GEER 2010

Greater Everglades Ecosystem Restoration

The Everglades: A Living Laboratory of Change

Planning, Policy and Science Meeting

Program & Abstracts

July 12-16, 2010

Naples, Florida

Welcome to the GEER 2010 Planning, Policy and Science Meeting!

The Greater Everglades comprises more than one and a half million acres of natural landscape – or roughly 10,800 square miles spanning the southern third of Florida. It is a complex ecosystem, and as we move into the next decade "Facing Tomorrow's Challenges", it is more critical than ever that we reinforce the significant linkage between Planning, Policy and Science towards implementing sustainable restoration of Florida's Greater Everglades".

In fact, as we more closely examine Florida's ever-changing Greater Everglades landscape, we see a model living laboratory for assessing and predicting change. Hence, the theme for the GEER 2010 Conference, ***"The Greater Everglades: A Living Laboratory of Change".*** That change comes in many forms . . . Degradation Change, Restoration Change, Human Influence Change, Threatened and Endangered Species Change, Invasive Species Change, Nutrients-Contaminants Change, Climate Change, Change in Sea Level Rise and Natural Hazard Change. All of these "Changes" are actively impacting the Greater Everglades. It is imperative we understand change so we can predict change (Science), that we integrate the 'Science of change' into Planning for the future; and, that we use Science and Planning to help us move forward with effective Policy for a sustainable future.

The diversity of presentations at this meeting is further evidence of the challenges associated with restoring the Everglades. GEER 2010 provides a valuable forum for all of us involved in this effort to share current data and discuss these challenges concerning restoration of our national treasure – the Greater Everglades. We are pleased you are here to participate in this important endeavor and be part of the dialogue.

To that end, daily breaks, the opening reception and evening poster sessions are programmed to allow time for colleagues to network and exchange valuable information about our different roles in restoring the Everglades. We encourage you to visit the informational exhibits to see the latest in technology and resources available to you, be it federal, non-profit or private enterprise.

Appreciation goes to everyone who contributed toward the success of GEER and especially to our session organizers and chairs who facilitated an impressive array of oral and poster presentations. We would also like to thank those who submitted abstracts and prepared talks and poster presentations as well those who made time to attend. Without you, there would be no GEER. Lastly, we would like to thank the partnering organizations for their ongoing commitment and support.

Following the conference, the abstract book and PDFs of speaker and poster presentations will be available on the GEER web site, along with videos from our Plenary Sessions and Session One throughout the week. So stay tuned to the web site at www.conference.ifas.ufl.edu/GEER2010 – it is a tremendous resource.

Again, we welcome you to GEER 2010 and trust you will have a productive and rewarding experience.

Best Wishes,

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Meeting Organizer and Chair
Soil and Water Science Department
University of Florida / IFAS

G. Ronnie Best, Ph.D., PWS
Meeting Chair – Technical Sessions
U.S. Geological Survey

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List of Exhibitors and Contributing Partners

Aquatic Plant Management, Inc.

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National Park Service

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Southeastern Chemtreat, Inc

South Florida Ecosystem Restoration Task Force

US Army Corps of Engineers – Jacksonville District

US Department of Interior

US Fish & Wildlife Service

US Geological Survey

University of Florida / IFAS
Soil and Water Science Department

ECSIMA Background Information
Everglades Cooperative Invasive Species Management Area (ECISMA)

What is a CISMA?

A Cooperative Invasive Species Management Area is a formal partnership of federal, state, and local government agencies, tribes, individuals and various interested groups that manage invasive species and is defined by a geographic boundary.

Why a CISMA in the Everglades?

Florida has a long history of invasive species organization cooperation such as the Florida Exotic Pest Plant Council, Noxious Exotic Weed Task Team, Florida Invasive Animal Task Team and Invasive Species Working Group.

Everglades restoration poses new challenges for invasive species management and has created a need for a more defined commitment to cooperation among agencies and organizations at higher levels of policy and management.

What will the Everglades CISMA provide?

Everglades restoration will be enhanced by the establishment of a formal framework for staff and management cooperation among agencies and other coordinating bodies such as the South Florida Ecosystem Restoration Task Force, Working Group and Science Coordination Group.

An Everglades CISMA is needed to:

- Formalize areas of coordination and cooperation among agencies.
- Define specific geographical areas and prioritize species for Everglades restoration.
- Integrate coordination, control and management of invasive species at regional, multi-jurisdictional levels.
- Directly involve high-level policy makers and managers in Everglades invasive species coordination and areas of cooperation through a formal agreement.
- Be eligible for additional funding opportunities that are only available to CISMA-type organizations.
- Provide multi-organizational agreement and support toward the development of an Invasive Species Master Plan as part of CERP.
- Organize an Invasive Species Steering Committee to provide direction, coordinate actions and funding, and provide regular oversight and updates to the Invasive Species Master Plan.
- Resolve interagency coordination issues that require higher level management involvement (such as coordination of budget planning).
- Help ensure the success of Everglades restoration.

ECSIMA Everglades Invasive Species Summit Information

Monday, July 12, 2010
9:00am – 5:30pm

As Everglades restoration progresses, we continue to face the ever-growing challenge of invasive species management. To that end, GEER 2010 will host the Everglades Invasive Species Summit on Day One of our program. The Everglades Cooperative Invasive Species Management Area (E-CISMA) will present updates on operations in the Big Cypress National Preserve, Everglades National Park, the Loxahatchee National Wildlife Refuge, South Florida Water Management District conservation areas, Florida Fish and Wildlife Conservation Commission management areas and tribal lands. The Invasive Species Summit will develop a shared understanding of the threat of invasive species to Florida's natural resources, economy, and quality of life.

Summit Background:

The Everglades Invasive Species Summit (EISS) is organized annually to improve cross-agency communication and to develop an effective, coordinated invasive species control strategy for the Everglades region. ECISMA is a formal partnership between federal, state, and local government agencies, tribes, individuals and various interested groups that manage invasive species in the Greater Everglades area.

Summit Objective:

The objective of the summit is to bring together operational personnel and managers from the Greater Everglades area to discuss current and future operations, issues and successes in order to effectively and efficiently combat invasive species through the development of a multi-agency annual work plan. These discussions will acquaint participants with the various roles, activities and complexities required to manage invasive species throughout the Greater Everglades.

For more information, visit the ECISMA web site:

www.evergladescisma.org

ECISMA
Everglades Invasive Species Summit Agenda

Monday July 12, 2010 – Royal Palm 1-3

9:00am	Welcome
9:10am	ECISMA introduction
	Operations Reports
9:40am	Everglades National Park (Plants)
10:00am	Everglades National Park (Animals)
10:20am	Big Cypress National Preserve
10:40am	Break
11:00am	Seminole Tribe of Florida
11:20am	South Florida Water Management District
11:40am	Florida Fish & Wildlife Conservation Commission
12:00pm	Lunch on Own
1:00pm	Florida Fish & Wildlife Conservation Commission (Plants and Animals)
1:20pm	Miami-Dade County
1:40pm	Loxahatchee National Wildlife Refuge
2:00pm	South Florida Water Management District
2:20pm	Miccosukee Tribe
2:40pm	US Department of Agriculture, Wildlife Services
3:00pm	Break
3:20pm	Florida Power and Light
3:40pm	Florida Department of Transportation
4:00pm	Biological Controls
	Committee Reports
4:20pm	Operations Sub-Committee Report
4:40pm	Early Detection/Rapid Response Sub-Committee Report
5:00pm	Research Sub-Committee Report
5:20pm	Outreach Sub-Committee Report
5:30pm	Summit Session Concludes

Program Agenda

WELCOME TO GEER 2010: The Greater Everglades Ecosystem Restoration Planning, Policy and Science Meeting

