 400 km2 cells were compiled from existing databases, while insuring representation of plants from peatland, marsh, and swamp habitats. We first tested in a separate analysis two approaches (spatially-constrained and random) to choose a pseudo-absence selection strategy and retained the one that led to better model accuracy, i.e., spatially-constrained strategy. We coupled presence/pseudo-absence data with recent (1961-1990) interpolated weather station data for model training and testing using growing degree days, total annual precipitation, and water balance (i.e., difference between total annual precipitation and evapotranspiration) as predictors. The models were constructed using a combination of regression (GLM, GAM, MARS), classification (CTA), and machine learning (GBM, RF) methods with the BIOMOD platform. We developed an approach for optimal selection of future climate scenarios from global and regional climate models using clustering analysis. A single consensus prediction was produced for each species for 2041-2070 and 2071-2100.

At the scale of our study, the selected climate predictors allowed an accurate mapping of current plant species distribution. Models for all species yielded high scores for predictive accuracy with AUC values ranging from 0.83 to 0.99, increasing confidence in future projections. For future projections, the spatially explicit maps produced from the models displayed considerable latitudinal shifts in climatically suitable habitat for the two time periods and for all species considered. Results provide spatially-explicit Information relevant to our understanding of how novel wetland communities may arise in a rapidly warming climate and can inform the selection of plant species for wetland restoration projects.

Contact Information: Sylvie deBlois, Plant Science and McGill School of Environment, McGill University, Macdonald Campus, 21 111 Lakeshore Road, Ste-Anne-de-Bellevue, Québec, Canada, H9X 3V9, Phone: +1-514-398-7581; Fax: +1-514-398-7897, E-mail: Sylvie.deblois@mcgill.ca

BARRIERS TO COLONIZATION IN RESTORED SEDGE-DOMINATED WETLANDS

Susan Galatowitsch
University of Minnesota, Saint Paul, MN, USA

Wetlands dominated by sedges (*Carex* spp.) are widespread in cold regions of the northern hemisphere, at high latitudes and high altitudes. Like other kinds of wetlands, sedge meadows (also called damplands or wet meadows) in many parts of the world have been lost or altered by human land uses. Restoration of sedge meadows is widely reported to be problematic. In many cases, re-establishing *Carex* populations has been a key limitation. Although the bipolar distributions of some *Carex* spp. suggest the potential for long-range dispersal, researchers have reported very low rates of local dispersal in highly fragmented landscapes. Dispersal is likely reduced by the loss of water pathways, but also by diminished propagule strength in these landscapes. In agricultural landscapes of the Midwestern US, for example, sedges have been displaced by introduced species, such as *Phalaris arundinacea,* in remnant, ephemerally inundated wetlands. This competitive displacement is typically due to multiple stressors of landscape-scale origin, especially high levels of soil nutrients and altered hydrology. Poor viable seed production has been widely reported by ecological restoration practitioners, suggesting propagule strength for some widespread *Carex* spp. has likely depended on large populations rather than on high seed production by individuals. Low rates of viable seed set in wild *Carex* populations severely limits seed supplies for restoration projects, which thwarts plans to overcome dispersal limitations by sowing seeds. Seed supply limitations have important implications for several very large scale wetland restoration efforts in North America tied to resource development. More research and development investments into vegetative propagation systems, similar to those used in some forest restorations on mined lands, is needed.

Contact Infromation: Susan Galatowitsch, University of Minnesota, 1970 Folwell Avenue, Saint Paul, MN 55108, USA, Phone: 612-624-3242, Fax: 612-624-4941, email: galat001@umn.edu

BIOGEOMORPHIC FEEDBACKS DRIVE DYNAMICS OF VEGETATION–LANDFORM COMPLEX IN A COASTAL RIPARIAN SYSTEM

Daehyun Kim
University of Kentucky, Lexington, KY, USA

Vegetation succession in riparian zones is traditionally considered to be mainly driven by allogenic hydrogeomorphological factors, while the importance of autogenic, plant-induced processes may become more significant as landform stability is achieved. This conventional notion was tested at selected point bars and cutbank edges along a salt marsh creek system in southwestern Denmark. It was predicted that, within each narrow habitat (ca. 5 m-width), sites closer to the creeks experience more dynamic changes in hydrogeomorphology, and hence, more changes in plant species composition than those farther away from the creeks. These sites were compared in terms of the rate of vegetation succession between 2006 and 2011, using nonmetric multidimensional scaling. In the resulting two-dimensional diagram, the Euclidean distance between any two samples representing the same quadrat of different time periods was interpreted as the degree of changes in species composition.

The predicted differences in succession rates among sites with varying distances from the channel were not observed. Locations adjacent to the creek have experienced the most intensive allogenic fluvial-geomorphic processes. However, the rate of allogenic succession under such physical dynamism has not necessarily been greater than that of the autogenic succession that was highly dominant at locations slightly away from the creeks.

Allogenic and autogenic factors are probably equally, or at least simultaneously, important to vegetation dynamics even under dynamic hydrogeomorphology. Such a view is in disagreement with the conventional belief in fluvial ecology, calling for a more explicit inclusion of autogenic processes in modelling the evolution of vegetation–landform complexes in the riparian zone. In other words, a true biogeomorphic nonlinearity exists in highly dynamic fluvial systems in that output (i.e. vegetation and landform dynamics) is not necessarily a direct product of input (i.e. hydrogeomorphic effects), due to an unexpectedly significant intervening variable, autogenesis.

Contact Information: Daehyun Kim, Department of Geography, University of Kentucky, KY 40506, USA, Phone: 859-257-6057, Fax: 859-323-1969, Email: biogeokim@uky.edu

PHYSIOLOGICAL RESPONSES TO SUBMERGENCE IN *TECTICORNIA* SPECIES GROWING AT SALT LAKES IN AUSTRALIA

***Dennis Konnerup*[1]**, *Ole Pedersen*[2] and *Timothy David Colmer*[1]
[1]University of Western Australia, Australia
[2]University of Copenhagen, Denmark

Salt lakes of inland Australia are harsh environments, characterized by high soil salinity in combination with extreme changes in water availability, where both flooding and drought may occur. Stem succulent halophytic shrubs of the genus *Tecticornia* (Chenopodiaceae) inhabit lake margins at the Fortesque Marshes and the communities exhibit patterns of species zonation. The species distributions might be influenced by gradients in elevation, depth to groundwater, flooding frequency and salinity.

In the present study, physiological responses to submergence were evaluated in two species (*T.medusa* and *T. auriculata*) which may sometimes be completely submerged in freshwater as occurs after cyclonic rainfall events in the field. Plants were submerged for 3, 6 and 12 days and *T. medusa* showed highest tolerance with 100% survival in all treatments whereas *T. auriculata* could not survive longer than 6 days submergence.

The submergence sensitivity in *T. auriculata* was associated with swelling and rupturing of tissue eventually leading to necrosis. Underwater photosynthesis rates were compared between the species and the submergence tolerant *T. medusa* actually had the lowest rate. Oxygen profiles and time traces in stems showed that *T. medusa* becomes anoxic in darkness although submerged in aerated water while *T. auriculata* still had aerobic tissue. However, measurements of tissue elasticity and strength demonstrated that *T. medusa* had higher tissue strength which was concluded to be the important trait for survival in the inundated marshes although the exchange of gases may be slower in *T. medusa* because of the less permeable tissue. This is the first study showing which mechanisms determine submergence tolerance in *Tecticornia* species and more studies are needed to find other possible differences between *Tecticornia* species.

Contact Information: Dennis Konnerup, School of Plant Biology, Faculty of Natural and Agricultural Sciences, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia. Phone: +61 86488 2562 Fax: +61 86488 1108, Email: dennis.konnerup@biology.au.dk

WETLAND VEGETATION REESTABLISHMENT FOLLOWING LARGE SEDIMENTATION (BURIAL) EVENTS

Todd J. Lemein and *Dennis Albert*
Oregon State University, Corvallis, OR, USA

Although infrequent, the damage to coastal areas from storm events can be extensive, and the rate of vegetation reestablishment in wetlands is dependent upon the extent of the disturbance and the type of vegetation present. Threesquare bulrush (*Schoenoplectus pungens*) is a perennial herbaceous emergent plant common to high energy open-water freshwater and brackish wetlands throughout the continental United States, where it is important for wave attenuation, erosion control and sediment stability. In major coastal storms, roots and rhizomes of threesquare bulrush stands may be buried by large amounts of sediment, resulting in mortality or slowing reestablishment. Following burial, wetland services provided by threesquare bulrush, including erosion control and wildlife habitat value for fish, waterfowl, and invertebrates, are lost or reduced.

In a controlled experiment, threesquare bulrush was grown under 0cm (control), 10cm, 20cm, 40cm and 80cm of sediment to simulate sediment deposition by a storm event, and growth rates were monitored. Sediment cores were collected monthly from March through October and processed to identify the amount of biomass, location, and type (root/rhizome, culm) of new growth throughout the sediment column to quantify growth rate and survival. After a complete growth cycle, no plants tolerated burial by 80cm of sand, and biomass production was reduced under 20cm and 40cm treatments, relative to biomass production under 10cm of burial and in the control (0cm). The number of culms and their maximum above-ground height decreased with increasing sediment depths. Root/rhizome biomass moved upward through the sediment column resulting in a new base rooting level for subsequent growing seasons.

The ecological implications of plant burial on the timing of vegetation emergence, changes in biomass production and the upward movement of roots and rhizomes will be discussed in terms of ecological services, such as sediment retention and erosion control. Decreased growth rates at burial levels greater than 10cm indicate that a managed restoration effort may be needed if threesquare bulrush reestablishment to pre-burial conditions is desired within a single growing season. However, the emergence of vegetation following 40cm of burial indicates that restoration of ecological services is likely to occur naturally over several growing seasons if subsequent burial events do not occur.

Contact Information: Todd J. Lemein, Environmental Science Program, Oregon State University, 4017 Agricultural and Life Sciences Building, Corvallis, OR 97331 USA, Phone: 650-867-7230, Email:lemeint@onid.orst.edu

IMPACTS OF FLOODING ON SUCCESSIONAL SPECIES TURNOVER IN RESTORED FLOODPLAIN WETLANDS

Jeffrey W. Matthews[1], *Geoffrey E. Pociask*[2], *Eric T. Plankell*[2]
[1]Illinois Natural History Survey, Prairie Research Institute, University of Illinois, Champaign, IL, USA
[2]Illinois State Geological Survey, Prairie Research Institute, University of Illinois, Champaign, IL, USA

Restoration is often described in terms of facilitating or accelerating natural succession. Assumed successional patterns, such as increasing species richness and a temporal shift in plant community dominance from annual to perennial species, are borne out across a variety of plant community types including many wetlands. Vegetation change occurs rapidly in the first few years following major disturbance, land abandonment or restoration, but the initially rapid rates of species turnover and colonization by new species predictably decrease over successional time. Decreasing colonization rates can be caused by competition from previously established plants and the increasingly limited availability of microsites for germination, and because as sites age and species richness increases, an increasing proportion of the incoming propagules are from species that have already established at the site. Despite these regular trends, successional trajectories may be erratic in frequently disturbed habitats like floodplains. We investigated the effects of flood exposure and time since restoration on annual rates of plant species colonization and local extinction in 20 restored floodplain wetlands. Vegetation was surveyed in each site for 4 to 8 consecutive years, and a flood exposure index was calculated from continuous hydrologic data for each site and year. Annual rates of species loss were unrelated to time since restoration but increased significantly in years with greater flood exposure. Up to 46% of the plant species were lost from sites in years with major flood disturbances. Years with high flood exposure coincided with increased losses of both annual and perennial plant species and both hydrophytes and non-hydrophytes. Of these groups, non-hydrophytes had local extinction rates that were most strongly accelerated by increasing flood exposure. As expected based on previous successional studies, annual colonization by new species was highest in recently restored wetlands and generally declined with time since restoration. However, colonization rates of annuals and non-hydrophytes also increased the year following major a flood year, contributing to a rapid recovery of species richness after disturbance. Although colonization by new species tends to decrease as sites age, suggesting stabilization, restoration trajectories can be difficult to predict in frequently disturbed ecosystems. Floods temporarily decrease plant species richness by removing many species, especially those species more typical of uplands. Rapid colonization after floods, however, possibly due to the input of propagules via hydrochory and the creation of suitable sites for germination and establishment, maintains resilience in the successional trajectories of restored floodplain wetlands.