MON	**MONDAY, JULY 12, 2010**					
7:00-5:30	**Conference Registration Open**					
7:00	**EXHIBIT HALL OPEN FOR POSTER & EXHIBITOR MOVE-IN (MORNING REFRESHMENTS WILL BE AVAILABLE)**					
9:00-5:30	**Invasive Species Summit**					
10:30-10:45	**REFRESHMENT BREAK - CONTINUANCE OF POSTER & EXHIBITOR SET-UP**					
10:00-5:30	**IMPROMPTU MEETINGS** (Four small rooms are blocked for GEER attendees who wish to have private meetings with colleagues while at the conference. Sign-up sheets to reserve these rooms will be posted on BOARD #1 in the Exhibit Hall.)					
noon-1:30	**LUNCH ON OWN**					
1:30-4:30	**Workshop on Application of Adaptive Management to Address Climate Change Related Challenges**					
3:00-3:30	**PM BREAK**					
5:30-7:00	**EARLY BIRD NETWORKING SOCIAL - THE VISTA ROOM (POOLSIDE)**					
TUES	**TUESDAY, JULY 13, 2010**					
7:30-5:30	**Conference Registration Open**					
7:30-8:30	**MORNING REFRESHMENTS**					
8:30-10:00	**Concurrent Sessions**					
	Royal Palm IV-V	**Royal Palm I-II**	**Royal Palm VI-VII**	**Acacia 1-3**	**Royal Palm III**	**Royal Palm VIII**
	Flow Effects in the Greater Everglades: Hydrologic and Ecological Drivers: Part 1	**System-Wide Science: Part 1**	**Loxahatchee's Living Laboratory: Part 1**	**Wading Bird Habitat Characterization**	**Invasive Species: Part 1**	**Past, Present & Future Hydrology: Management Implications: Part 1**
MODERATOR	**Jud Harvey**	**Chris Boruch**	**Marcie Kapsch**	**Becky Burns**	**Art Roybal**	**Frank Marshall**
8:30-8:40	**Introduction and Overview**					
8:40-9:00	**Matt Cohen** Flow and Pattern in the Ridge-Slough Mosaic: Predictions of Two Alternative Mechanisms for Landform Development	**Katie McCallion** The Real World - Merging Science and Engineering for Ecosystem Restoration	**Robin Boyle** Diet Composition of White Ibis Chicks in Loxahatchee National Wildlife Refuge: Crayfish, Crayfish and more Crayfish	**Rena Borkhataria** The Importance of South Florida for Wintering Wood Storks (*Mycteria americana*)	**Michael Avery** USDA/Wildlife Services: Tools and Strategies for Burmese Python Control	**Debra Willard** Long-term Spatial and Temporal Heterogeneity within Everglades Marl Prairies: A Late Holocene Perspective
9:00-9:20	**Agnes McLean** Band 1: Simulating and Analyzing the Effects of 10 Everglades Restoration Projects for the Comprehensive Everglades Restoration Plan	**Eliza Hines** The Role of a Robust Science Program in Large-Scale Ecosystem Restoration: Comparison of CERP and the Missouri River Restoration Program	**Rebekah Gibble** Growth and Survival of *Pomacea paludosa*, Say (Florida apple snail) Associated with Water Chemistry Gradients in the A.R.M. Loxahatchee National Wildlife Refuge	**Jason Lauritsen** Assessment of Wood Stork Foraging Opportunity for Southwest Florida	**Chuck Bargeron** IveGot1.org – Reporting and Tracking Invasive Species in the Everglades	**Lynn Wingard** Salinity History of the Southern Estuaries: Information to Estimate Past Flow Regimes and Set Restoration Targets
9:20-9:40	**Jennifer Richards** Characterizing Plant Community Hydrology Using the Everglades Depth Estimation Network	**Jim Vearil** Stuff Happens: Robustness and Flexibility as Tools for CERP Adaptive Management	**Tiffany Trent** Water Chemistry Effects on Apple Snail *(Pomacea paludosa*, Say) Reproductive Patterns in the Northern Everglades	**Shawn Liston** Aquatic Prey Communities in Southwest Florida Wood Stork Foraging Sites	**Teresa Cooper** The Mexican Bromeliad Weevil *(Metamasius callizona):* Changing Florida's Canopy	**Peter Harlem** Historic Surface Water Discharge to Biscayne Bay via the Transverse Glades
9:40-10:00	**Jay Sah** Changing Cape Sable Seaside Sparrow Habitat Conditions in Marl Prairie Landscape and their Implications for Everglades Restoration	**Michael Bauer** A Twenty Year Plan to Restore Naples Bay	**Laura Brandt** Amphibians and Muskrats as Potential Indicators of Ecological Change	**Tyler Beck** The Importance of Treatment Wetlands as Avian Habitat in South Florida	**Ikuko Fujisaki** Risk Assessment of Invasive Wildlife Species in South Florida	**Anna Wachnicka** Response of Diatom Communities to the 20th Century Changes in Water Quality Conditions in Biscayne Bay
10:00-10:30	**AM Break**					

TUES	TUESDAY, JULY 13, 2010 (continued)					
10:30-noon	Concurrent Sessions					
	Royal Palm IV-V	Royal Palm I-II	Royal Palm VI-VII	Acacia 1-3	Royal Palm III	Royal Palm VIII
	Flow Effects in the Greater Everglades: Modeling to Guide Restoration Part 2	**System-Wide Science: Part 2 - Science of the Trophic Hypothesis**	**Loxahatchee's Living Laboratory: Part 2**	**Program Management and Project Implementation: Part 1**	**Invasive Species: Part 2**	**Past, Present & Future Hydrology: Modeling & Application: Part 2**
MODERATOR	Vic Engel	Dale Gawlik	Tiffany Trent	Brian Files	Chuck Bargeron	Lynn Wingard
10:30-10:40	Introduction and Overview					
10:40-11:00	**Jim Heffernan** Ecohydrologic Feedbacks and Topographic Pattern in Everglades Peatlands: A Model of the Self-organizing Canal Hypothesis	**Peter Frederick** Wading Bird Nesting as a Tool for Understanding Everglades Ecology: Keystone Integrator	**Paul Conrads** Development of Empirical Hydrologic and Water-Quality Models of Loxahatchee National Wildlife Refuge Using Data-Mining Techniques	**Stu Appelbaum** The South Florida Ecosystem Restoration Program and the Integrated Delivery Schedule	**James Cuda** Apocnemidophorus pipitzi *(Coleoptera: Curculionidae),* a New Candidate for Biological Control of Brazilian Peppertree, *Schinus terebinthifolius (Anacardiaceae)*	**Frank Marshall** Coupling Statistical Models with Paleoecological Information - A Synthesis of Pre-drainage Hydrology and Salinity Estimates in the Greater Everglades Ecosystem
11:00-11:20	**Katie Skalak** Quantifying Vegetative Flow Resistance and Predicting its Influence on Velocity and Water Depth in the Everglades	**Evelyn Gaiser** How to Incorporate Variability in Community Sensitivity in Detecting Ecological Response to Management Driven Shifts	**Mauro Nalesso** Integrated Surface-Ground Water Modeling in Wetlands with Improved Methods to Simulate Vegetative Resistance to Flow	**Karen Tippett** South Florida Ecosystem Restoration Program Authorities and Project Funding Implications	**Dennis Giardina** Everglades CISMA Rapid Response to Python Sebae in Miami Dade County	**Judson Harvey** Incorporating Vegetation Resistance into Hydraulic Models as a Tool for Managing a Free Flowing Everglades
11:20-11:40	**Marc Stieglitz** Scale-Dependent Nutrient Feedback as a General Mechanism for Vegetation Patterning and Tree Island Formation in Wetland Ecosystems	**Joel Trexler** Linking Aquatic-Consumer Biomass to Environmental Drivers and Algal Ecology	**Matthew Harwell** Loxahatchee's Living Laboratory	**Eric Bush** South Florida Ecosystem Restoration Issues Resolution and Change Control	**Jeffrey Hutchinson** Evaluation of Annual Herbicide Application for Control of *Lygodium microphyllum* on Tree Islands in A.R.M. Loxahatchee National Wildlife Refuge	**Bernard Cosby** Relating Observed Extreme Salinity Events in Florida Bay to Physical and Hydraulic Conditions Simulated Using the FATHOM Model
11:40-noon	**Laurel Larsen** Modeling to Predict Causes of Degradation and Likely Outcomes of Restoration of the Everglades Ridge and Slough Ecosystem	**Aaron Parker** Environmental Filters of Wet-Season Aquatic Communities into Dry-Season Pools	**Interactive Discussion**	**Nanciann Regalado** South Florida Ecosystem Restoration Outreach and Strategic Communication	**Krish Jayachandran** Potential for Use of Native Phytopathogens as Biocontrol Agents for Invasive Plant Species	**Patrick Pitts** An Evaluation of the CERP Florida Bay Salinity Performance Measure
noon-1:30	LUNCH ON OWN					
1:30-3:00	**WELCOMING PLENARY SESSION** ***Welcome to the 2010 Greater Everglades Ecosystem Restoration (GEER) and Invasive Species Summit Joint Meetings, Workshops and Special Sessions: Helping Us Do Our Jobs Effectively, Efficiently in the Spirit of Partnership*** – **G. Ronnie Best,** US Geological Survey and **K. Ramesh Reddy,** University of Florida / IFAS, Co-Moderators ***Greater Everglades Restoration…CERP and Beyond*** – **COL Alfred A. Pantano, Jr.,** District Commander, Corps of Engineers – Jacksonville Office ***Keynote Address*** – **Eric Buermann,** Chairman, Governing Board, South Florida Water Management District					
3:00-3:30	PM BREAK					

TUES	TUESDAY, JULY 13, 2010 (continued)					
3:30-5:00	**Concurrent Sessions**					
	Royal Palm IV-V	**Royal Palm I-II**	**Royal Palm VI-VII**	**Acacia 1-3**	**Royal Palm III**	**Royal Palm VIII**
	PANEL SESSION: Flow Effects in the Greater Everglades	**System-Wide Science: Part 3 - Translating a Trophic Hypothesis Foundation for Restoration**	**Taylor Slough Basin Restoration**	**Program Management and Project Implementation: Part 2**	**Invasive Species: Part 3**	**Southern Coastal Systems - Responses to Hydrologic Conditions in the Mangrove Ecotone**
MODERATOR	**Matt Cohen**	**Joel Trexler**	**Matt Harwell**	**Brian Files**	**Tony Pernas**	**Mark Zucker**
3:30-3:40	**Introduction and Overview**					
3:40-4:00	**PANEL MEMBERS:** Jim Heffernan, FIU Laurel Larsen, USGS Vic Engel, NPS Eric Bush, USACE Bruce Boler, NPS **Guiding Questions:** 1.) How will restoration of sheetflow influence landscape topography and habitat diversity and connectivity and associated biological communities? 2.) What are the relative merits of pulsed flow versus continuous flow inputs to accomplish restoration? 3.) What are the achievable end states for ridge-slough-tree island landscapes given realistic constraints on water quantity and quality? 4.) What do managers need from scientists to proceed with hydrologic restoration ?	**Bryan Botson** Modeling Tropic Linkages with Wading Bird Prey Concentrations: Turning Ecosystem Attributes into Wading Bird Food	**Kevin Kotun** A Recent History of Taylor Slough Hydrology	**Ingrid Bon** Herbert Hoover Dike Rehabilitation Program Management	**Kevin Heatley** More than an Inventory: Prioritizing Invasive Treatment Sites with Limited Resources	**Paul Conrads** Analysis of the USGS Coastal Gradient Real-time Gaging Network
4:00-4:20		**Dale Gawlik** A Synthesis of Recent Studies Showing How Prey Availability Effects Wading Bird Habitat	**Donatto Surratt** Recent Degradation of the Vegetation Community in Taylor Slough Wetlands (Everglades National Park)	**Tom St. Clair** Comparison of South Florida with Other Large-Scale Ecosystem Restoration Programs	**Elliott Jacobson** The Ability of Large Constrictors to Invade Areas of the United States Beyond South Florida: Fact vs. Fiction	**Mark Zucker** Monitoring Freshwater Flow to Florida Bay and the Southwestern Coastal Estuaries of Everglades National Park in Support of the Comprehensive Everglades Restoration Plan
4:20-4:40		**Amanda Banet** Using CERP MAP Data and Ecological Forecasting Methods to Develop an Assessment Protocol for Everglades Restoration	**Jimi Sadle** Recent Vegetation Changes in Taylor Slough, Everglades National Park	**Lacy Shaw** Project Implementation: A Case Study of Picayune Strand from Planning Through Construction	**Art Roybal** Everglades Invasive Species Early Detection and Rapid Response Plan: A Coordinated Framework of Partners and Procedures	**Jennifer Rehage** Effects of Abiotic Drivers on the Distribution and Abundance of Fishes at the Marsh-Mangrove Ecotone: What are the Implications for Predator-Prey Interactions?
4:40-5:00		**James Beerens** Resource Selection Function as an Empirical Approach to Developing a Wading Bird Habitat Suitability Index	**Nick Aumen** Restoration Implications of Recent Ecological Changes in Taylor Slough, Everglades National Park	**Tony Buitrago** Program Management Support Contracts and Everglades Partners Joint Venture	**Elroy Timmer** Control Options for the Most Common Invasive Plants in Arthur Marshal and Similar Areas of the Everglades	**Edwin Brown** The Effects of CERP Increasing Freshwater Flows to the Oligohaline and Mesohaline Areas of North East Florida Bay
5:00-7:00	**Poster Session I and Networking Reception** (Poster Session I Presenters Remove Displays Upon Conclusion)					
7:30-5:30	**Conference Registration Open**					
7:30-8:30	**MORNING REFRESHMENTS** (Poster Session II Presenters Set-up Displays)					
8:30-10:00	**PLENARY SESSION** **Greater Everglades Ecosystem Restoration — "Hot Topics"** ***Invasive Species* – COL Alfred A. Pantano, Jr.,** District Commander, Corps of Engineers – Jacksonville Office ***A Wetter Everglades...Increased Freshwater Flows* – Robert Johnson,** Everglades National Park, National Park Service, Homestead, FL ***The Skyway Bridge...The Right Solution* – Rock Salt,** Principal Deputy Assistant Secretary of the Army, Washington, DC					
10:00-10:30	**AM Break**					

WED	WEDNESDAY, JULY 14, 2010					
10:30-noon	Concurrent Sessions					
	Royal Palm IV-V	Royal Palm I-II	Royal Palm VI-VII	Acacia 1-3	Royal Palm III	Royal Palm VIII
	Climate Change, Sea Level & Natural Hazards Part 1: Modeling	**Development of a National Community of Ecosystem Restoration Practitioners**	**Tree Islands Part 1: Managing a Changing Landscape**	**Picayune Strand Restoration Project: Wetlands Restoration of a 58,000 Acre Drained Residential Development - Part 1**	**Invasive Species: Part 4**	**Southern Coastal Systems - Submerged Aquatic Vegetation Responses to Hydrologic Conditions**
MODERATOR	Glenn Landers	Cheryl Ulrich	Sharon Ewe	David Bauman	Dennis Giardina	Don Deis
10:30-10:40	Introduction and Overview			**Kathy Worley** The Picayune Strand Restoration Project: From Wetland Ecosystem to Failed Residential Development and Back	Introduction and Overview	
10:40-11:00	**Paul Hearn** The IMMAGE Project - Internet-based Modeling, Mapping, and Analysis for the Greater Everglades	**Bill Leary** The Time is NOW for a National Coalition for Ecosystem Restoration	**Paul Wetzel** Knowledge Gaps in Tree Island Ecology		**Tony Pernas** Digital Aerial Sketch Mapping (DASM) for Invasive Plant Survey and Mapping in the Everglades Cooperative Species Management Area (ECISMA)	**Thomas Frankovich** Opposite Seasonal Patterns in Chara and Halodule Communities in the Mangrove Lakes and Estuaries of the Coastal Everglades: Relationships to Environmental Variables
11:00-11:20	**Kris Esterson** The Sea Level Projections of USACE EC 1165-2-211 in Context	**John Adornato** America's Great Water Coalition	**Agnes McLean** The Conceptual Ecological Model for Everglades Tree Islands	**Brad Foster** Picayune Strand Restoration: Alternatives Evaluation and Selection of the Recommended Plan	**Chris Matson** Replacing Torpedograss *(Panicum repens)* with Native Species in Shallow Herbaceous Wetlands	**Darrell Herbert** Projected Reorganization of Florida Bay Seagrass Communities in Response to Increased Freshwater Inflow with Everglades Restoration
11:20-11:40	**James Watling** Climate-based Distribution Models for the American Crocodile, *Crocodylus acutus:* Challenges and Management Opportunities	**Cheryl Ulrich** Creation of a National Community for Ecosystem Restoration	**Michael Ross** Linking Soils, Hydrology, and Forest Structure in Everglades Tree Islands		**Frank Mazzotti** Performance Measures for Adaptive Management of Burmese Pythons	**Theresa Strazisar** Seedbank, Germination and Abiotic Factors Control *Ruppia maritima* Dynamics across the Freshwater-Marine Transition Zones in Florida Bay
11:40-noon	**Juan Carlos Vargas-Moreno** Participatory Scenario Planning for Climate Change and The Greater Everglades Landscape	**Interactive Discussion**	**Tiffany Troxler** Interactions of Biological and Hydrogeochemical Processes Facilitate Phosphorus Dynamics in an Everglades Tree Island	**Roger Copp** Use of Hydrological Modeling for Selection of the Recommended Picayune Strand Restoration Plan	**John Volin** Does Water Hyacinth *(Eichhornia crassipes)* Compensate for Simulated Defoliation? Implications for Effective Biocontrol	**Piero Gardinali** Contaminants in Biscayne Bay: Everything Else but Nutrients
noon-1:30	LUNCH PROVIDED IN PRE-FUNCTION AREA					