<u>Contact Information</u>: Jeffrey W. Matthews, Illinois Natural History Survey, Prairie Research Institute, University of Illinois, 1816 S. Oak St, Champaign, IL 61820 USA, Phone: 217-244-2168, E-mail: jmatthew@illinois.edu

MODELLING SPACE-TIME DYNAMICS OF WETLAND VEGETATION OF THE PANTANAL OF MATO GROSSO (BRAZIL) BASED ON NEIGHBORHOOD INTERACTION AND FLOODING EFFECT

*J. Arieira[1], D. Karssenberg[2], **C. Nunes da Cunha**[1], E.G. Couto[3]*

[1] Instituto Nacional de Ciência e Tecnologia em Áreas Úmidas (INAU)/ Federal University of Mato Grosso, Cuiabá-MT, Brazil

[2] Department of Physical Geography, Faculty of Geosciences, Utrecht University, Utrecht, The Netherlands

[3] Department of Soils, Faculty of Agronomy, Federal University of Mato Grosso,Cuiabá-MT, Brazil

Advanced modelling approaches have been developed to describe and interpret vegetation dynamics. In the present study, we use a spatiotemporal Markov chain model (STMC) to implement and test a successional vegetation model for the vegetation of the Pantanal.

The conceptual successional model is developed based on literature and expert knowledge about physiological requirements of plant species, life history traits and ecosystem functioning. The parameter values are tuned by trial and error to handle parameter uncertainty and comparing predicted and observed spatial patterns of vegetation distribution. Model performance is evaluated by describing space-time model dynamics.

The model predictions corresponded closely to observed space-time patterns of vegetation. Inundation affected vegetation dynamics by controlling the expansion of communities according with their tolerance to flooding. The speed of vegetation development was slowed down under long-last flooding resulting in cyclic succession. Waiting times before transitions simulated species longevity and strategies to handle adverse site conditions avoiding overestimation of the vegetation sensitivity to environmental changes. Neighborhood parameter controlled the degree of adhesivety of communities increasing the residence time of communities with aggregate distribution.

The modelling approach developed in this study is relevant for conservation of the Pantanal wetlands because it helps to understand how environmental conditions and spatial interaction in biological processes may affect vegetation dynamics.

Contact Information: J. Arieira, Instituto Nacional de Áreas Úmidas (INAU), Cuiabá-MT. 78060-900. Brazil, e-mail: juarieira@ufmt.br, phone: 55 (65) 3664 1121

A SPLIT-ROOT APPROACH TO MONITOR RESPONSES OF *SALIX NIGRA TO* SPATIAL HETEROGENEITY IN SOIL REDOX

Samuel C. Pierce [1], *Melissa B. Koontz* [2], *S. Reza Pezeshki* [2] and *Robert Kröger* [1]
[1]Department of Wildlife, Fisheries, and Aquaculture, Mississippi State University, Starkville, MS, USA
[2]Department of Biology, University of Memphis, Memphis, TN, USA

Inundated soils in wetlands and riparian zones often become a reducing environment within a few days of flooding, resulting in root, and subsequently leaf, dysfunction. Although flooding occurs on a scale that encompasses the entire root system of a plant, the oxidation-reduction potential (Eh) of the soil reflects processes occurring at much finer spatial scales. Experimental comparisons of localized physiological and morphological responses of roots and their relations to whole-plant stress responses are lacking. The objective of this research was to determine if localized soil reduction altered photosynthesis and morphology of *Salix nigra.* The experiment utilized split-root minirhizotrons with two separate chambers, allowing for half of the root system of each plant to be flooded while the other half was allowed to drain. Plants from these heterogeneous treatments were compared to plants in which the entire root system was flooded or drained. Following treatment initiation, data on soil Eh, photosynthesis, leaf area, and root architecture were recorded at seven-day intervals.

Soil Eh was anoxic in the flooded treatment, but generally remained oxic in the non-flooded chambers (Eh >350 mV). While the split-root treatment demonstrated decreased photosynthesis compared to the control, over the course of the study, only the flooded treatment was significantly different from the control. Changes in leaf and root area (estimated from *in situ* root scans) demonstrated no overall treatment effect. An initial analysis of root architecture, however, revealed a significant treatment effect on the fractal dimension and the lacunarity of the root system. These results indicate that while moderately reducing soil Eh may have little obvious impact on general plant function, *S. nigra* subtly alters its root architecture to compensate for localized dysfunction. Because *S. nigra* is widely used for bank stabilization in stream restoration, a more fundamental understanding of the impacts of local soil conditions on growth and root development can have practical application in engineered systems.

Contact Information: Samuel C. Pierce, Department of Wildlife, Fisheries and Aquaculture, Mississippi State University, Box 9690, Mississippi State, MS 39762-9690 USA, Phone: 662-325-4722; Fax: 662-325-8726, Email: spierce@cfr.msstate.edu

ANCIENT TREES IN AMAZONIAN FLOODPLAINS: IMPLICATIONS FOR TROPICAL FOREST ECOLOGY AND CLIMATE CHANGE

***Jochen Schöngart*[1]**, *Florian Wittmann*[1], *Maria Teresa F. Piedade*[2] and *Wolfgang J. Junk*[3]

1Max Planck Institute for Chemistry (MPIC), Mainz, Germany
2National Institute for Amazon Research (INPA), Manaus, Brazil
3National Institute for Wetlands, Cuiabá, Brazil

The age of tropical trees is an important ecological parameter especially in the discussion about the conservation of tropical forests and maintenance of their environmental services, sustainable management of timber resources, biogeochemical cycles in the background of an ongoing climate change. However, the maximum age of tropical trees is controversially discussed in literature. While tree-ring analysis (dendrochronology) indicates maximum tree ages in the range of 500-600 years for tropical angiosperms, radiocarbon dating and growth models based on repeated diameter measurements yield age estimates of more than 1,200 years for some species of the lowland Amazonian forests (terra firme). In other climate zones such high tree ages are only known for gymnosperms growing at the edge of forest establishment. The inter- and intraspecific competition at these marginal sites is very low, since few, often only one tree species have the morpho-anatomical and physiological adaptations to grow under limiting environmental factors such as low temperatures and short photoperiods, drought, flooding, fire, or oligotrophic conditions. Also in the tropics such marginal sites occur, for instance, in the black-water floodplains, locally called igapó, along the Negro River and its tributaries in the Amazon basin. The igapó is regularly inundated by black-water rivers which have their catchments in the over 600 million-old Guyana shield. The water of these rivers has a low pH, almost no sediment load, but a high content of organic acids and consequently the regularly flooded soils of the igapó have an extreme low nutrient content. Tree species adapted to the monomodal flood pulse over millions of years. *Eschweilera tenuifolia* (Lecythidaceae) is an endemic tree species in the igapó which developed sophisticated adaptations enabling this species to occupy the lowest topographical elevations. There opened monospecific stands of this species are subjected to inundations of up to 8 m flood height lasting up to 10 months per year. The monomodal flood pulse triggers tree growth leading to the formation of annual tree rings since tree growth is mainly restricted to the terrestrial phase. In the Jaú National Park in central Amazonia we sampled cores of more than 100 trees of *E. tenuifolia* distributed over different diameter size classes. The wood samples were prepared, tree rings were identified by wood anatomical features (alternating fiber and parenchyma bands) and ring width was measured to construct diameter growth trajectories. Trees with diameters over 140 cm have ages of more than 1,000 years supporting the hypothesis from other climate zones that such high tree ages can only be achieved at marginal sites, but not at the optimum of forest establishment and occurrence such as in the Amazonian terra firme forests, where per hectare over 500-700 trees from more than 200 species with diameters above 10 cm compete for water, light and nutrients resulting in a dynamic forest ecosystem. The occurrence of ancient trees at the lowest elevations in the Amazonian floodplains also indicates that climate in the Amazon basin did not change towards wetter conditions during the last 1,000 years, since consecutive years of flooding would have killed these trees.

Contact Information: Jochen Schöngart, INPA/MPIC cooperation, Av. André Araújo, 2936, Aleixo, Manaus, 69.060-001, Brazil, Phone: 0055 (0)92 3643-3136, Fax: 0055 (0)92 3643-3136, Email: j.schoengart@mpic.de

SEEDLING RECRUITMENT IN VARIABLE HYDROLOGIC REGIMES

***Douglas J. Spieles**, Miranda Carter, Simonne Benoit* and *Jackson Means*
McPhail Center for Environmental Studies, Denison University, Granville, OH, USA

In the current structure of wetland mitigation in the United States, great emphasis is placed on the rapid establishment of an appropriate plant community. We evaluate the extent to which this goal is compatible with the rapid community turnover of early succession. We analyze the vegetation and seed bank composition of a mitigation wetland in central Ohio during its first three years. Specifically, we apply indices of floristic quality, hydrophytic dominance, and plant diversity to the full spectrum of hydrologic zones in the wetland, from permanently flooded to permanently exposed, and to soil quality variables. The results suggest that plant species turnover and the survival of planted species are a function of hydrologic stability. Year-to-year variability in plant community indices was significantly greater in zones of variable hydrology, as was seed bank expression and planted stock mortality. Hydrologic regime was a better predictor of vegetation change than soil quality attributes. We conclude that a stable hydrologic regime is conducive to the rapid establishment of a desirable plant community, and that this may come at the expense of long-term response diversity.

Contact Information: Douglas Spieles, 100 W. College St., Denison University, Granville, OH, 43023, USA, Phone: 740-587-5732, Fax 740-587-5784, Email spielesd@denison.edu.

VEGETATION SUCCESSION OF CREATED WETLANDS IN OHIO

Kay C. Stefanik and *William J. Mitsch*
Olentangy River Wetland Research Park, The Ohio State University, Columbus, OH, USA

Vegetation succession of two 1-ha created flow-through wetlands (one planted, one unplanted) was examined over three years at the Olentangy River Wetland Research Park (ORWRP), Ohio State University. The goals of this study were to (1) compare emergent macrophyte structure and function between a planted and unplanted wetland from fifteen to seventeen years after wetland creation, and (2) examine transitional/fringe vegetation succession of both herbaceous and woody species. Samples for emergent macrophyte vegetation were collected at twenty four 0.5 m2 plots in the two wetlands for three years. Transitional zone herbaceous and woody vegetation were sampled in twelve transects on a monthly basis for two years. Data collected included above and belowground biomass (used to estimate net primary productivity), species richness, number of plant communities, area of the dominant plant communities, and litter fall. Emergent macrophytes and herbaceous fringe vegetation were harvested to determine biomass, while regression equations were used to estimate woody biomass.

There was little difference in species richness between the two wetlands or from year to year in each wetland (planted wetland, 97 to 99 species; unplanted wetland, 92 to 95 species). Weighted aboveground net primary productivity (ANPP) was higher for emergent vegetation in the unplanted wetland (796±112 to 866±159 g DW/m^2) than in the planted wetland (673±130 to 712±114 g DW/m^2). Aboveground biomass accumulation was highest in May for both wetlands, all three years. Weighted belowground net primary productivity was similar between the two wetlands for all three years. Within the newly forested transitional zone, aboveground herbaceous biomass was slightly higher around the planted wetland (105±26 to 117±28 g DW/m^2) than unplanted wetland (79±27 to 98±37 g DW/m^2). Dominant woody vegetation within the transitional zone of both wetlands consisted of *Populus deltoides*, *Acer saccharinum,* and *Salix nigra*. Preliminary findings suggest that there are slight differences between these two wetlands, but the effect of planting on vegetation communities was minimal after 15 to 17 years.

Contact Information: Kay C. Stefanik, Olentangy River Wetland Research Park, 352 W. Dodridge Street, The Ohio State University, Columbus, OH 43202, Phone: 614-247-7984, Email: stefanik.13@buckeyemail.osu.edu

THE BIOMECHANICAL PROPERTIES OF SALT MARSH VEGETATION RELATED TO WAVE AND STORM SURGE ATTENUATION

James Chatagnier, ***Guoping Zhang*** and *Q. Jim Chen*
Louisiana State University, Baton Rouge, LA 70803, USA

The Northern coast of the Gulf of Mexico is threatened by storm surge and waves from tropical storms. It has been long known that marsh vegetation attenuates storm surge and waves and is vital for sustaining marsh edges. However, little is known about the relationship between plant properties and the amount of storm surge and wave reduction the plants provide. In order to better understand the stiffness properties and physical dimensions of saltmarsh vegetation, which are directly related to their ability to attenuate waves and storm surge, this study has been conducted. Stiffness of salt marsh vegetation was determined through direct bending and through board drop testing at multiple locations along the Southeast Louisiana Gulf Coast from August 13, 2009 to September 15, 2011.