WED	WEDNESDAY, JULY 14, 2010 (continued)					
1:30-3:00	Concurrent Sessions					
	Royal Palm IV-V	**Royal Palm I-II**	**Royal Palm VI-VII**	**Acacia 1-3**	**Royal Palm III**	**Royal Palm VIII**
	Climate Change, Sea Level & Natural Hazard Part 2: Water	**PANEL SESSION: Implications of New Scientific Knowledge for Restoration: Update on the RECOVER Knowledge Gained Initiative**	**Tree Islands Part 2: Managing a Changing Landscape**	**Picayune Strand Restoration Project: Wetlands Restoration of a 58,000 Acre Drained Residential Development Part 2**	**Water Quality and Gradients Across the Everglades: Part 1**	**Southern Coastal Systems - Ecological Responses to Hydrologic Conditions in the Southern Everglades Ecosystem**
MODERATOR	**Leonard Berry**	**Tom St. Clair**	**Mike Ross**	**David Bauman**	**Dave Krabbenhoft**	**Dave Bornholt**
1:30-1:40	**Introduction and Overview**			**Lacy Shaw** Picayune Strand Restoration Project: From Planning to Construction — Lessons Learned in Project Implementation	**Introduction and Overview**	
1:40-2:00	**Lisa Beever** An Integrated Approach to Climate Change Vulnerability, Resiliency and Adaptation	**Panel Members:** Don Deis, EPJV Matt Harwell, FWS Kelly Keefe, USACE Jed Redwine, EPJV **Discussion Topic:** Panel members will present updates to scientific information obtained over the past ten years pertinent to Everglades restoration that will be used to help define restoration success	**Sharon Ewe** Landscape-scale Trends and Decadal Spatial Patterns of Ghost Islands in the Everglades		**Bill Orem** Impacts of Sulfate-Enriched Water Discharged into Northwestern Water Conservation Area 2A	**Maria Criales** The Effect of a Preconditioning Salinity on Survival and Growth of Postlarvae and Juvenile Pink Shrimp
2:00-2:20	**Jessica Bolson** An Assessment of an Integrated Participatory Scenario Development Framework that Addresses Climate Impacts on South Florida Water Resource Management		**Binhe Gu** Soil Phosphorus Distribution in Ghost Tree Islands and Surrounding Marsh along a Hydrological Gradient in Water Conservation Area 2A	**Tom Leicht** Picayune Strand Restoration Project: Engineering Design; Pump Stations and Other Project Features	**David Evans** Mercury Concentrations and Stable Carbon and Nitrogen Isotopes in Fish along the Freshwater to Estuarine Transition in Eastern Florida Bay	**Chris Kelble** Juvenile Sportfish Populations in Florida Bay: Influence of Salinity
2:20-2:40	**John Meeder** Coastal Hypoxia in South Florida Associated with Projected Sea Level Rise and Holocene Organic Carbon Sediment Export		**Jennifer Vega** Vegetation Ecology of Ghost Islands in the Everglades	**Kim Dryden** Assessing Project Effects on Wildlife in Picayune Strand Restoration Project	**George Aiken** Dissolved Organic Matter in the Florida Everglades: Implications for Ecosystem Restoration	**John Baldwin** Long-term Population Trends (1958-2008) of Bald Eagles *(Haliaeetus leucocephalus)* in Florida Bay, Everglades National Park
2:40-3:00	**Barry Heimlich** Effects of Sea Level Rise on Southeast Florida's Water Resources		**Interactive Discussion**		**Piero Gardinali** Presence, Distribution and Potential Environmental Implications of the Presence of Endosulfan Sulfate Residues in Waters, Sediments and Biological Samples in South Florida	**Jerome Lorenz** Banding and Tracking of Roseate Spoonbills Suggests Florida Bay May be at a Tipping Point in Reference to Everglades Restoration Efforts
3:00-3:30	**PM Break**					

WED	WEDNESDAY, JULY 14, 2010 (continued)					
3:30-5:00	Concurrent Sessions					
	Royal Palm IV-V	Royal Palm I-II	Royal Palm VI-VII	Acacia 1-3	Royal Palm III	Royal Palm VIII
	Climate Change, Sea Level & Natural Hazards Part 3: Sea Level Rise	**Everglades Science in Support of Restoration – What Do Decision Makers Need? Part 1**	**Tree Islands Part 3: Management of a Changing Landscape**	**Picayune Strand Restoration Project: Wetlands Restoration of a 58,000 Acre Drained Residential Development Part 3**	**Water Quality and Gradients Across the Everglades: Part 2**	**Biscayne Bay Physical and Ecological Processes: Part 1**
MODERATOR	Steve Traxler	Joel Trexler	Miguel Fernandes	David Bauman	Bill Orem	Joan Browder
3:30-3:40	Introduction and Overview			**Angie Huebner** Picayune Strand Restoration: Preparing the Exotic and Nuisance Native Vegetation Management Plan	Introduction and Overview	
3:40-4:00	**Glenn Landers** An Update on USACE Sea Level Change Guidance and Preliminary Applications for Everglades Restoration Projects	**Paul Wetzel** Everglades Science in Support of Restoration – Synthesis of Everglades Restoration and Ecosystem Services (SERES)	**Pamela Sullivan** Hydrodynamics of Recently Planted Tree Islands: Implications for Shallow Groundwater Nutrient and Ion Concentrations		**Darren Rumbold** Source Identification of Florida Bay's Methylmercury Problem: Mainland Runoff versus Atmospheric Deposition and In situ Production	**Erik Stabenau** Improving Estuarine Conditions in Biscayne Bay by Optimizing the Timing and Distribution of Freshwater Discharge
4:00-4:20	**Todd Hopkins** The Florida Landscape Conservation Cooperative – a Strategic, Partnership-driven Conservation Program for Florida's Future Generations	**Paul Wetzel** OPEN DISCUSSION ON: Key Science Management Questions related to SERES project	**Jay Sah** Understory Vegetation Composition and Biomass on the Tree Islands in the Loxahatchee Impoundment Landscape Assessment (LILA) Experimental Site	**David Bauman** Creating the Picayune Strand Restoration Project Environmental Monitoring Plan	**Larry Fink** A Trophodynamic Model of Methylmecury Bioaccumulation following a First-Flush Anomaly in a Constructed Wetland in South Florida: Part 1. Model Development Using Structural Sensitivity Analysis	**Sarah Bellmund** Salinity Variation and Groundwater Flows to Biscayne National Park and Southern Biscayne Bay
4:20-4:40	**John Meeder** Accelerated Near Future Sea Level Rise (SLR), a Given, Based upon the Florida Stratigraphic Record, Implications for GEER	**Christopher McVoy** Integrating Everglades Science for Restoration Planning	**Amartya Saha** Water Utilization in Woody Plant Communities in the Everglades Indicates that Hardwood Hammocks are the Most Hydrologically-Sensitive		**Young Cai** Fate of Seasonally Deposited Mercury in the Florida Everglades	**Henry Briceno** What's so Special about Biscayne Bay Waters? An Assessment of their Properties and Trends as a Contribution to Nutrient Criteria Development
4:40-5:00	**James Murray** Using Floral and Faunal Assemblages and Observed Habitat Associations to Monitor Sea Level Rise	**Christa Zweig** The Semiglades and Beyond: Incorporating Novelty Into Restoration	**Xin Wang** Using Stable Isotopes and Remote Sensing to Study Nutrient and Water Relations in the Everglades Tree Islands	**David Bauman** Current Status and Future of the Picayune Strand Restoration Project	**David Krabbenhoft** Influence of Canal Water Releases on Distribution of Mercury, Methylmercury, Sulfate and Dissolved Organic Carbon in Everglades National Park	**William Nuttle** The Influence of Watershed Inputs on Salinity and Water Quality in Biscayne Bay
5:00	EVENING ON OWN					

THURS	THURSDAY, JULY 15, 2010					
7:30-5:30	Conference Registration Open					
7:30-8:30	MORNING REFRESHMENTS					
8:30-10:00	**PLENARY SESSION: Greater Everglades Ecosystem Restoration — "Hot Topics"** ***Climate Change & Sea Level Rise* – Paul Souza,** Field Supervisor, South Florida Ecological Services, US Fish and Wildlife Service, Vero Beach, FL ***Deepwater Horizon/BP Oil Spill…The Latest State of Play* – Erik Stabenau,** National Park Service, Homestead, FL					
10:00-10:30	AM BREAK					
10:30-noon	Concurrent Sessions					
	Royal Palm IV-V	**Royal Palm I-II**	**Royal Palm VI-VII**	**Acacia 1-3**	**Royal Palm III**	**Royal Palm VIII**
	Climate Change, Sea Level & Natural Hazards Part 4: Biological Systems	**Everglades Science in Support of Restoration – What Do Decision Makers Need? Part 2**	**Tree Islands Part 4: Management of a Changing Landscape**	**Lake Okeechobee Restoration: Part 1**	**Water Quality and Gradients Across the Everglades: Part 3**	**Biscayne Bay Physical and Ecological Processes: Part 2**
MODERATOR	Leonard Pearlstine	Tom Van Lent	Sharon Ewe	Jim Vearil	Rob Daoust	Sarah Bellmund
10:30-10:40	Introduction and Overview					
10:40-11:00	**Danielle Ogurcak** Persisting Effects of Hurricane Wilma Storm Surge in Pine Rockland Habitat on Big Pine Key, FL	**Louis Gross** Florida Panther Recovery: Evidence, Models and Implications for Public Policy	**Martha Nungesser** Hydrologic Factors Related to the Presence of *Lygodium microphyllum* (Old World Climbing Fern) in Water Conservation Area 3 of the Everglades, South Florida	**Lewis Hornung** The History of Lake Okeechobee Restoration Efforts and Where We Are Today	**Peter Kalla** Mercury in Mosquitofish of the Greater Everglades: Changes in Biochemistry and Trophic Complexity Over Time and Space - REMAP 1995 - 2005	**Melinda Lohmann** BISECT: A Hydrologic Model of South Florida for Evaluating Ecosystem Restoration and Sea Level Rise
11:00-11:20	**Joseph Smoak** Sediment Accumulation in Everglades National Park Mangrove Forest	**Jon Cline** Application of an Individual-Based Model of Roseate Spoonbills to Ecosystem Restoration	**Miguel Fernandes** The Influence of Tree Island Size and Hydroperiods on Two Common Everglades' Rodents: *Sigmodon hispidus* and *Oryzomys palustris*	**Del Bottcher** Legacy P and its Impact on Restoration Efforts	**Jud Harvey** Sediment and Particulate Phosphorus Transport in a Free Flowing Everglades	**Peter Swart** A Nitrogen Isotopic Study of Greater Biscayne Bay: Implication for Sources of Nutrients
11:20-11:40	**Michael Parenti** Hurricane Effects on Mangrove NDVI and EVI values estimated from SPOT and MODIS Imagery	**Steve Friedman** Modeling Vegetation Succession Dynamics to Evaluate Landscape-level Responses to Everglades Restoration	**Charles Coultas** Bone Phosphorus Dominates Fixed Tree Island Soil in the Everglades WCA3	**Anwar Khan** Lake Okeechobee Sediment Management	**Andrew Bramburger** A Preliminary Examination of the Influence of Canal Inputs on Ambient Surface Water Chemistry at the Tamiami Pilot Swales Sites	**Diego Lirman** Status and Trends of Nearshore SAV Communities of Biscayne Bay: A Multi-Scale Approach
11:40-noon	**Brad Stith** Manatees, Restoration, and Severe Winters: How Haloclines Shelter Manatees From Cold in Southwest Florida	**Craig Conzelmann** EverVIEW: Bringing Ecological Modeling, NetCDF Data Manipulation and Visualization to the Natural Resource Manager's Desktop	**John Volin** Trophic Focusing of Nutrients on Tree Islands in the Florida Everglades	**Clell Ford** Management Issues And Long-Term Phosphorus Trends For Lake Istokpoga And Its Watershed – Are We Moving In The Right Direction For Lake Okeechobee?	**Guangliang Liu** Mass Distribution of Mercury Among Ecosystem Components in the Florida Everglades	**Interactive Discussion**
noon-1:30	LUNCH PROVIDED IN PRE-FUNCTION AREA					

THUR	THURSDAY, JULY 15, 2010 (continued)					
1:30-3:00	Concurrent Sessions					
	Royal Palm IV-V	Royal Palm I-II	Royal Palm VI-VII	Acacia 1-3	Royal Palm III	Royal Palm VIII
	Climate Change, Sea Level & Natural Hazards Part 5: The Built Environment	**Linking Science to Decision-Making as Managers Are Listening: Part 1**	**CO2 Uptake and Carbon Dynamics of Wetland Communities: Part 1**	**Lake Okeechobee Restoration: Part 2**	**Predicting Past and Future Impacts of Sea Level Rise on Coastal Habitats and Species: Integrating Hydrological and Ecological Models**	**Biscayne Bay Physical and Ecological Processes: Part 3**
MODERATOR	Karl Havens	Matt Harwell	Vic Engel	Bob Pace	Catherine Langtimm	Patrick Pitts
1:30-1:40	Introduction and Overview					
1:40-2:00	**Ricardo Alvarez** Synergy under Climate Change: The Coupled Everglades Urban Coastal Florida System	**Gretchen Ehlinger and Bob Doren** Overview of System-wide Science Efforts	**Len Scinto** Decomposition of Flocculent Detrital Organic Matter (Floc) in Everglades Ridge and Slough	**Eric Bush** The Federal Civil Works Program and the Restoration of Lake Okeechobee	**Eric Swain** Predicting Coastal Landscape Changes by Modeling Long-Timescale Impacts of Hydrodynamic Fluctuations on Salinity and Hydroperiods	**Ligia Collado-Vides** The Development of a Macroalgal Indicator of Salinity Patterns in Biscayne Bay
2:00-2:20	**Lisa Beever** Selecting Environmental Indicators of Climate Change	**Stephanie Johnson** NRC Perspective on Science for CERP Decision Making	**Oliva Pisani** Photo-Induced Generation of Dissolved Organic Matter (DOM) from Floc in the Shark River Slough of the Florida Coastal Everglades (FCE)	**Stephen Friant** Chemical Treatment of Phosphorus in Lake Okeechobee Sediments as a Management Option to Reduce Bioavailability	**Dennis Krohn** Inferring Effects of Historic Extreme Storms in the Everglades from Hindcast Models	**Joan Browder** Epifauna Community of South Biscayne Bay in Relation to Salinity
2:20-2:40	**Steve Traxler and Michael Flaxman** Stakeholder Development of Alternative Futures and Attractiveness Models for Resource Agency Planning in South Florida	**John Ogden** Perspectives on the Role and Effectiveness of Science in Decision-making.	**Rudolf Jaffe** Characterizing the Dynamics of Dissolved Organic Matter (DOM) in the Greater Everglades Ecosystem: Assessment of Spatial and Temporal Variability and Reactivity	**James Jawitz** Temporal Dynamics in Phosphorus Export from the Okeechobee Basin: Explanations, Predictions, and Implications	**Donald DeAngelis** Effects of Sea Level Rise (SLR) and Storm Surge Events on Coastal Vegetation Communities	**Joseph Serafy** Mangrove Shoreline Fishes of Biscayne Bay and Adjacent Waters
2:40-3:00	**Climate Change Session Overview & Discussion on Application to Policy**	**Panel Discussion** Structured Q & A	**Xavier Comas** Multi-Scale Characterization of Biogenic Gas Dynamics in Peat Soils Using Hydrogeophysical Methods: Implications for Biogenic Gas Distribution and Carbon Fluxes	**Erik Powers** Revisiting Ecological Integrity on the Kissimmee River: Are We There Yet?	**Thomas Smith** Vectors of Change in the Coastal Everglades: Sea Level Rise, Storms, Freezes and Fire	**Luke Gommermann** Seagrasses and Subaqueous Soils of Lake Surprise, Florida
3:00-3:30	PM BREAK					

THUR	THURSDAY, JULY 15, 2010 (continued)					
3:30-5:00	Concurrent Sessions					
	Royal Palm IV-V	Royal Palm I-II	Royal Palm VI-VII	Acacia 1-3	Royal Palm III	Royal Palm VIII
	Integrating the Impact of Climate Change into Policy, Planning and Implementation of Everglades Restoration	**Linking Science to Decision-Making as Managers are Listening: Part 2**	**CO2 Uptake and Carbon Dynamics of Everglades Wetland Communities: Part 2**	**Hydrologic Scaling**	**Predicting Past and Future Impacts of Sea Level Rise on Coastal Habitats and Species - Integrating Hydrological and Ecological Models**	**Application of Adaptive Management for Everglades Restoration**
MODERATOR	G. Ronnie Best	Matt Harwell	Vic Engel	Jed Redwine	Eric Swain	Dave Tipple
3:30-3:40	Introduction and Overview					
3:40-4:00	**Moderated Panel Discussion**: The focus will be on addressing Everglades' restoration targets, research needs, modeling needs, and resource-related policy and management issues that need further consideration in the context of climate change. Len Berry Michael Flaxman Karl Havens Glenn Landers Leonard Pearlstine	**Greg May** Using System-wide Science for Restoration Planning	**Danielle Watts** Hydrologic Controls on Ecosystem Carbon Exchange in Ridge-Slough Landscape	**Rene Price** Groundwater/Surface Water Interactions in Taylor Slough - Everglades National Park	**Kiren Bahm** Everglades National Park and Sea-Level Rise: Using the TIME Model to Predict Salinity and Hydroperiods	**Andy LoSchiavo** CERP Adaptive Management Integration
4:00-4:20		**Paul Souza** Using Science to Manage Water in WCA-3A to Benefit the Everglade Snail Kite	**Jay Munyon** Contrasting Ecosystem Productivity Between and Long- and Short-hydroperiod Marsh in the Florida Everglades	**Zhixiao Xie** Revision and Assessment of Water-Surface Modeling of the Everglades Depth Estimation Network (EDEN)	**Tim Green** Using a Spatially Explicit Crocodile Population Model to Predict Potential Impacts of Sea Level Rise and Everglades Restoration Alternatives	**Laura Mahoney** Adaptive Management Application at the Project Level
4:20-4:40		**Barry Heimlich** Counteracting the Effects of Sea Level Rise on Southeast Florida's Water Resources	**Edward Castaneda** Above and Below Ground Biomass and Net Primary Productivity Landscape Patterns of Mangrove Forests in the Florida Coastal Everglades	**Quan Dong** Linear Man-made Structures, Hydroscape Domestication, and Ecological Consequences	**Jeremy Decker** Hydrodynamic Modeling to Assess Factors Affecting Thermal Properties of a Passive Thermal Refuge in Southwest Florida	**Steve Traxler** Linking Learning with Future Decision Making
4:40-5:00		**Panel Discussion** Structured Q & A	**Tiffany Troxler** Mangrove Forest Soil Respiration: Short- and Long-term Responses to Hurricane Disturbance	**Jing-Yea Yang** Three Dimensional Computational Fluid Dynamics (CFD) Flow Modeling for Culvert in South Florida	**Michael Ross** Contemplating the Fate of Fresh-water Dependent Florida Keys Ecosystems: What to Do about Species Threatened with Extinction due to Sea Level Rise	**Agnes McLean** Resolution of Competing Objectives
5:00-7:00	POSTER SESSION II AND NETWORKING RECEPTION					