Biomechanical properties of salt marshes, including plant dimension and bending stiffness modulus, were measured on coastal marshlands on the Southeast gulf coast of Louisiana, and are correlated with plant canopy height, stem height, stem diameter, plant stem density, and seasonal variations and botanical behavior. Two methods were employed, including direct stem bending and indirect board drop tests. The dataset is analyzed in depth to develop empirical equations of plant stiffness and compared with those found in the literature derived based on vegetation on river floodplains. These wave and surge measurements along with vegetation data are applicable to calibrating wave models that incorporate the reduction of energy due to wetland vegetation.

The mitigation of wave energy and storm surge is critical to the survival of Louisiana's wetlands and coastline. Salt marsh vegetation has the ability to mitigate the potential damage caused by storm surges and large waves. This study will improve our understanding of the role of vegetation in attenuating waves and storm surge and the accuracy of the parameterization of the vegetation effects in the-state-of-the-art wave models. The successful quantification of wave and surge attenuation by salt marshes will be a positive contribution to the coastal protection and restoration.

Contact Information: James Chatagnier, Department of Civil & Environmental Engineering, 3418 Patrick F. Taylor Hall, Louisiana State University, Baton Rouge, LA 70803 USA, Telephone: 225-578-6588, Fax: 225-578-4945, Email: jchata2@tigers.lsu.edu

RIDGE AND SLOUGH MULTISTATE MODELING FOR LANDSCAPE MANAGEMENT

Christa L. Zweig[1] and *Wiley M. Kitchens*[2]

[1] University of Florida, Florida Cooperative Fish and Wildlife Research Unit, Gainesville, FL, USA

[2] USGS, Florida Cooperative Fish and Wildlife Research Unit, Gainesville, FL, USA

The ridge and slough landscape of the Florida Everglades is a patterned peatland that has been degraded by water management over the past century. Because the processes that create the ridge and slough landscape function at a decadal scale, modeling their dynamics has been difficult. We classified LANDSAT imagery from 1987, 1993, 1999, 2003, and 2007 into ridge and slough to create input for a multistate model. Multistate models are likelihood-based models that predict transition probabilities from one state to the other and can incorporate covariates such as hydrology. We used modeled hydrology (1957-present) from two wells within our study area to represent the hydrologic legacy of two very different areas (impounded and non-impounded). Variables that represented extremes (maximum/minimum) and duration were calculated as input. Duration variables were most important to the conversion between ridge and slough. This model was created to provide specific hydrologic variables to managers as guidelines for restoration.

Contact Information: Christa Zweig, Box 110485, Bldg 810, Gainesville, FL 32611-0485, USA. Email: czweig@ufl.edu. Phone: 352-846-0639. Fax: 352-846-0841.

WETLANDS IN AGRICULTURAL WATERSHEDS

THE IMPACTS OF WETLAND LOSS IN A PRAIRIE WATERSHED

Pascal H. Badiou[1], *Bryan Page*[1], *Lyle Boychuk*[2], *Shane Gabor*[1] and *Wanhong Yang*[3]

[1]Ducks Unlimited Canada, Institute for Wetland and Waterfowl Research, Stonewall, MB, Canada

[2]Ducks Unlimited Canada, Regina, SK, Canada

[3]Department of Geography, University of Guelph, ON, Canada

Eutrophication as a result of phosphorus pollution is a widespread problem throughout North America, and has lead to the degradation of numerous lakes, rivers, wetlands, and estuaries across the continent. In the U.S. nonpoint sources are now the dominant input of P to surface waters and this is also likely the case in Canada. In the Canadian prairies non-point phosphorus pollution is largely due to agriculture and agricultural intensification over the last century. One of the main mechanisms facilitating the leakage of nutrients from agricultural landscapes is surface water drainage. This is of particular concern in the North American Prairie Pothole Region (PPR), where between 50 and 70% of wetlands have been lost, with some regions experiencing rates of loss in excess of 90%. Wetlands continue be lost at an alarming rate in the Canadian prairies. In order to quantify the effects of wetland loss Ducks Unlimited Canada (DUC) has been intensively monitoring the Broughton's Creek watershed situated in southwestern Manitoba. Using automated continuous hydrometric stations we measured discharge at the sub-watershed level as well as from individual drained wetland basins. Detailed water quality sampling was also conducted across the entire basin. This Information was combined with DUCs inventory of drained and intact wetland basins and basin wide elevation data to determine nutrient export coefficients at a sub-watershed level. Our results indicate that drained wetlands act as hotspots for nutrient export in the Canadian prairies. In addition to water quality implications our results also indicate that wetland drainage has substantially increased the amount of runoff from the watershed which could have implications for downstream flooding.

<u>Contact Information</u>: Pascal H. Badiou, Institute for Wetland and Waterfowl Research, Ducks Unlimited Canada, 1 Mallard Bay, Stonewall, MB R0C 2Z0 Canada, Phone: 204-467-3277; Fax: 204-467-3410, Email: p_badiou@ducks.ca

PREDICTING IMPACTS OF DEVELOPMENT AND LAND USE CHANGE UPON COMPLEX WETLAND SYSTEMS IN LARGELY UNDEVELOPED CATCHMENTS IN NORTHERN AUSTRALIA

***Damien Burrows**, Colton Perna* and *Barry Butler*
TropWATER, James Cook University, Townsville, Qld, Australia

Most of northern Australia is tropical savanna with strongly seasonal rainfall. Due to low population levels, remoteness and limited development, most catchments here are generally considered to be in relatively good condition. Dominant land uses are free-range cattle grazing and some areas of mining activity. Wetland impacts are mostly centred around grazing, riparian and wetland weeds, and feral pigs. These largely unregulated river systems carry 24% of Australia's total runoff. With salinisation, drought and over allocation afflicting southern catchments that provide most of Australia's irrigated production, the considerable pressure to more fully exploit northern water resources for economic development is now one of the larger social and political debates in Australia. The Burdekin catchment (136,000km^2) is the most heavily developed large catchment in northern Australia. As such, this catchment illustrates the types of water resource and wetland management issues to be faced in other northern Australian catchments if their exploitation increases.

The Burdekin River floodplain is dominated by irrigated agriculture, principally sugar cane. Although irrigation has occurred there for >100 years, the irrigated area greatly expanded after the construction, in 1987, of a 1,860,000ML dam. The conversion of grazing land to irrigated agriculture, and the loss of the strong seasonality which once drove the floodplain ecology, has had profound consequences upon the environment. Most of these impacts were unpredicted at the time of development, leaving the question as to whether further irrigation development in northern Australia can be any better managed. Over 80% of coastal wetlands have been lost, and those remaining are afflicted by poor water quality and low aquatic diversity. More than 200km of river channel downstream of the dam, and numerous wetlands numerous wetlands on the floodplain through which irrigation water is pumped, have greatly increased turbidity. The hydrology of streams and wetlands has been greatly altered by distribution of irrigation water and by bund wall construction along the coastal margins, leading to altered water quality and widespread dominance by aquatic weeds which thrive in the now more stable water regime. Aquatic weeds and fish passage barriers are the greatest management problems and the focus of most wetland restoration efforts.

This paper contrasts the ecology and management issues of the heavily developed, and largely undeveloped, wetlands and floodplain ecosystems of northern Australia. Irrigation development and the dominance of aquatic weeds, has forced changes to the way these wetlands are managed, particularly whether to manage for maintaining wetlands in their natural state.

<u>Contact Information</u>: Damien Burrows, Director, TropWATER – Centre for Tropical Water and Aquatic Ecosystem Research, James Cook University, Townsville, Qld, 4811 Australia, Phone: (61)-7-47814262, Email: Damien.Burrows@jcu.edu.au

PLANNING WETLAND RESTORATION IN AGRICULTURAL WATERSHEDS

Francisco A. Comín[1]*, Ricardo Sorando*[1]*, Alfonso Calvo*[2]*, Victor Guirado*[3]*, Nadia Darwiche*[1]

1Instituto Pirenaico Ecologia-CSIC, Zaragoza, Spain
2 Confederación Hidrográfica del Ebro-MMARM, Zaragoza, Spain
3CKV Consultores, Madrid, Spain

Agricultural watersheds are characterized all over the world by water flow regulations, increased pollutants in their natural waters and decreased biodiversity and landscape diversity. Restoring wetlands at watershed scale should be a positive action as wetlands have been shown as efficient tools to remove pollutants from contaminated waters and they have been largely removed, desiccated, and disturbed. However, planning wetland restoration at watershed scale requires planning the distribution of actions in a territory and efficient allocation of efforts according to objectives. The process of wetland restoration already followed in the Flumen watershed (Ebro River Valley, NE Spain) provides a type of guide of successful and failures and is useful to develop strategies for wetland restoration at watershed scale.

The program for wetland restoration in the Flumen watershed (1430 km^2 in a semiarid territory with 70% of the area used for irrigated agriculture, alfalfa, barley, wheat and rice) is a European Union Life Program managed by Comarca Monegros, the local government body for this territory who received this program from the European Union (http::/ www.creamagua.com). In order to establish a program for improving wastewater from irrigated lands discharged to the river and improve biodiversity wetland restoration was planned at watershed scale in zones were wetlands existed in the past or were observed as disturbed wetland sites at present time. Using SWAT (Soil and Water Assessment Tool) water and nitrate discharges through affluents to the main river were estimated. A preliminary selection of 100 potential sites (for wetland restoration was done based on: the potential capacity to remove nitrates (the major pollutant causing water quality deterioration) according to an areal first order removal model for designing discharge wetlands in the lower parts of subwatersheds and evaluation of ecological status based on geomorphologic and biological indexes for reaches of the main river. A second criteria based on social availability (the potential for land owners to offer their lands to establish wetlands) was used for a further selection of sites for wetland restoration. Finally, accordance between available sites and funding was used to define 300 ha as zones for the restoration of discharge wetlands with surface flow and 54 has in the river Flumen shores for restoration of riparian sites and defining the set of actions to be performed.

While writing the restoration projects and carrying out the restoration works, a set of restrictive measures were established to finally agree funding, social availability and ecological requirements to improve biodiversity at site and watershed scale and to decrease nitrate and other pollutants in the waters discharging to the rivers from the agricultural areas. General ideas and detailed lessons learned from this case study are discussed and how they can be used for upscaling and integrating the experience in land use and agricultural policies.

Contact Information: Francisco A. Comín, Instituto Pirenaico Ecologia-CSIC, Av. Montañana 1005, 50192 Zaragoza, Spain. Phone:34-976-369393 (Ext. 880061), Email:comin@ipe-csic.es

WATER QUALITY PERFORMANCE OF WETLANDS RECEIVING NONPOINT SOURCE LOADS

William G. Crumpton

Iowa State University, Ames, IA, USA

Wetland restoration is a promising strategy for reducing surface water contamination in agricultural watersheds but effectively using this strategy requires recognition of (1) the special characteristics of nutrient transport in agricultural landscapes, (2) the primary controls on wetland nutrient transformations at high nutrient loading rates, and (3) the variable and dynamic nature of non-point source hydraulic and nutrient loading rates. Much of the U.S. Corn Belt is underlain by networks of subsurface drainage tile that have dramatically altered surface and subsurface hydrology and provide the primary pathway of nitrogen transport to streams in these landscapes. Under the Iowa Conservation Reserve Enhancement Program (CREP), wetland restorations are strategically targeted to intercept loads from 500 to 4000 acre agricultural drainage basins. A unique aspect of the Iowa CREP is that nitrate reduction is not simply assumed based on wetland acres enrolled but rather is estimated based on the measured performance of CREP wetlands. As an integral part of the Iowa CREP, a subset of wetlands is monitored and mass balance analyses performed to document nitrate reduction. By design, the wetlands selected for monitoring span the 0.5% - 2.0% range in wetland/watershed area ratio approved for Iowa CREP wetlands. The wetlands also span a 2-3 fold range in average nitrate concentration. The wetlands thus provide a broad spectrum of major external forcing functions affecting wetland performance: hydraulic loading rate, residence time, nitrate concentration, and nitrate loading rate. The selected wetlands were instrumented for continuous flow measurement and automated sampling at inflows and outflows. Mass balance analyses were used to calculate mass removal rates of nitrate, TN, TRP and TP. The wetlands span a broad range of hydraulic and nutrient loading rates and as expected vary considerably with respect to nutrient removal efficiency. However, analysis of 27 “wetland years” of mass balance data (13 wetlands with 1-5 years of data each) demonstrates that much of the variability in nutrient removal can be explained by models incorporating hydraulic loading rate, residence time, temperature and nutrient concentration. Results demonstrate that even with the highly variable flows typical of agricultural drainages, wetlands can provide substantial nutrient reduction if the wetlands are positioned so as to intercept significant nutrient load and designed appropriately.