FRI	FRIDAY, JULY 16, 2010					
7:30-noon	Conference Registration Open					
7:30-8:30	**MORNING REFRESHMENTS**					
8:30-10:00	**Concurrent Sessions**					
	Royal Palm IV-V	**Royal Palm I-II**	**Royal Palm VI-VII**	**Acacia 1-3**	**Royal Palm III**	**Royal Palm VIII**
	Unifying Concepts, Principles and Practices in Restoration Planning	**Sampling Tools and Technologies to Support Restoration Science**	**CO2 Uptake and Carbon Dynamics of Everglades Wetland Communities: Part 3**	**Remote Sensing of Everglades Ecohydrology**	**Human Dimension Aspects of Ecosystem Restoration**	**Ecosystem Services and Ecosystem Indicators**
MODERATOR	**Larry Fink**	**Jennifer Stiner**	**Vic Engel**	**Shimon Wdowinski**	**G. Ronnie Best**	**Eric Powers**
8:30-8:40	**Introduction and Overview**					
8:40-9:00	**Francine Matson** Unifying Concepts for Environmental Restoration Planning: Quality Assurance & Quality Control	**Kevin Cunningham** Integration of Ichnology, Cyclostratigraphy, Hydraulic Well Testing, and Lattice Boltzmann Methods for Carbon Aquifer	**Jose Fuentes** Controls on Mangrove Carbon Cycling in Western Florida Everglades	**Shimon Wdowinski** Space-based High-Resolution, Multi-temporal Monitoring of Wetland Water Levels: Case Study of WCA1 in the Northern Everglades	**Jim Barnes** Compliance with the Everglades Forever Act: A Local Government Perspective	**Alicia Dixon** Anuran Use of Natural Wetlands, Created Pools, and Existing Canals Within Picayune Strand Restoration Project
9:00-9:20	**William Nuttle** Integrating Human Dimensions into Ecosystem Management of the Florida Keys and Dry Tortugas: Preliminary Findings from the MARES Project	**Daniel Slone** Manatee Telemetry Data Leads to Discovery and Delineation of Seagrass Beds in the Ten Thousand Islands	**Jessica Schedlbauer** Ecosystem CO2 Exchange in Short- and Long-Hydroperiod Everglades Marshes	**Daniel Gann** Evaluating Remote Sensing Methods to Differentiate Plant Communities in Florida's Everglades	**Paul Stevenson** CERP Master Recreation Plan - A Living Document Overview	**Peggy VanArman** Effects of Hydrology on Growth and Survival of Juvenile *Procambarus alleni* and *Procambarus fallax*
9:20-9:40	**Dianna Hogan** Regional Ecological Effects of Local Scale Land Use Change	**Kristen Hart** Use of South Florida's Protected Areas by Threatened and Endangered Marine Turtles	**Barclay Shoemaker** Carbon Cycling in a Big Cypress National Preserve Marsh	**Jordan Barr** Mangrove Ecosystem Carbon Budgets Using Eddy Covariance and Satellite-based Products	**Jon Ahlschwede** Public Recreation Facilities and Ecosystem Restoration; Living in Harmony	**Nathan Dorn** Wetland Drying Has Substrate and Species-Dependent Effects on Crayfish *(Procambarus spp.)* Populations
9:40-10:00	**Larry Fink** Bioenergetics as a Unifying Concept for Environmental Restoration Planning	**Paul Conrads** Development of Inferential Sensors for Real-time Quality Control of Water-level Data for the EDEN Network	**Session Overview, Discussion & Wrap-up**	**John Jones** Augmenting Everglades Fire History Data through Satellite Remote Sensing	**Stan Bronson** Linking the Everglades and the Netherlands - DOI Florida-Holland Team Report	**Brent Bellinger** Microbial Community Responses to Active Management of a Eutrophic Area of the Everglades Determined through Lipid Biomarkers
10:00-10:30	**AM BREAK AND SESSION II POSTER REMOVAL** (Posters must be removed from display boards no later than noon as the boards will be removed by the exhibit services company.)					
10:30-noon	**CLOSING PLENARY SESSION**					
noon	**CONFERENCE CONCLUDES**					