<u>Contact Information</u>: William G. Crumpton, Department of Ecology, Evolution and Organismal Biology, Room 253 Bessey Hall, Iowa State University, Ames, IA 50011 USA, Phone 515-294-4752, Fax: 515-294-1337, Email: crumptonb@iastate.edu

EUTROPHICATION EFFECTS ON PLANT-SOIL INTERACTIONS IN WET GRASSLANDS

Keith R. Edwards*, Hana Čížková, Eva Kaštovská* and *Tomáš Picek*
Department of Ecosystem Biology, Faculty of Science, University of South Bohemia, České Budějovice, Czech Republic

Increased nutrient additions, leading to eutrophication, is a continuing problem for many wet grassland ecosystems. It is well established that eutrophication leads to changed plant and animal species composition and diversity, but less is known about the impact on soil processes and plant-soil interactions or how soil type may affect these eutrophication effects. A field experiment was established in 2006 to determine the effects of nutrient additions on plant-soil interactions in two wet grasslands, one on mineral soil and the other on organic soil. The organic site (Záblatské Louky, ZL) is a marginal wetland dominated by *Carex acuta* and *C. vesicaria*. The mineral site (Hamr, HA) is in the floodplain of a small river and is dominated by *C. acuta* and *Glyceria maxima*.

Four blocks, each consisting of three plots (12.25 m^2), were established in both wet grasslands in spring 2006. Nutrient treatments (0, 65 and 300 kg NPK * ha^{-1} * yr^{-1}) were randomly assigned to each plot in each block, using a commercial fertilizer (Lovofert 15:15:15 NPK). Photosynthetic rates of the common species were measured biweekly to monthly using a LICOR 6400. Aboveground biomass was determined monthly using the harvest method, from which was calculated net aboveground production (NAPP). Ingrowth core bags were used to determine net belowground production (NBPP). Soil was sampled three times during the growing season (composite samples from four cores per plot) and analyzed for soil and microbial chemical and biochemical factors. Lastly, total gas emissions (CO_2, CH_4, NO_2) were measured monthly in each plot using the static chamber method.

There was a significant positive nutrient effect on aboveground biomass in ZL at times of maximum biomass, which was not found in the mineral HA site. However, NAPP did not significantly differ among the nutrient treatments in both sites, even though it increased with fertilization. Also, NBPP increased with fertilization, but these differences were not significant. There was greater biomass allocation (NAPP:NBPP) to aboveground structures with fertilization, but again this was not significant. The differences in plant biomass and production were not due to changed photosynthetic rates, as these did not increase with fertilization.There were significant nutrient effects for only a few soil factors (C_{mic}, microbial C:N, N assimilation) and only in ZL. CO_2 emissions significantly increased with fertilization in ZL. Emissions also increased with fertilization in HA, but the differences were not significant.

Short-term nutrient additions affected the organic site more than the mineral grassland, and plant variables and CO_2 emissions more than soil factors. Preliminary carbon budgets showed the organic site still acts as a carbon sink, though the effect is weaker with fertilization, while increased nutrients have resulted in the mineral site becoming a weak carbon source.

Contact Information: Keith R. Edwards, Department of Ecosystem Biology, Faculty of Science, University of South Bohemia, Branišovská 31, 37005 České Budějovice, Czech Republic, Phone: +420-38-777-2259; fax: +420-38-777-2368; email: kredwards59@yahoo.com

CONVERSION OF WETLANDS TO ROW CROPS IN THE PRAIRIE POTHOLE REGION

Carol A. Johnston
South Dakota State University, Brookings, SD, USA

Conversion to agriculture is the greatest source of wetland loss in the Prairie Pothole Region. Recent demand for corn ethanol, expiration of agricultural conservation contracts, and increasing commodity prices may have stimulated efforts to convert wetlands to row crops. I performed a GIS analysis to quantify rates of wetland-to-row-crop conversion by intersecting the 2010 National Agricultural Statistics Service Cropland Data Layer (CDL) with wetlands mapped by the National Wetlands Inventory (NWI) in the Prairie Pothole Region of eastern North and South Dakota. The CDL uses multi-date satellite imagery and field data to classify agricultural crops and other land uses; reported accuracies for corn and soybeans exceed 90% in the Dakotas. The NWI used aerial photography to map wetlands, and the date of the aerial photos used was the 1980s and late 1970s for most of the region. I identified areas of apparent wetland loss (AWL) as NWI wetlands mapped as corn or soybeans by the 2010 CDL. I examined the 168 largest AWLs (each >10 ha, cumulative area = 3,023 ha) on high resolution (= 1m) aerial photography taken in 2003 and 2010 to evaluate if AWLs were truly wetlands converted to croplands, and if such conversion occurred before or after 2003. I also inspected the AWLs against a topographic map background to verify that NWI wetlands were correctly mapped.

The cumulative AWL area was 135,686 ha, 8.7% of all NWI palustrine wetland area for the region. Sixteen percent of the AWL area inspected was incorrectly mapped as row crops, and was actually wetlands. Lush cattail stands were sometimes mapped as corn, possibly because of similar spectral properties that would confuse CDL satellite image analysis. Other sources of error included Missouri River sandbar wetlands mapped as row crops, wet pastures mapped as row crops, and a sewage lagoon for the City of Fargo that was mapped as soybeans. No errors were detected in NWI wetland identification.

The remaining 143 AWLs contained row crops, an area totaling 2,543 ha, but the majority (2,213 ha) had been altered prior to 2003. In fact, most of the AWLs were wetter in 2010 than they had been in 2003. Highly positive values of the Palmer Drought Index computed by the NOAA Climate Prediction Center indicated the region's wetter than normal soil moisture in 2009 and 2010. Record 2010 flooding on the Missouri, Vermillion, and James Rivers had inundated several floodplain AWLs that were row crops in previous years. The relative lack of recent wetland conversion may therefore be due to climatic impediments rather than agronomic choices.

Contact Information: Carol Johnston, Department of Natural Resource Management, Box 2104A, South Dakota State University, Brookings, SD 57007 USA, Phone: 605-688-6464, Fax: 605-688-6677, Email: carol.johnston@sdstate.edu

WETLAND FUNCTIONS IN THE TEXAS RICE BELT

Dan Keesee
USDA-NRCS, Temple, Texas, USA

In Texas, rice production concentrates in 16 counties along the state's upper Gulf coast. Within a roughly 200-mile arc paralleling the Texas upper Gulf coast, 290 square miles of cropland (185,641 acres) were planted and harvested for rice in 2010, a level of production that has declined 40 percent since 1995. Seventy-two percent of 2010's production occurred in five of the 16 counties. For all intents and purposes, rice grown and produced in this area is long-grain. Together with the rice fields of southwest Louisiana, the Texas rice belt makes up one of four regions producing almost the entire U.S. rice crop.

In the U.S., rice is a high-cost, high-yielding, large-scale commodity sold world-wide. However, the physical requirements for growing rice limit its production to specific areas. Economically sound rice production requires:
High average temperatures during the growing season,
A plentiful supply of water,
A smooth land surface, and
A sub-soil hardpan.

Over the past 75 years, rice producers found all the major requirements for rice production in plentiful supply along the upper Texas coast. Consequently, numerous wetlands were converted for rice production. Despite their conversion and use as cropland fields, these former wetlands continue to provide numerous wetland functions that include wildlife habitat, water quality improvement, and macro-invertebrate habitat. In some instances, the functioning level of the converted wetlands may equal that in wetlands considered more natural. For instance, evidence indicates waterfowl species wintering in the Texas rice belt extract a significant portion of their annual caloric requirements from the rice fields there. Similarly, aquatic invertebrate diversity in the drainage ditches may equal their diversity in nearby natural wetlands.

Contact Information: Dan Keesee, USDA–Natural Resources Conservation Service, 101 S Main ST, Temple, Texas 76501 USA. Phone: (254) 742-9833. E-mail: dan.keesee@tx.usda.gov

EFFECT OF PLANT COMBINATIONS ON NITRATE REMOVAL IN CHESAPEAKE BAY WETLANDS

*Team SWAMP (Superior Wetlands Against Malicious Pollutants) – Arsh Agarwal, Allison Bradford, Kerry Cheng, Ramita Dewan, Enrique Disla, Addison Goodley, Nathan Lim, Lisa Liu, Lucas Place, Raevathi Ramadorai, **Jaishri Shankar**, Michael Wellen, Diane Ye* and *Edward Yu*
University of Maryland, College Park, Maryland, USA

Harmful algal blooms caused by nitrates and phosphates negatively affect estuarine ecosystems, such as the Chesapeake Bay. These blooms release toxins and block sunlight needed for submerged aquatic vegetation, leading to hypoxic areas of the Bay. Artificial wetlands have been utilized to reduce the amount of nitrate pollution in waters affected by agricultural runoff. This project will test three wetland plant species native to Maryland, *Typha latifolia* (cattail), *Panicum virgatum* (switchgrass), and *Schoenoplectus validus* (soft-stem bulrush), for their potential in nitrate removal.

The main focus of our project is testing the *T. latifolia, P. virgatum,* and *S. validus* each individually and in various combinations to see which test group decreases effluent nitrate concentration the most. In order to increase statistical significance in the nitrate removal differences between plant combinations, we will use a carbon-based organic amendment to stimulate nitrate removal. The team will confirm the most effective organic amendment (between glucose, sawdust, and wheat straw) by testing each one on the *T. latifolia*. We plan to use the ANOVA test in order to determine the significance of our findings for each phase – first by determining which organic amendment most significantly improves nitrate removal in our microcosms, and then by determining which plant combination most significantly improves nitrate removal. We will conclude our testing of organic amendments in February and our testing of the different plant combinations in April. Based on our data, future environmental groups can make a more informed decision when choosing plant species for artificial wetlands.

Contact Information: Jaishri Shankar, University of Maryland, 0100 Ellicott Hall, College Park, MD, USA, Phone: 240-994-2597, Email: jaishri.shankar@gmail.com

GREENHOUSE GAS EMISSION FROM AGRICULTURAL WETLAND (RICE FIELD): ORGANIC VS. CONVENTIONAL FARMING

H. Pathak[1], ***Debjani Sihi***[2], *D. K. Sharma*[1] and *P. W. Inglett*[2]
1Indian Agricultural Research Institute, New Delhi, India
2University of Florida, Gainesville, FL, USA

Agricultural wetlands, such as rice fields, may be important contributors to greenhouse gases (methane and nitrous oxide), due to their global prevalence, periodic flooding schedules and high use of nitrogenous fertilizers. Role of agricultural soils to act as a source or sink for climatic trace gases and the impact of agricultural practices as a key to control emissions has so far only been briefly examined concerning CH_4 and N_2O. A study was carried out with the objective of assessing environmental impacts of organic farming compared to conventional system of basmati rice cultivation in terms of quantification of greenhouse gas (GHG) emission during *kharif* season (July to October) of 2009 at Kaithal district of Haryana, India. The study area comprised of 7 organic and 7 conventional fields spread over six villages in Kaithal, where organic farming is practiced for last 9 years. Based on the input used in both package of practices (organic and conventional system) calculations have been done on the potential of greenhouse gas (GHG) emission with the help of a decision support system (DSS), named InfoRCT (Information on Use of Resource Conservation Technologies in Agriculture), a simulation model developed to quantify greenhouse gases (GHG) in the rice-wheat system (Pathak, et al., 2005). The DSS integrates analytical and expert knowledge on biophysical, agronomic, and socioeconomic features to establish input output relationships related to water, fertilizer, and biocide uses and GHG emissions in the rice-wheat system. Estimated GHG emission was higher in organic fields over conventional fields.

Some argued that organic agriculture enables ecosystems to better adjust to the effects of climate change and offers a major potential to reduce the emissions of agricultural greenhouse gases as it absorb and retain significant amounts of carbon in the soil. However, there is other school of thought that emissions per unit of produce is not necessarily lower in organic systems, but to a greater extent linked with the efficiency of the production systems.

Though global warming potential (GWP) due to farm operations, off farm operations and nitrogenous fertilizer application were higher in case of conventional system but total GWP was quite higher in organic systems (2135.5 kg CO_2 eq. ha^{-1}) as compared to conventional systems (1477 kg CO_2 eq. ha^{-1}). Application of manures in organic fields enhances methane emission by adding organic carbon and N required for growth of methanogenic archaea. Presence of additional amount of organic matter in the form of organic manure also serves as an additional source of electrons which creates more anaerobic conditions and higher CH_4 emission. The findings suggest that agricultural wetlands especially organic rice fields may be important hotspots for GHGs emission, and warrant additional research.

Contact Information: Debjani Sihi, Soil & Water Science Department, University of Florida/IFAS, Gainesville, FL 32611 USA, Phone: 352-222-5655, Email: dsihi@ufl.edu

MACROINVERTEBRATE AND WATERFOWL COMMUNITIES OF ROTATIONALLY GRAZED PRAIRIE POTHOLE WETLANDS

Carly Silver[1] and *Steven Vamosi*[2]
1TERA Environmental Consultants, Calgary, AB, Canada
2University of Calgary, Calgary, AB, Canada

Temporary wetlands of the Prairie Pothole Region of North America (PPR) contain standing water from early spring through mid summer. Over half of the temporary wetlands in the PPR have been drained for agricultural purposes and nearly all those remaining have agriculturally-impacted margins.

Cattle grazing is a common practice in the PPR. Generally, the cattle are given uncontrolled access to any wetlands located within their pastures. One management system currently used to increase the availability of year-round forage for cattle is rotational grazing. Rotational grazing utilizes several pastures, with cattle grazing one pasture while the others are rested. The success of this practice in increasing the suitability of rested wetlands for macroinvertebrate and waterfowl communities was evaluated.

We examined how the timing of cattle grazing impacted the macroinvertebrate and waterfowl communities of temporary PPR wetlands. We repeatedly sampled macroinvertebrate communities and evaluated waterfowl usage and water chemistry parameters of thirteen rotationally grazed temporary wetlands. Seven wetlands were in an early grazed pasture (i.e., grazed when wetlands wet), and six wetlands were in an adjacent late grazed pasture (i.e., grazed when wetlands dry).

Both the macroinvertebrate and waterfowl were communities were found to be more diverse and abundant on the late grazed wetlands compared to the early grazed wetlands. The late grazed wetlands were also found to be less eutrophic than the early grazed wetlands. Our results suggest that rotational grazing may have a positive influence on the abundance and diversity of the macroinvertebrate and waterfowl communities in grazed pastures by allowing some wetlands to escape grazing pressure during the wet season.

Contact Information: Carly Silver, TERA Environmental Consultants, Calgary, AB T2P 3P2 Canada, Phone: 403-265-2885, Fax: 403-266-6471, Email: csilver@teraenv.com

TREATMENT WETLANDS FOR REMOVAL OF SULFATE FROM TILE DRAIN WATER

A. J. Stalboerger[1]*, W. Lin*[2]*, D. L. Jacob*[1] and *M. L. Otte*[1]

[1]Wet Ecosystem Research Group, NDSU, Fargo, ND, USA

[2]Department of Civil Engineering, NDSU, Fargo, ND, USA

Treatment wetlands (TWs) are used in industry and by researchers for wastewater treatment and other water quality improvements. Treatment wetlands can be constructed to target specific pollutants based on the aerobic and anaerobic conditions of the soil and water available. We constructed a TW with a settlement pond and two treatment ponds to reduce sulfate and phosphate in tile drain water. The settlement pond was designed to increase residence time within the TW by allowing water to lose energy before entering the first treatment pond. Treatment pond 1 was made anaerobic by introducing high amounts of organic material into the substrate and by keeping the water level shallow relative to the soil. Studies have shown that anaerobic conditions facilitate sulfate reduction into sulfide, which may then bind to iron, effectively immobilizing it. A byproduct of sulfate reduction is the displacement of phosphate, which can cause downstream eutrophication. We will use treatment pond 2 to control excess phosphate. Treatment pond 2 was made aerobic by having 10 times deeper water than treatment pond 1, and the wetland plants *Typha* angustifolia and *Salix* viminalis QC83 which provided aeration via radial oxygen loss. Phosphate in the water will be reduced by plant uptake and immobilized by binding with the substrate. We expect that the water exiting the TW will be reduced in sulfate and phosphate.

<u>Contact Information</u>: Alex J. Stalboerger, Department of Biological Sciences – Environmental & Conservation Sciences, North Dakota State University, Dept. 2715, Fargo, ND 58108-6050 USA, Phone: 701-388-7275; Email: Alex.Stalboerger@my.ndsu.edu

PLANT COMMUNITIES OF ISOLATED WETLANDS AND THEIR RELATIONSHIP TO SURROUNDING LAND USE

O. Stribling Stuber[1,2]*, L. Katherine Kirkman*[2] *,*and *Jeff Hepinstall-Cymerman*[3]
1Odum School of Ecology, University of Georgia, Athens, GA, USA
2Joseph W. Jones Ecological Research Center at Ichauway, Newton, GA, USA
3Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA, USA

Predicting environmental condition from remotely-sensed land use data is of growing interest as a potential tool for regional assessments of wetland condition. In this study, we examine the effects of land use on the condition of geographically isolated wetlands within Georgia's Dougherty Plain, a 6,690 km^2 physiographic province containing over 11,600 isolated wetlands; half are less than 1 ha in size. These small, typically shallow, seasonally ponded wetlands are important habitats for a unique and highly diverse fauna and flora, and are especially vulnerable to degradation in a landscape dominated by agriculture and silviculture. Our specific objectives were to relate land use to macrophyte community and to identify indicator species affiliated with specific land use classes.

We selected 35 isolated wetlands throughout the Dougherty Plain for vegetation and water quality sampling based upon the dominant land use in the surrounding upland. We focused on five most common land uses: pine plantations, irrigated agriculture, dryland agriculture, pecan orchards, and natural forest. A land use was considered "dominant" if it composed at least 75 percent of a 100 meter-wide zone surrounding the isolated wetland. Land use was determined through photo-interpretation of 2010 aerial photography. Our study includes seven wetlands in each of the five land use categories and 10 reference wetlands (relatively undisturbed sites). Wetland area ranged from 0.1 – 7.0 ha. We sampled vegetation in fall 2011. Sampling points were distributed randomly throughout the wetlands; the number of points was scaled by wetland area. At each point, all species within a 1 m^2 plot were recorded. If the wetlands were inundated, water samples were collected monthly March - May 2012 and analyzed for alkalinity, phosphates, nitrates, ammonia, and suspended sediments.

We compared macrophyte communities among wetlands using measures of diversity, as well as metrics which indicate the level of disturbance or change from reference conditions (e.g. annual/perennial ratio, native/non-native ratio, and percent obligate wetland species). Community composition and water quality relative to land use category were examined using PCA and non-metric multidimensional scaling. Indicator species analysis was also conducted. Preliminary results indicate wetland size is strongly correlated to disturbance metrics, although land use is also a strong predictor. Relative to reference wetlands, smaller wetlands surrounded by irrigated agricultural land use were the least diverse and composition differed the most based on ordination distances. Wetlands situated within pine plantations were most similar to reference sites in both macrophyte community composition and water quality. Results of this study will be used in a regional-scale wetland assessment model, and will contribute to collaborative restoration research with the USDA NRCS.

Contact Information: O. Stribling Stuber, Joseph W. Jones Ecological Research Center, 4009 Entrance Drive, Newton, GA 39870 USA, Phone: 229-734-4706, Email: sstuber@jonesctr.org

ENHANCED CONSTRUCTED WETLAND TECHNOLOGIES FOR CONTROLLING AND REMEDIATING WATER EUTROPHICATION

Xiao-E Yang[1], *Zhen-Li He*[3] , *Ying Feng*[1], *Wencheng Wang*[2] and *Peter J Stoffella*[3]

[1]Ministry of Education Key Laboratory of Environmental Remediation and Ecological Health, Zhejiang University, Zhijinguang Campus, Hangzhou 310058, China

[2]Ningbo Drinking Water Source Group Ltd., Ningbo 315195, China

[3]University of Florida, IFAS, Indian River Research and Education Center, Fort Pierce, FL34945, USA

Has become a worldwide environmental problem in recent years, and the development of novel technologies for controlling water eutrophication and/or remediating eutrophic water has attracted great attention of scientists, governments and enterprises alike. As water eutrophiocation is actually the results of aquatic ecosystem imbalance, phytoremediation technologies, especially through phyto-eco-control and -remediation approaches, are one of the low-cost, most effective, and sustainable measures to control water eutrophication. In this paper, recent advances in developing enhanced constructed wetland phytotechnologies for controlling or remediating eutrophic waters were reviewed.

The major phytotechnologies include: 1) ecological engineering of treating waste water in rural area; 2) abatement of agricultural non-point pollution by removing nutrients using resource plants; 3) phytoremediation of river/stream waters by constructing enhanced self-purification plant ecosystems; 4) purification of eutrophic waters using complex constructed wetlands in inundated area of reservoirs/lakes; 5) in situ phytoremediation of eutrophic reservoir/lake waters by constructing floating eco-island systems with enhanced purification capacity on water surface. These phytotechnologies has been applied to many catchments of drinking water source reservoirs in China, and some case studies are discussed in this paper. The combination of ecological remediation of water eutrophication with bioenergy production proves to be a promising approach for mitigating water eutrophication on a large scale.

Contact Information: Xiao-E Yang, Zhejiang University, College of Environment and Natural Resources, Hangzhou 310058, China, Phone/Fax: 0086-571-88982907, Email xyang@zju.edu.cn or xyang581@gmail.com

WETLANDS IN GLOBAL CONTEXT

SULFUR IS A POTENTIAL CHEMICAL TOOL FOR PLANT INVASIONS: AN INSIGHT FROM THE *SPARTINA* INVASIONS

Shuqing An and *lu Xia*
The Institute of Wetland Ecology and School of Life Science, Nanjing University, Nanjing , China

It has been shown that high sulfide concentration in soil is poisonous to most plants, although sulfur is a macro nutrient for plant growth. However, some species from Gramineae and Compositae, the two families with the most invasive plants, can actively store unusually high amounts of sulfur (osmoprotectant DMSP and its derivatives). Sulfur within the biomass may be released to the ambient environment by plants in the forms of sulfide and sulfate through microbe-mediated decomposition of dead plant tissues, resulting in high sulfide concentration in their habitats. Invasive species, such as *Spartina* spp., the model invasive species for research of plant invasions, succeed in their competition with the indigenous species, such as *P. australis,* using high sulfur release as a competitive mechanism. As sulfur supply increases due to acid rain and increasing inundation due to raising sea level, this chemical mechanism will be more likely found in more habitats around the world. In the costal areas where there are high sulfate concentrations in seawater and in the polluted areas where acid rain provides high sulfur, the sulfur storage of the soil will increase, resulting in the reduction or collapse of sulfur-sensitive plants and the expansion or invasion of sulfur-tolerant plants. The accelerated growth of sulfur-tolerant plants in the environment with high soil sulfur will accumulate more sulfur, which alters the soil microbial composition, especially the SRB, and results in even higher sulfur storage in the soil; these processes will eventually lead to slower growth rates or the disappearance of the sulfur-sensitive plants.

Contact Information**:** Shuqing An, The Institute of Wetland Ecology and School of Life Science, Nanjing University, Nanjing 210093, China. E-mail: anshq@nju.edu.cn

HYDROLOGIC CONNECTIVITY OF DRAINED WETLANDS IN IOWA'S PRAIRIE POTHOLE LANDSCAPE

Nandita B. Basu and *Kevin Stunkel*
University of Iowa

The Prairie Pothole Region (PPR) is a vast area of glacially formed depressional wetlands that extends from Alberta to Minnesota, with the southern tip reaching into Iowa. The portion of the PPR that extends into Iowa is known as the Des Moines Lobe and covers an area of 3.5 million ha. This region of the state is heavily farmed for the production of row crops, with more than 95-99% of the wetlands drained for agricultural use. Despite efforts to "dry out" these wetlands by subsurface drainage tiles, many of them still flood during particularly wet periods when the tile capacity is exceeded, and often produce only marginal crop yields. Restoration of these marginal farmed areas back to wetlands could provide a myriad of environmental benefits, including decreased downstream flooding, improved water quality and habitat for waterfowl and other migratory birds. Little research has been done into the effect that this could have upon the environment, and while restoration works are ongoing it is difficult to understand how beneficial they may be, especially at the watershed scale. Studies have been primarily focused on individual wetlands, but the role of hydrologic connectivity of distributed wetlands in maintaining seasonal inundations is still mostly unknown. The overall objective of this research is to understand the dynamics of water storage in wetland networks as a function of their size distribution and degree of surface and sub-surface connectivity, and use the understanding to develop a parsimonious hydrologic model that adequately captures the water flow dynamics.