Poster Directory

GEER Poster Directory – Session One

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39 ***Christian Avila,*** Relations of Seagrass and Physical Trends in Southern Biscayne Bay
13 ***Charles Bargeron,*** Bugwood: Resources to Support Invasive Species and Ecosystem Health Education
40 ***Amanda Booth,*** Discharge and Water Quality Trends, Southwest Coast of Everglades National Park
36 ***Adam Brame,*** Episodic Use of Tarpon Bay, Shark River, in ENP as Nursery Habitat for Common Snook
72 ***Laura Brandt,*** Hurricane Impacts and Colonization of *Lygodium microphyllum* on Tree Islands of the A.R.M. Loxahatchee National Wildlife Refuge
47 ***Becky Burns,*** RECOVER and the Role of Science in Everglades Restoration
14 ***Leonardo Calle,*** Anthropogenic Resource Utilization in the Diet of the Sacred Ibis
74 ***Elizabeth Lisle Carwell,*** Projects and the Role of Science in Everglades Restoration — A Closer Look at C-111
71 ***Chunfang Chen,*** Setup, Formulation and Validation of a Spatially Explicit Hydrodynamic and Surface Water Chloride Concentration Model
38 ***Paul Conrads,*** Conceptual Components for the Coastal Everglades Depth Estimation Network
58 ***Paul Conrads,*** Hindcasting Water-Surface Elevations for Water Conservation Area 3A South
15 ***Zhanao Deng,*** Developing Genetic and Molecular Tools for Assessing and Controlling the Invasive Potential of *Lantana camara*
48 ***M. Brett Gallagher,*** Effects of Seasonal Hydrology and the 2010 Cold Snap on the Distribution & Abundance of Snook
8 ***Brandon Gamble,*** Changing how Projects are Managed while Maintaining Traditional Protocols
16 ***David Gandy,*** How do Canals Function as Habitat for Native & Nonnative Fishes in the Everglades Ecosystem?
76 ***Gregory Garis,*** Biscayne Bay Salinity Monitoring Program
49 ***Peter Gottfried,*** SAV Monitoring in the Southern Indian River Lagoon, St. Lucie Estuary, Lake Worth Lagoon, and Caloosahatchee River and Estuary
17 ***Denise Gregoire,*** Salinity Tolerance of Wild-caught Hatchling Burmese Pythons
57 ***Thomas Harmon,*** Potential Anthropogenic Changes in Dove Lake
18 ***Elizabeth Harrison,*** Evaluating the Impacts of *Cichlasoma urophthalmus* in the Southern Everglades
19 ***Kristen Hart,*** A Field Trial of Trap Effectiveness for Invasive Burmese Pythons
20 ***Savannah Howington,*** Hybridization of Typha Species Contributes to Cattail Invasion and Landscape Vegetation Change in Wetlands
64 ***Freddie James,*** Analysis and Simulation of the C-111 Detention Area System
50 ***Brian Jeffery,*** Alligators as an Indicator of Ecological Change in Greater Everglades Ecosystems
41 ***Darlene Johnson,*** Canal-Related Influences on Biscayne Bay Seagrass and Mangrove Fishes and Invertebrates
70 ***Marcie Kapsch,*** Vegetation Site Characterization at A.R.M. Loxahatchee National Wildlife Refuge
21 ***Jeffrey Kline,*** Island Apple Snails in Everglades National Park: 5 Years Later
43 ***Gregory Koch,*** Seasonally Changing Surface Water Discharge Drives Ecosystem Metabolism Rates in Estuarine Taylor River
9 ***Jon Lane,*** USACE Invasive Species Policy
35 ***Laurel Larsen,*** Using Fluorescence Spectroscopy to Trace Seasonal DOM Dynamics, Disturbance Effects, and Hydrologic Transport
6 ***Melinda Lohmann,*** Potential Impacts of Localized Hydrologic Features on Sea-Level Rise Induced Saltwater Intrusion in South Florida
22 ***Diana Lopez,*** Trait Variation across the Range of an Invasive Species: African Jewelfish
11 ***Andrew LoSchiavo,*** Biscayne Bay Coastal Wetlands Project Adaptive Management Plan
44 ***Morgan Maglio,*** Modeling Surface-Subsurface Exchange of Water and Reactivity of Solutes in the Ridge and Slough Landscape
51 ***Frank Mazzotti,*** Crocodiles as an Indicator of Ecological Change in Everglades Ecosystems
7 ***Katie McCallion,*** The Southwest Florida Feasibility Study
52 ***Ryan Moore,*** High-Density Aquatic Vegetation Baseline Surveys of Lake Istokpoga and the Kissimmee Chain of Lakes
23 ***James B. Murray,*** Decline in Populations of the Non-Native Red Rimmed Melania in Biscayne Bay National Park, FL
46 ***Erin Myers,*** The Florida Invasive Species Partnership
1 ***Paul R. Nelson,*** The Disappearing Islands of Whitewater Bay
33 ***C. Mindy Nelson,*** Fish Health of the St. Lucie River Estuarine System in Relation to Canal Discharges and Water Quality
45 ***Tae-Goo Oh,*** Spatial Occurrence of Ridge Senescence in Water Conservation Area 3A, 3B, and Everglades National Park
69 ***Todd Z. Osborne,*** Vegetation Community Responses to Prescribed Fire Regimes in the A. R. M. Loxahatchee National Wildlife Refuge
24 ***Dianne Owen,*** The Effect of Hydrology, Fire Regime and Exotic Invasion on the Postburn Successional Trajectory of Plant Communities in Big Cypress
53 ***J.P. Perea-Rodriguez,*** Prevalence of a Parasitic Isopod, Probopyrus spp, on Palaeomonid Shrimp along a Marsh-Estuarine Gradient in the S. Everglades
63 ***Amy Renshaw,*** Effect of Water Management Changes to the Stage-Discharge Relationship in Upper Taylor Slough
56 ***Gregg Reynolds,*** Comparison of Everglades Slough Vegetation Hydrologic Suitability from Scientific Literature, and Experimentally Determined Plant Species Responses
42 ***Mike Robblee,*** Temporal and Spatial Patterns of Juvenile Pink Shrimp in South Florida Estuaries
25 ***Michael Rochford,*** Movements, Habitat-Use, Thermal Biology, and Diet of Burmese Pythons in the Everglades
26 ***Christina Romagosa,*** The Northern African Python in South Florida
27 ***Kory M. Ross,*** Factors Affecting Exotic Fish Distribution at Babcock Ranch
68 ***William Roth,*** A Compartmental Screening Model for Stage and Water Quality in a Large Everglades Wetland
77 ***Amartya Saha,*** Development of a Hydrological Budget for Shark River Slough
28 ***Pamela Schofield,*** Why Ecophysiology Matters
2 ***Mark Shafer,*** Assessing Sea Level Rise Impacts to CERP Coastal Projects
62 ***Dilip Shinde,*** Simulation of Water Flow and Phosphorous Transport in a Highly Interactive Surface Water Groundwater System in the Series of S-332
75 ***Sahas Shrestha,*** Modeling Hydrologic Flow across a Marsh-Mangrove Ecotone in Ten Thousand Islands
55 ***Lars Soderqvist,*** Seasonal and Spatial Distribution of Freshwater Flow and Salinity in the Ten Thousand Islands Estuary
60 ***Roy Sonenshein,*** A Hydrologic Model to Evaluate Seepage beneath Levee 31N from Northeast Shark River Slough
29 ***Pushpa Soti,*** Role of Mycorrhizal Fungi in Supporting Invasiveness of Old World Climbing Fern in South Florida Natural Areas
3 ***Erik Stabenau,*** Status and Trends in Marine and Estuarine Conditions, Florida Bay
54 ***Jennifer Stiner,*** Science Communication: Evolution of the CERP System
34 ***Suresh Subedi,*** Determination of Nutrient Limitation on Trees Growing in LILA Tree Islands
37 ***Zoltan Szantoi,*** Classification of Marl Prairie and Marsh Vegetation Communities in the Everglades National Park
73 ***Craig Thompson,*** Quantifying Freshwater Inflows to the Caloosahatchee River Estuary
4 ***Ginger Tiling-Range,*** Mapping the Changing Coastline of Southwest Florida
67 ***Louise Venne,*** Response of Wading Birds to Fire in the Central Everglades
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66 ***Michael Waldon,*** Designing and Testing Modeled Hydrological Performance Measures
30 ***Susan Walls,*** Presence of Invasive Cuban Treefrog Reduces Probability of Occurrence of Native Treefrog
31 ***Theresa Walters,*** Nested Conceptual Models for Understanding Ecological Impacts of Burmese Pythons
32 ***Kevin R.T. Whelan,*** Corridors of Invasiveness Plant Monitoring
5 ***Kathy Worley,*** Mangrove Restoration in Selected Areas of Pine Island Sound after Hurricane Charlie
65 ***Zhixiao Xie,*** Revisions to the EDEN Ground-Surface Digital Elevation Model and Water Surface Model in the Water Conservation Area 1

Session One Posters are on display beginning at 8:30am on Monday, July 12. A formal Poster Networking Session is scheduled Tuesday, July 13 from 5:00pm-7:00pm. Presenters will stand at their posters from 6:00pm-7:00pm. Poster Session One should be removed upon conclusion of the evening session.

NOTE: Poster abstract titles in this listing are abbreviated. Consult the poster directory in the program book for full reference.

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41 ***Tim Bargar,*** A Water Quality Criteria-Based Evaluation of Copper Impacts to South Floridaís Freshwater Environment

42 ***Tim Bargar,*** A Risk Assessment of Methylmercury to Fish in South Florida

48 ***Jim Barnes,*** Low Impact Development Strategies: Tools and Techniques for Sustainability

53 ***Ian Bartoszek,*** American Alligator and Selective Faunal Surveys for the Picayune Strand Restoration Project

6 ***Laura Belicka,*** Biochemical Markers of the Effects of Canal-Induced Nutrient Gradients on Food-Webs in a Taylor Slough

54 ***Marcia Berry,*** Hydrologic Information of the Western Tamiami Trail and the Ten Thousand Islands

22 ***Amanda Booth,*** Water Quality Monitoring at McIntyre Creek, J. N. "Ding" Darling National Wildlife Refuge

49 ***Richard Botta,*** Effects of Lake Stage and Marsh Elevation on Wading Bird Nesting Effort at Lake Okeechobee

68 ***Ross Boucek,*** Resource Partitioning Among Five Mesopredators in the Upper Shark River Estuary

7 ***Laura Brandt,*** Planning for Climate Change in South Florida: Climate Envelope Modeling for Threatened and Endangered Species

40 ***Edwin Brown,*** Forecasting Effects of Nutrient Loading and Availability of an Ecosystem Restoration in the Caloosahatchee and St. Lucie Estuaries

50 ***Edwin Brown,*** The Effects of CERP, upon Submerged Aquatic Communities in Lake Okeechobee

18 ***Becky Burns,*** CERP Adaptive Management Program Implementation

69 ***Brittany Burtner,*** Do Wading Birds Nest Near Alligators by Choice?

32 ***David W. Ceilley,*** An Update of the Biological Monitoring Plan for the Lake Trafford Restoration Project, Collier Co. FL

73 ***Gail Chmura,*** Bone-rich Anthropogenic Sediments on Everglades Tree Islands

36 ***Philip Darby,*** Modeling Apple Snail Population Response to Hydrologic Change in the Everglades

74 ***Vic Engel,*** Tree Island-Grass Coexistence in the Everglades Freshwater System

12 ***Kris Esterson,*** Making Sea Level Rise Projections Actionable For Engineering

39 ***Larry Fink,*** A Time-Dependent, Multi-Trophic Level Model of First-Flush Methylmecury Bioaccumulation. Part 2.

35 ***Ann Foster,*** Fire History in Everglades National Park and Big Cypress National Preserve

38 ***Piero Gardinali,*** Using Large Datasets to Develop Background Concentration Ranges of Trace Elements in Soils

64 ***Roxanne Gause,*** Modeling Nutrient and Biological Sources within Hendry and Mullock Creek Basins

75 ***Matthew Hanson,*** Foraging Ecology of Nesting Bald Eagles (Haliaeetus leucocephalus) in Florida Bay, Everglades National Park

61 ***Kristen Hart,*** Inter-Nesting Habitat for Dry Tortugas Loggerhead Sea Turtles

61 ***Kristen Hart,*** Mercury Bioaccumulation in Everglades Pythons

76 ***Judson Harvey,*** Sediment and Particulate Phosphorus Transport in a Free Flowing Everglades

47 ***J. Matthew Hoch,*** Monitoring Fish Communities and Populations on the Eastern Boundary of Everglades National Park

43 ***Rebecca Howard,*** Effects of the Picayune Strand Restoration Project on Vegetation Assemblages of the Mangrove/Marsh Transition

17 ***Angie Huebner,*** Lessons Learned: Invasive Plant Management at 8.5 Square Mile Area

65 ***David Krabbenhoft,*** Bacterial Mercury Methylation: The Role of Dissolved Organic Carbon

10 ***Jon Lane,*** The Everglades Cooperative Invasive Species Management Area

5 ***Sylvia Lee,*** Trajectory Analysis of Everglades Diatom Community Response to Natural and Anthropogenic Influences

66 ***Yanbin Li,*** Degradation of Methylmercury and Its Effects on Mercury Distribution and Cycling in the Florida Everglades

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Session Two Posters are on display beginning at 7:30am on Wednesday, July 14 through 10:30am on Friday, July 16. A formal Poster Networking Session is scheduled Thursday, July 15 from 5:00pm-7:00pm. Presenters will stand at their posters from 6:00pm-7:00pm. Poster Session Two posters should be removed upon conclusion of the 10am break on Friday.