Contact Information: Nandita Basu, Department of Civil and Environmental Engineering, University of Iowa, IA 52242, Ph 3193841727, Email: nandita-basu@uiowa.edu

PLANT–NUTRIENT INTERACTIONS IN A NEOTROPICAL OMBROTROPHIC PEATLAND

***Alexander W. Cheesman*[1]**, *Jorge Hoyos*[2], *Omar Lopez*[3], *Sofie Sjogersten*[2] and *Benjamin L. Turner*[1]

[1] Smithsonian Tropical Research Institute, Apartado 0843–03092, Balboa, Ancon, Republic of Panama

[2] University of Nottingham, School of Biosciences, Sutton Bonington Campus, , UK

[3] Institute of Advanced Scientific Research and High Technology Services (INDICASAT), Edificio 219 Ciudad del Saber, Clayton, Republic of Panama

The San San Pond Sak peatland is a 164 km^2 mosaic of freshwater and marine-influenced wetlands on the Caribbean coast of Northwest Panama. The site forms an important model ecosystem for studying plant–nutrient interactions in neotropical wetlands, because it supports a series of distinct vegetation communities spanning a strong nutrient gradient. Seven distinct plant communities occur from the margins to the center of the wetland: (i) *Rhizophora mangle* mangrove swamp, (ii) mixed back-mangrove swamp, (iii) *Raphia taedigera* palm swamp, (iv) mixed forest swamp, (v) *Campnosperma panamensis* forest swamp, (vi) sawgrass/stunted forest swamp, (vii) *Myrica-Cyrilla* bog-plain. Along this vegetation gradient, nutrients in surface peat decrease markedly from the marginal *Raphia* swamp to the interior sawgrass marsh. Multiple biogeochemical measurements, including total nitrogen and phosphorus, readily-extractable nutrients, total and microbial nutrient ratios, and hydrolytic enzyme activities, all indicate strengthening phosphorus limitation towards the wetland interior. In addition, a large fraction of the total soil phosphorus appears to be contained within microbial biomass, consistent with high polyphosphate concentrations determined by solution ^{31}P NMR spectroscopy. There are parallel changes in forest structure along the nutrient gradient: basal area decreases dramatically from the fertile margins to the oligotrophic interior, while tree diversity is greatest at sites with extremely low concentrations of available phosphate. The variation in nutrients and vegetation interact to influence peat chemistry and its accumulation along the gradient, which in turn influences carbon gas fluxes to the atmosphere. Taken together, these results demonstrate that nutrient status exerts a strong influence on above and below-ground processes in neotropical wetlands. It is therefore likely that nutrient availability will control the impact of climate and land use change within these ecosystems, which in turn has important implications for carbon dynamics in tropical peatlands.

Contact Information: Alexander W. Cheesman, Smithsonian Tropical Research Institute, Apartado 0843–03092, Balboa, Ancon, Republic of Panama. Tel: 011-507-212-8000; Fax: 011-507-212-8148; Email: CheesmanA@si.edu

LATITUDINAL VARIATIONS IN ECOLOGICAL STOICHIOMETRY IN MANGROVE COMMUNITIES: WHAT IS THE IMPACT OF NUTRIENT LOADING ON CANOPY AND BENTHIC FOOD WEBS?

Ilka C. Feller[1], *Anne H. Chamberlain*[1], and *Catherine E. Lovelock*[2]
[1]Smithsonian Environmental Research Center, Smithsonian Institution, 647 Contees Wharf Rd., Edgewater, MD , USA
[2]Centre for Marine Studies/School of Integrative Biology, University of Queensland, St Lucia, QLD , Australia

Mangroves form complex marine ecosystems with spatial differences in structural complexity, biodiversity, biogeochemistry, and hydrology that vary at local and regional scales. Although mangroves provide critical ecosystem goods and services, they are threatened globally by changes in climate and nutrient over-enrichment of the coastal zone. Using latitude and tidal elevation as proxies for climate change and sea level rise, the objective of this project is to determine how excess nutrients interact with these consequences of global change to alter community structure, food webs, and patterns of herbivory in mangrove ecosystems.

We used a series of long-term fertilization experiments across ~ 2185 km and 18º of latitude that have been maintained at three locations along the Atlantic coast (Indian River Lagoon, Florida; Twin Cays, Belize; Bocas del Toro, Panama). At each location, red mangrove (*Rhizophora mangle*) trees are fertilized with one of three nutrient enrichment treatments (control, +nitrogen (N), +phosphorus (P)) in two tidal elevations (fringe, scrub) along transects perpendicular to shorelines. We determined the abundance of the primary consumers at each fertilized tree and measured herbivory as a function of folivory, loss of yield, and tissue mining. To characterize food webs and elemental stoichiometry of individual organisms, we also sampled marine, benthic, and terrestrial communities at each of the fertilized trees. Samples were analyzed for elemental composition and stable isotopes.

All sites were nutrient limited, but patterns of nutrient limitation varied by zone and latitude. At IRL, growth was N-limited; at Twin Cays, the fringe was N-limited, but the scrub forest was P-limited; at Bocas del Toro, the fringe was N-limited, but the scrub forest was both N- and P-limited. Fertilization also altered the elemental composition of plant tissues and had dramatic effects on herbivory that varied by treatment, zone, latitude, and species. Responses to nutrient over-enrichment depended on site characteristics, the species considered, and the nature of nutrient limitation. Nutrient enrichment had dramatic effects on herbivory that varied by treatment, tidal elevation, latitude, and species. Responses to eutrophication of mangrove ecosystems will depend on site characteristics, the species considered, and the nature of nutrient limitation. Predicting how food webs will respond to nutrient over-enrichment requires an assessment of spatial heterogeneity coupled with feeding strategies and species-specific behavior, measured on multiple scales of response.

Contact Information: Ilka C. Feller, Smithsonian Environmental Research Center, Smithsonian Institution, 647 Contees Wharf Rd., Edgewater, MD 21037 USA: Phone: 443-482-2269, Fax: 443-482-2380, Email: felleri@si.edu

REDD+ AND WETLANDS: WETLAND HUMAN INTERACTIONS AND THE NEED FOR ROBUST SCIENCE

CM Finlayson
Institute for Land, Water and Society, Charles Sturt University, Albury, Australia

The policy framework for the Ramsar Convention is based on the principle of wise use of wetlands, which is also interpreted as taking action to maintain the ecological character of wetlands. This incorporates the complex science issues of establishing a baseline and determining the significance of change in ecological character and, when necessary, determining restoration measures. The complexity of maintaining or restoring the ecological character of wetlands will be exacerbated by global climate change and, potentially, also by policy responses to climate change. There is increasing possibilities to link the development of REDD+ schemes for reducing greenhouse gas emissions and storing carbon in forested wetlands while maintaining other ecosystem services to these measures. These efforts will require more robust science to be successful. In particular, tools and guidance are required for identifying when change in ecological character has occurred, as well as for implementing effective restoration projects that will sequester carbon and enhance the provision of ecosystem services with co-benefits for biodiversity and communities. In developing these tools and guidance, wetland scientists and practitioners should engage with policy-makers promoting REDD+ projects and also with the potential beneficiaries to ensure that funding is targeted at projects and programs with ecologically sound designs, and sufficient attention is directed towards the science needed to underpin these. As a further step it may be necessary to also articulate the social benefits and identify potential pitfalls when implementing REDD+, including the trade-offs that almost inevitably will arise.

Contact Information: Max Finlayson, Institute for Land, Water & Society, PO Box 789, Albury, Australia, Phone: 61458271580, Email: mfinlayson@csu.edu.au

WETLANDS GOVERNANCE: ALIGNING LEGAL DOCTRINE WITH BIOLOGICAL DIVERSITY

D.E. Fisher
Faculty of Law, Queensland University of Technology, Brisbane, Queensland, Australia

Wetlands provide a range of ecological services for the benefit of humans and for the benefit of ecosystems. The Ramsar Convention on Wetlands is the only international instrument that deals specifically with wetlands. However a number of international conventions such as those dealing with biological diversity, desertification and watercourses impact upon how wetlands are managed. Legal doctrine in a number of jurisdictions has approached the values of land and those of water separately. However it is becoming increasingly realised that the law needs to address water and land in an integrated and more coherent fashion. This involves recognising not only the interests of humans in how wetlands are managed but also the interests of nature in its widest sense in how wetlands are managed. These are issues for the international community as well as for national communities. This paper considers how these issues are currently addressed by the relevant international and national legal arrangements and suggests how a more integrated and coherent set of arrangements might be developed.

Contact Information: D. E. Fisher, Faculty of Law, Law School, Queensland University of Technology, GPO Box 2434, Brisbane QLD 4001 Australia, Phone: + 61 7 3138 1599, Fax: +61 7 3138 1161, Email: d.fisher@qut.edu.au

THE INTERSECTION OF WETLAND LAW, POLICY, AND SCIENCE THROUGH THE RAMSAR CONVENTION

R. Gardner
Stetson University College of Law, Gulfport, Florida, USA

As a multilateral environmental agreement, the Ramsar Convention imposes obligations on its 160 Contracting Parties. The three primary pillars of the Ramsar Convention are the wise use of wetlands, the conservation of wetlands of international importance (Ramsar Sites), and international cooperation. At the international level, there is debate about whether these treaty obligations are "hard law" (binding) or "soft law" (more aspirational). To what extent, however, does the Ramsar Convention affect domestic laws, policies, and practices? And what is the role of wetland science?

Expectations concerning how Contracting Parties should implement the Ramsar Convention are elaborated through resolutions that are adopted at triennial Conferences of the Parties (COPs). Many of these resolutions are developed by or with the advice of the Ramsar Scientific and Technical Review Panel. Ramsar resolutions – the subject matter of which can range from environmental impact assessments to wetland restoration – are adopted by consensus, a practice which has ramifications under international law.

This presentation will examine the role that wetland science plays in the development of Ramsar resolutions, which in turn can influence the Contracting Parties' implementation of the Ramsar Convention through the adoption of domestic laws and policies. It will consider several cases where the Ramsar Convention has played a role in protecting wetlands (e.g., Het Lac in Bonaire and the Olentangy River Wetland Research Park in the US). In doing so, it will discuss the legal significance of Ramsar resolutions. It will also review a current wetland transboundary case before the International Court of Justice, a dispute between Costa Rica and Nicaragua, which implicates the Ramsar Convention.

Contact Information: Royal Gardner, Stetson University College of Law, 1401 61st Street South, Gulfport, Florida, USA, Phone: 727-562-7809, Email: gardner@law.stetson.edu

HYDROLOGIC VARIABILITY AS A GLOBAL DRIVER OF COLONIAL WATERBIRD NESTING

Dale E. Gawlik[1, 2] and *Richard T. Kingsford*[2]

[1]Environmental Sciences Program, Florida Atlantic University, Boca Raton, FL, USA

[2]Australian Wetlands and Rivers Centre, University of New South Wales, Sydney, NSW, Australia

One of society's most pressing issues is to meet the growing demand for freshwater without causing irreversible degradation to wetland ecosystems. Two serious impacts to wetlands stem from reduced water flows and shifts in the timing and magnitude of flood pulses. Waterbirds have emerged as a group of indicator species that respond strongly to hydrologic manipulations. These species often nest colonially and have analogue species on almost every continent.

The ubiquitous nature of waterbirds and their biological similarities as a group led us to investigate the patterns of bird responses to hydrologic variability. We compared responses to water level fluctuations by waterbirds on five continents with a meta-analysis and two case studies; one in the Everglades in North America and the other in desert rivers in the Murray-Darling Basin in Australia. The Everglades is a vast subtropical herbaceous marsh interspersed with small tree islands. The Murray-Darling basin is comprised of 19 rivers and covers one-sixth of southeastern Australia. Many of the rivers inundate large floodplain wetlands that comprise a mosaic of reed beds, shrubs, and trees.

Annual variability in nesting numbers differed qualitatively among species and ecosystems. For storks, variability in nest numbers tended to be higher for wetland obligates than for species that commonly forage in uplands. When hydrologic conditions were good, nest numbers (all species pooled) were higher in the Murray-Darling than in the Everglades. Birds in the Murray-Darling had a longer interval between years with good nesting, and in both systems that interval increased after flow regimes were altered.

Birds in both ecosystems exhibited differences in the timing of nest initiation, which likely corresponded to foraging preferences and food availability. One key difference was that in the Murray-Darling birds nested during rising or peak water levels. Desert rivers have long inter-flood intervals so the density of terrestrial prey can increase during dry periods and then become available to birds on the rising water edge, as prey refuges get flooded or local rainfall produces a surge in terrestrial food sources. Thus, food availability is high with rising water and again when aquatic prey concentrate in drying pools. Birds in the Everglades probably respond to food in the same way but there is no pulse of availability with rising water and nesting is not initiated until water levels drop and aquatic prey are concentrated into pools. Although birds in different regions exhibited differences in the magnitude and timing of nesting, we hypothesize that these differences were a consistent response to food availability driven by hydrologic fluctuations.

Contact Information: Dale E. Gawlik, Environmental Sciences Program, Florida Atlantic University, 777 Glades Road, Boca Raton, FL 33431, USA, Phone: 561-297-3333, Email: dgawlik@fau.edu

HABITAT CLASSIFICATION OF WETLANDS: A POWERFUL TOOL FOR RESEARCH, MANAGEMENT, AND PROTECTION.

***Wolfgang J. Junk*[1,2]**
[1]National Institute for Science and Technology in Wetlands (INCT-INAU),
[2]Federal University of Mato Grosso, Cuiabá, Brasil

Large wetlands are complex ecosystems composed of many different habitats. These habitats are used by different plant and animal communities and differ with respect to primary and secondary production, biomass, and biogeochemical processes. Furthermore, they interact in multiple ways, for instance, by the periodic dislocation of animals for feeding and reproduction. Humans have also found varied uses for wetland habitats in and in the process have induced environmental changes, such as hydrology, that affect wetland habitats to differing extents.

Basic and applied research and legislation regulating wetlands management must take all of these considerations into account by adopting a habitat-specific approach. In the Brazilian savannah belt, there are four large wetlands: the Pantanal of Mato Grosso, and the floodplains of the Guapore, Araguaia, and Paraná Rivers. Of these, the first three are relatively undisturbed by humans, whereas the Parana River floodplain has been strongly modified by reservoir construction.

Ongoing studies by the Brazilian National Institute for Science and Technology in Wetlands (INCT-INAU) are aimed at classifying these wetlands according to their climate, hydrology, water and soil chemistries, and higher vegetation. These parameters allow a uniform habitat classification of the four wetlands that differs only in a few major habitat types and at the species level of higher vegetation. Major changes in hydrology and sediment load first impact the river channel and related habitats whereas changes in the nutrient status and vegetation cover of the adjacent floodplain habitats occur slowly and are habitat-specific; however, they will, in the long run, modify species composition and productivity on a large scale.

Moreover, habitat-specific research on large wetlands is of particular importance in order to describe and anticipate the impact of climate change, as some habitats are more vulnerable than others.

Contact Information: Wolfgang J. Junk, INCT-Wetlands, UFMT, Cuiabá, MT Brazil,78060-090, Phone: 0055-65-36158896, Fax 0055-65-36158878: Email: wjj@evolbio.mpg.de

SOCIO-ECONOMIC DIMENSIONS TO WETLAND SCIENCE

Ritesh Kumar
Wetlands International – South Asia, New Delhi, India

Inclusion of ecosystem services within ecological character underlines its social construct subjecting wetland wise use to societal preferences for the benefits people receive or desire to receive from these ecosystems. Understanding socio-economic dimensions requires recognizing wetlands as nested socio-ecological systems wherein their biophysical environment stand embedded within socio-economic and cultural context with mutually reinforcing pathways. Human societies are linked to wetlands from the core requirements for water and food, through their cultural identifies, the choices and tradeoffs they make and the governance systems that influence their behaviour in and around these ecosystems. Livelihood systems of wetland dependent communities often involve adapting with the overall ecological character of the wetland to optimize livelihood outcomes. Understanding the ways in which ecosystem services integrate with livelihood capitals, particularly the factors that determine capability to deploy ecosystem services as part of livelihood strategies have important consequences for achieving wise use. Institutions play an important role in providing a cognitive framework to interpret biophysical Information on wetland components and processes for setting rules and constraints for coordinating human action and defining incentive structure for human exchanges related to ecosystem services. Valuation as a means of expressing linkages of human societies with natural resources is an important institution in itself to engender change in the way societies respond to the crises of continued wetland loss and degradation. This requires developing credible processes not only as a tool for achieving economic efficiency, but also social fairness and ecological sustainability. The fit between institutions and the biophysical components and processes of wetlands plays an important role in determining their efficiency in achieving wise use. There is also a need to develop indicator systems for wetland wise use which capture the socio-economic dimensions by relating to human well-being.

Contact Information: Wetlands International – South Asia, A-25, Second Floor, Defence Colony, New Delhi – 110024, India, Email: ritesh.kumar@wi-sa.org

THE WETLANDS WORKING GROUP: OPPORTUNITIES FOR COLLABORATIVE RESEARCH IN TROPICAL WETLANDS OF PANAMA

Omar R. Lopez[1,2], *Alexander W. Cheesman*[2], *Jorge Hoyos*[3], *Sofie Sjogersten*[3], *Benjamin L. Turner*[2]

[1] Institute of Advanced Scientific Research and High Technology Services (INDICASAT), Edificio 219 Ciudad del Saber, Clayton, Republic of Panama

[2]Smithsonian Tropical Research Institute, Apartado 0843–03092, Balboa, Ancon, Republic of Panama

[3]University of Nottingham, School of Biosciences, Sutton Bonington Campus, LE12 5RD, UK

Tropical wetlands provide critical ecosystem services, including ground water recharge, removal of excess nutrients from surface waters and carbon sequestration. These services support social integrity, cultural heritage, and form the economic basis for human populations nearby. At the ecological level they provide refugia for threatened wildlife species and serve as centers of speciation and biodiversity. Yet despite their importance within a global context, tropical wetlands remain poorly studied are often under immediate threat from both local (i.e., land use change) and global (i.e., climate change) pressures. Extensive areas of Panama are considered wetlands, from isolated high altitude peatlands in the Talamanca Cordillera, to sea level mangrove swamps along the Caribbean and Pacific coasts and extensive coastal seasonally flooded forests in the Gulf of Montijo, Coiba Islands and Darién. Most of these areas are nationally protected reserves covering approximately 1800 km^2, which are recognized under the Ramsar convention as being of international importance. The Wetland Working Group (WWG) at the Smithsonian Tropical Research Institute provides a multidisciplinary research platform for collaborative study of Panama´s wetlands. At present, research within the WWG centers on the San San Pond Sak peat land, a 164 km^2 mosaic of freshwater and marine-influenced wetlands on the Caribbean coast of Northwest Panama. The site forms an important model ecosystem for studying plant–nutrient interactions in neotropical wetlands, because it supports a series of distinct vegetation communities spanning a strong nutrient gradient. In addition, WWG researchers are developing a network of long-term monitoring plots in forested wetlands across Panama, in which all plant species and stems greater than 10 cm diameter at breast height within 0.1 hectare plots are being identified, measured, and mapped. This effort provides a research platform that aims at understanding gradients in species diversity and productivity paying particular emphasis on their distinctive geomorpholocial features and its potential influence on forest structure, species abundance and monodominance within wetlands across Panama. In this presentation we summarize the research being conducted by the WWG in Panama, with emphasis on the structure, species abundance, and composition of forested tropical wetlands.

<u>Contact Information</u>: Omar R. Lopez, Institute of Advanced Scientific Research and High Technology Services (INDICASAT), Edificio 219 Ciudad del Saber, Clayton, Republic of Panama. Email: olopez@indicasat.org.pa. Phone: (507) 6948-9613

DEVELOPMENT OF A NEW FRAMEWORK OF COOPERATION BETWEEN RAMSAR STRP AND SWS

G.P. Lukacs[1] and *N.C. Davidson*[2]
[1]James Cook University, Townsville, Queensland, Australia
[2]Ramsar Convention Secretariat, Gland, Switzerland

The Ramsar Convention's Science and Technical Review Panel (STRP) was established by Resolution V.5 (Kushiro, 1993) as a subsidiary body of the Convention to provide scientific and technical guidance to the Conference of the Parties, the Standing Committee, and the Ramsar Secretariat. The STRP is currently a relatively small team comprising an independent Chair, regional representatives (6), appointed experts (8) and representatives of the International Organization Partners (5). Additionally, experts and consultants are invited as required. The Society of Wetland Scientists (SWS) is represented on the STRP as one of the 24 officially Invited Observer Organizations. Engagement between STRP and SWS is guided by a Memorandum of Understanding and fulfilled through SWS attendance at STRP meetings and assisting with activities specified in the STRP Work Plan. Often this results in individual SWS members contributing to STRP tasks or the Society providing advice more broadly to the various bodies of the Ramsar Convention. For more than 18 years the STRP has proven itself to be an effective advisory body, providing timely Information to Ramsar's Contracting Parties on important and emerging issues in global wetland conservation management.

The opportunity exists to further develop the Ramsar science-policy interface. Contracting Parties have recently reaffirmed the critical importance of the STRP (Resolution X.9) but logistical and other factors, including financial, constrain the ability of the STRP to develop a more meaningful relationship with the STRP National Focal Points, the representatives identified by each Contracting Party. A more iterative and regional relationship is required to better allow technical issues critical to each Contracting Party to be "opened up" and discussed or "closed down" and brought swiftly into policy considerations.

It is proposed SWS could facilitate (together with other wetland scientific societies) such regional engagement through their extensive scientific and technical networks. For example, SWS membership in the USA, Europe, Australia, South America and Asia could assist with the establishment of complementary scientific and technical fora to support regional Ramsar meetings. Ad Hoc Technical Expert Groups, as utilized by the Standing Committee of the Convention on Biological Diversity, could also be a mechanism supported by SWS to help provide Ramsar STRP and COP with detailed scientific, technical and technological Information on specific priority issues.

Strengthening of the Ramsar STRP-SWS relationship would bring benefits to both organizations. The creation of a new Science-Policy Framework which fosters the salience, legitimacy and credibility of political and scientific actors in wetland conservation and management would be welcomed by all stakeholders. Inherent would need to be processes which i) allow for greater participation and dialogue between political and scientific stakeholders, ii) provide opportunity and incentive for co-production and iii) encourage transparency and direct lines of responsibility and accountability. Further, within such a Framework, both scientific advocacy and political concerns could be more constructively considered.

Contact Information: G.P. Lukacs, James Cook University, Townsville, Queensland, Australia, 4812. Phone: +61 7 47814262, Email: George.Lukacs@jcu.edu.au

AN INUNDATED WETLANDS EARTH SYSTEM DATA RECORD: GLOBAL MONITORING OF WETLAND EXTENT AND DYNAMICS

Kyle C. McDonald [1,2], *Ronny Schroeder*[1,2], *Bruce Chapman*[2], *Erika Podest*[2], *Marzieh Azarderakhsh*[1] *Jane Whitcomb*[3], *Mahta Moghaddam*[3], *Lucas Jones*[4], *John Kimball*[4] and *Laura Hess*[4]

[1] City College of New York, City University of New York
[2] JPL/California Institute of Technology
[3] The University of Michigan
[4] The University of Montana
[5] University of California Santa Barbara

Wetlands exert major impacts on global biogeochemistry, hydrology, and biological diversity. The extent and seasonal, interannual, and decadal variation of inundated wetland area play key roles in ecosystem dynamics. Despite the importance of these environments in the global cycling of carbon and water and to current and future climate, the extent and dynamics of global wetlands remain poorly characterized and modeled**,** primarily because of the scarcity of suitable regional-to-global remote-sensing data for characterizing their distribution and dynamics. As part of a NASA Earth science project, we are constructing a global-scale Earth System Data Record (ESDR) of inundated wetlands to facilitate investigations on their role in climate, biogeochemistry, hydrology, and biodiversity. The ESDR is being developed using legacy algorithms developed from spaceborne remote sensing data sets. The ESDR is comprised of two complementary components: (1) Fine-resolution (100m) maps of wetland extent, vegetation type, and seasonal inundation dynamics, derived from Synthetic Aperture Radar (SAR), for continental-scale areas covering crucial wetland regions, and (2) global monthly mapping of inundation extent at ~25 km resolution for the period 1992-2009, derived from multiple satellite observations. We present details of ESDR construction including remote sensing algorithm application, cross-product harmonization, and planned data set distribution. This ESDR will provide the first accurate, consistent and comprehensive global-scale data set of wetland inundation and vegetation, including continental-scale multitemporal and multi-year monthly inundation dynamics at multiple scales.

Portions of this work were carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

Contact Information: Kyle McDonald, City College of New York, New York, NY, USA, Phone: 818-434-8937, Email: kmcdonald2@ccny.cuny.edu

FIGHTING ON ARRIVAL AND FIGHTING FOR SURVIVAL: A DELPHI STUDY ON THE THREATS AND RESILIENCE OF MANGROVES

Nibedita Mukherjee[1,2*], *Farid Dahdouh-Guebas*[1,2] and *Nico Koedam*[2]

[1]Université Libre de Bruxelles, Brussels, Belgium

[2]Vrije Universiteit Brussel, Brussels, Belgium

Vulnerability of mangroves varies considerably (location, scale and intensity) across the globe. Both local and global drivers often act in tandem to shape the loss and degradation of mangroves. Lack of time-series data on mangrove ecosystem dynamics at regional levels pose serious deterrents to developing a comprehensive understanding at a global level. Given the alarming rate of their decline, it is essential to assess the relative importance of the major drivers threatening mangroves. In addition it is imperative to comprehend the resilience of this ecosystem. However, it is difficult for one person or a few individuals to arrive at a synthesized view on the threats to mangroves and their resilience at a biogeographic level.

In order to resolve these gaps in knowledge we invited 106 mangrove experts from around the globe to participate in an online iterative survey based on the Delphi method. The Delphi method is a group consensus technique widely used in medical sciences and nursing. The advantage of this method lies in its anonymous and iterative nature. The experts were chosen based on (i) their research experience and (ii) number of peer-reviewed publications related to mangrove ecology. The participants were asked to choose one country where they had conducted/ are conducting primary fieldwork on mangroves. Each expert was then requested to rank 10 different impacts on a Likert Scale of 1 to 5. Each impact had to be ranked independently for its 'geographic scale' and its 'intensity' within the country of their choice. Thirty three (33) experts participated in the first round. The responses were critically evaluated to check for expert bias (if any) and the presence or absence of a consensus view. The results of this initiative will help us develop a better understanding of the 'whole ecosystem' of mangroves rather than gather knowledge 'on a sum of its parts'. We also evaluate whether the issues raised by the experts may or may not have a bearing on mangrove management policies.

Keywords: Delphi method; ecosystem function; species composition; threats; Likert scale, ecosystem services

Contact Information: Laboratory of Systems Ecology and Resource Management, Dept. of Organism Biology, Faculty of Sciences, Université Libre de Bruxelles - ULB,CP 169, Avenue F.D. Roosevelt 50,B-1050, Brussels, Belgium

email: nibedita.41282@gmail.com

BIODIVERSITY AND MANAGEMENT OF PANTANAL WETLANDS: AN APPROACH FOR THE SUSTAINABLE USE OF BRAZILIAN WETLANDS

C. Nunes da Cunha[1,2] *, J.M. Penha*[1,2]*, J.B. Pinho*[1,2]*, M. Soares*[1,2]*, V. Layme*[1,2]*, M. Aragona*[1,2]*,*and*, C. Strüssmann* [1,2]

[1]National Institute for Science and Technology in Wetlands (INCT-INAU)

[2]Universidade Federal de Mato Grosso

Situated in the frontiers between major South American biomes, including Amazonia, Cerrado, Chaco and the Bolivian Dry Forest, Pantanal wetlands offer unique ecological conditions for flora and fauna. Influences of neighbor biomes plus different levels of flooding and types of soil produce specific habitats. Populations of plants and animals are distributed in the environmental gradient in accordance with their abilities and tolerance to the stress of flooding and drought.

A preliminary analysis of the knowledge on Pantanal biodiversity reveals that species lists are available for most of the taxonomic groups, while knowledge on abundances, distribution patterns and species/habitat relationships are rarely assessed, or had been studied from a local perspective only. In general, seasonality was not taken into account, thus limiting the use of this Information to subsidize management and conservation plans

In recent decades, it has been recorded that several native herbaceous and woody plant species are increasingly spreading over grassland and open savanna areas. This invasion has economic consequences for cattle ranches and is associated to loss of biodiversity. The effects of this invasion are similar to those of exotic shrub species. The “ invasive” native shrubs develop large, monospecific communities that eliminate the existing herbaceous communities, diminish habitat diversity for animals, and affect negatively the landscape. Maintenance of habitat diversity, of species diversity, and landscape aesthetics, however, are strong arguments for the protection of the Pantanal, not only because of their intrinsic values, but also because they are major drivers of ecotourism and related economic activities. One possibility to reach this goal is the mechanical eradication of the invasive species, locally called pasture clearing

The current State Law for the Management of the Pantanal, dealing with sustainable management strategies leaves several open questions that need to be resolved before pasture clearing becomes an efficient tool for landscape management. Understanding the interdependence of habitats and biodiversity is essential to support conservation of the biodiversity.

To fill these gaps, the Brazilian National Institute for Science and Technology in Wetlands (INCT-INAU) is developing scientific projects aiming at answering: 1) how selected animal *taxa* respond to the flood pulse by using different life strategies and movement patterns, 2- How plants react to the flood pulse by changing photosynthetic activity, wood increment rate, seed germination and plant establishment strategies and endophyte diversity and their functional role. 3- How management strategies affect biodiversity, 4- How the expansion of woody plant species over grassland areas is related with biodiversity.

This Information will help to establish new criteria for clearing natural pastures and at the same time, conserving biodiversity, in order to support the implementation of the Brazilian Law of Management of the Pantanal.

Contact Information: C. Nunes da Cunha, Depto Botânica e Ecologia, UFMT, INCT-Wetlands, Cuiabá, MT Brazil,78060-090, Phone: 0055-65-36158896, Fax 0055-65-36158878: Email: catianc@ufmt.br

BIOPROSPECTION FOR THE SUSTAINABLE USE OF WETLANDS

***Paulo T. de Sousa Jr**, Claudia L. Strada, ELiana F.C. Dores, E.L. Dall'Oglio* and *V.C.Silva*
Instituto Nacional de Ciência e Tecnologia em Áreas Úmidas (INAU) - Universidade Federal de Mato Grosso (UFMT)

The Pantanal, one of the biggest wetlands in the world, is characterized by a rich biodiversity, presenting around 1860 angiosperm species. Culturally, the region received the contribution of aborigines as well as of European and Afro immigrants that came in the last 300 years and learnt how to live sustainably in the region, mainly as cattle ranchers and fishermen. However, the rapid economic development process observed in the last 40 years is causing the loss of forest areas as well as affecting the traditional way of life, requiring urgent action in order to scientifically validate folk knowledge about the use of plants and other biodiversity elements. Furthermore, we believe that adding value to Pantanal's flora will also have a positive impact in the conservation public policies, since we tend to conserve what is useful for us. *Echinodorus macrophyllus* (Kunth) Michelilus occurs only in South America, with wide occurrence in different regions of Brazil. They are perennial herbaceous, emergent aquatic plants that occur at the edges of rivers, lakes, drainage ditches and swampy lowlands (Leite, 2007). In folk medicine, the leaves are used in the form of decoction or infusion and are administered to treat liver and venereal disease, arthritis, rheumatism, as well as anti-inflammatory and anti-hypertension, among others (De La Cruz, 2008). *E. macrophyllus* were selected for this study based on its use in folk medicine as antiinflammatory and also becouse it is one of the plants mentioned by Junk and Nunes da Cunha (2010) in their "Preliminary Classification of *Habitats* from the Pantanal". Previous studies carried out in our group with the ethanolic extract of the leaves of *E. macrophylus* (EELEm) demonstrated decreased inhibition in rat paw edema induced by dextran and carreginin [4, 20 and 100 �G doses (Tanus-Rangel *et. al.*, 2010)], presenting anti-inflammatory activity and confirming, so far, the folk wisdom. It has been also described the isolation and identification of two isomeric flavonoid *C*-glycosides, namely, vitexin and isovitexin, which may be the responsible for the antiinflammatory activity (Tanus-Rangel *et al*. 2010). The excellent results obtained so far encouraged our group to proceed with the studies with the goal of producting an herbal medicine from *E. macrophylus*. Thus, in this study we will describe the use of HPLC-DAD-MS to carry out the phytochemical profile and to perform the quantification of vitexin and isovitexin in eleven different samples of *E. macrophylus*, ten of the colleceted, at the same time, in different regions of the Pantanal. Preliminary results show vitexin concentrations in the ethanol-water (7:3) extract ranging from 0 to 1.06%. Studies to determine the concentrations of isovitexin as well as the phytochemical profile of the extracts are in progress.

Contact Information: Paulo T Sousa Jr, Universidade Federal de Mato Grosso (UFMT), Instituto Nacional de Ciência e Tecnologia em Áreas Úmidas (INAU), Departamento de Química - ICET, 78060-900 Cuiabá-MT, Brazil. Phone: +55-65-36158304; Mobile: +55-65-81113374; e.mail: teixeira@ufmt.br

A GLOBAL MODEL OF HUMAN IMPACT ON THE BIODIVERSITY OF WETLANDS AND AQUATIC ECOSYSTEMS

Jan H. Janse[1], *M.H.J.L. Jeuken*[1], *J.J. Kuiper*[2], *J.R.M. Alkemade*[1] and ***J.T.A. Verhoeven***[2]
[1] PBL Netherlands Environmental Assessment Agency, Bilthoven, The Netherlands
[2] Utrecht University, Utrecht, The Netherlands

World-wide biodiversity of wetlands and aquatic ecosystems is declining fast due to many interacting drivers, including alteration of catchment land use (causing eutrophication and other pollution); wetland conversion; habitat destruction and flow alteration due to hydro-infrastructural works; climate change; invasive species; and overexploitation (MEA, 2005). The aim of this study is the development of a global model (GLOBIO-aquatic) to evaluate the combined effects of these drivers on aquatic biodiversity, as a tool for policy makers on the global and national level. It complements a comparable model for terrestrial ecosystems.

The model framework consists of a biodiversity model, embedded in a global catchment model, and driven by the IMAGE model chain describing population, land use changes, climate change, water flow and nutrients. These drivers are modelled (at present) at a spatial resolution of 0.5° (lat/long) (approx. 50 km). Fluxes are accumulated downstream according to a digital network model combined with the Global Lakes and Wetlands Database map (Lehner and Doll, 2004).

The biodiversity model is mainly based on compilations and meta-analyses of literature data. The main indicator used for biodiversity, besides species richness, is 'naturalness': the remaining abundance of native species, relative to the corresponding natural abundance, on a 0-1 scale ('MSA', comparable to the 'Biodiversity Intactness Index'). This concept allows to scale and compare different ecosystem types and taxonomic groups. The results show an overall negative relation between catchment land use and the biodiversity intactness of lakes, rivers and wetlands, despite large variations between studies. Likewise, disturbances of natural river flow patterns were related to a decreased biodiversity intactness in rivers and riverine wetlands. Also climate change effects may be described by this. The different drivers were (as yet) assumed to be independent (multiplied). A module for (physical and socio-economic) drivers for wetland conversion is being developed.

Preliminary applications of the model show that aquatic biodiversity has declined considerably in many parts of the world, especially in Europe and in Asia, and is expected to decline further in the future following baseline scenarios, especially in Africa (PBL, 2010). A nutrient reduction scenario will reduce further biodiversity loss, like scenarios that reduce the demand for meat. For agricultural intensification, a trade-off may be seen between effects on local and continental scales.

Future developments of the model will be: incorporation of fisheries, improved integration of different drivers, and independent model validation, for which we welcome cooperation with the scientific community.

Contact Information: Jan H. Janse, PBL Netherlands Environmental Assessment Agency, P.O. Box 303, NL-3720 AH Bilthoven, The Netherlands, Phone: +31 30 2743136, Fax: +31 30 2744485, Email: jan.janse@pbl.nl
References on web sites: www.globio.info and www.pbl.nl

GENETIC DIVERSITY, ECOTYPE HYBRID AND MIXTURE OF INVASIVE *SPARTINA ALTERNIFLORA* LOISEL IN COASTAL CHINA

Lu Xia and *Shuqing An*
The Institute of Wetland Ecology and School of Life Science, Nanjing University, China

Spartina alterniflora Loisel., a native species of the east coast of North America, is currently the focus of increasing management concern due to its rapid expansion in coastal China. To assess the extent of genetic variation, ecotype hybrid and ecotype mixture, and provide genetic baseline to effectively control the species, we collected and analyzed 144 samples from seven populations throughout coastal China, using amplified fragment length polymorphisms (AFLP) markers. The results showed that genetic diversity of *S. alterniflora* in China was lower than expected, as *PPB*=23.24%, H_E =0.0692 and *H*pop=0.4427 at population level, as well as *PPB*=28.07%, H_E =0.1051 and *H*sp=0.5520 at species level. The majority of the variation was found within rather than among populations, as estimated by Nei's genetic diversity (20.39%), Shannon's Index (19.80%) and AMOVA (23.56%). Our results also indicated the existence of both hybrids and mixtures of ecotypes of the species in coastal China, especially in southern populations. We supposed that either ecotype hybrids or ecotype mixtures, together with the surviving of independent three originally introduced ecotypes of the species, had been contributing to the successful invasion and massive spread of the species in China.

Contact Information: Lu Xia, The Institute of Wetland Ecology and School of Life Science, Nanjing University, Nanjing 210093, China . E-mail: lulu8668@yeat.com

Author Index