NOTE: Poster abstract titles in this listing are abbreviated. Consult the poster directory in the program book for full reference.

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Listed alphabetically by presenting author.
Presenting author names appear in **bold**.

America's Great Waters Coalition

John Adornato III
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On December 8, 2009, the America's Great Waters Coalition launch took place at the US Capitol Visitors Center. The Coalition works to secure needed long-term federal funding commitments as well as a comprehensive policy for the restoration of many of America's large aquatic ecosystems. Effective federal restoration policies should take into account the true value and importance of our Great Waters, the threats that impact them, the current inadequate system of managing them, and the need for national solutions. We must invest in restoring the health of our nation's water resources and redesign the system of managing them to achieve long-term economic recovery and security. To manifest this vision, the coalition will focus on the following goals and objectives:

Make the restoration of our great waters a national priority - As a nation, we have failed to assign the proper value to our Great Waters—they provide a wealth of biodiversity, opportunities for recreation, and fresh water. For many Americans, our Great Waters define a way of life. In places like the Great Lakes, Coastal Louisiana, Chesapeake Bay, and Puget Sound, aquatic resources are regional economic drivers. Our elected officials must prioritize these waters not only because of their economic, social, and environmental importance, but because they are national treasures that must be preserved for the generations to come.

Secure sustainable dedicated funding for restoration – Federal funding for restoration continues to fall far short of the identified needs. Comprehensive restoration plans are in place for the vast majority of our large scale aquatic ecosystems, with costs estimated into the multi-billions. The EPA estimates that just upgrading the nation's waste and storm water systems, which is a critical component to many restoration plans, will require nearly $400 billion. At least another $100 billion is needed for ecosystem restoration of America's Great Waters. This estimate does not include most of the large river systems in the country that are also in dire need of restoration dollars. We must work to secure sustainable and dedicated funding for restoration nationwide.

Ensure sound implementation of restoration – Although the majority of ecosystems do have comprehensive restoration plans in place, it is critical that the restoration community remain involved in the process both at the federal and state level to ensure that funding is being spent in a transparent and efficient way and that restoration is achieving the largest ecosystem benefits possible for each dollar spent.

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Public Recreation Facilities and Ecosystem Restoration; Living in Harmony

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Stanley Consultants provided recreational enhancements to **Stormwater Treatment Areas (STA's)** within the South Florida Water Management District (SFWMD). Improvements to these facilities, **STA-1W and STA-3/4**, included significant vehicular and pedestrian access designs to the recreation facilities as well as designs for the recreation features.

The STA-1W project involved recreational enhancements to an existing 6,562-acre constructed wetland. Stanley Consultants was responsible for the civil, drainage and structural designs of the following project elements: earthwork, subsoil excavation, paved and unpaved parking areas, concrete sidewalks, canoe launch, information kiosks (with a shelter), composting toilet, an elevated timber boardwalk with covered observation areas, landscape improvements and turn lane improvements to CR 880. Stanley Consultants designed for the 153-foot span pedestrian bridge and abutments that provide foot, bike and equestrian access into the STA. *This bridge was designed for nature and ecosystem enthusiasts,* as this bridge offers a bird's eye view of the different vegetation types in the treatment marsh.

Public recreational facilities at the second site, STA 3/4, were implemented at the time the STA was being constructed in 2008. STA 3/4 was dedicated to a former SFWMD employee and is known as the **Harold A. Campbell Public Use Facility**, and is *the first public access site built in a constructed wetland*. The 16,554-acre site is located in western Palm Beach County. Stanley Consultants was responsible for all design activities including: a two-bay concrete boat ramp with handicap accessible docks that provide access to over 23 miles of perimeter canals that are exterior to the treatment area; covered information kiosks; paved parking areas; concrete sidewalks; composting toilet; landscape improvements and access road improvements. Stanley Consultants designed for the 170-foot span pedestrian bridge and abutments that provide foot, bike and equestrian access into the STA. *This bridge also offers a bird's eye view of the different vegetation types in the treatment marsh.* For both public use facility projects, Stanley Consultants provided design, post-design and construction inspection activities.

As part of this contract Stanley Consultants developed Design Guidelines and Details for SFWMD that became the standards for District Stormwater Treatment Areas to be used by all designers. Also, in coordination with Scheda Ecological Associates, Inc. our team created the native plant palette and landscape designs that became the standards for District STA's.

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Dissolved Organic Matter in the Florida Everglades: Implications for Ecosystem Restoration

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Dissolved organic matter (DOM) in the Florida Everglades controls a number of environmental processes important for ecosystem function including the light penetration, mineral dissolution/precipitation, transport of hydrophobic compounds (such as pesticides), and the transport and reactivity of metals. For instance, interactions of mercury (Hg) with DOM in the Everglades have been shown to play important roles in controlling the chemical speciation and geochemistry of Hg in surface waters, wetland soils, and porewaters; the partitioning of Hg and methylmercury (MeHg) between dissolved and particulate phases and biota in the water column; the bioavailability of Hg and MeHg, and the photoreactivity of Hg and MeHg. Efforts to return the Everglades to more natural flow conditions will result in changes to the current production and transport of organic matter in the system. Constituents that may be also transported to more pristine areas in association with DOM are those metals (e.g. Hg and Cu) and organic molecules (e.g. herbicides and pesticides) that interact strongly with DOM. In addition, imported DOM can influence the ecology of receiving waters by serving as a substrate and source of nutrients for the microbial community, by the absorption of light, and by controlling the bioavailability of other chemical constituents.

Assessment of DOM composition and transport is important for both short- and long-term evaluation of the effects of ecosystem management approaches and can provide a basis for understanding the accompanying concomitant changes in biogeochemical processes resulting from these actions. Three general areas are important to focus future efforts in the study of Everglades DOM with respect to restoration. First, given DOM reactivity, influence on ecosystem dynamics and significance to the success of water management (e.g. aquifer storage and recovery), further research is warranted to more clearly understand effects of DOM on overall water quality and ecosystem health. Second, to effectively utilize DOM to monitor the outcomes of water management decisions, it is important to establish current trends in seasonal variability in DOM concentration and composition at appropriate monitoring sites throughout the Everglades. Finally, consideration of management options could be important to mitigate negative impacts of DOM in downstream receiving waters. This is particularly important with regard to constructed wetlands and the return of lands formerly devoted to agriculture to water storage and nutrient removal purposes. To assist with the measurement and interpretation of DOM data, the link between the nature and reactivity of DOM and its optical properties can be exploited to provide powerful monitoring tools to assess the impacts of management practices on overall water quality, on DOM transport and transformation and on the transport of other chemical constituents of interest.

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Synergy under Climate Change: The Coupled Everglades-Urban Coastal Florida System

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The role of the Everglades as a critical component of the Kissimmee – Okeechobee – Everglades – Florida Bay ecosystem has been well documented and it is well understood. The Greater Everglades Ecosystem Restoration (GEER) program, involving several projects, reflects the not only the importance of this critical natural resource, but also the commitment of the public and private sectors to preserving the ecosystem.

Based on media coverage and public outreach events it would appear the main focus of the GEER is the restoration and preservation of interlinked natural systems and habitats involving flora and fauna, and both fresh water and marine habitats. Often overlooked are the services the Everglades provide for the urban environment in coastal regions of South Florida, including assisting in the replenishing of aquifers that are a critical component in the renewable water system supplying human needs in the region.

Relative to the linkage between the Everglades and the urban environment it is important that we recognize there is an interactive and dynamic character to it, which in essence results in a coupled Everglades-Urban Coastal Florida system. This is a system where there is actual synergy between its components. What this means is that the urban environment is affected by what happens in the Everglades and vice versa. Such synergy is and will continue to be affected as the region responds to climate change and the impacts of hazards that may be exacerbated by climate change.

A good example of such coupled Everglades-Coastal Urban system is the sub-region of South Florida comprising the tri-county Palm Beach – Broward – Miami-Dade large urbanized area along the southeastern coast. Examples of the synergy between the natural and urban components of this system are evident in the complex and large network of water control structures and facilities managed by the South Florida Water Management District. Another, little known, example is the flood control project developed by Miami-Dade county involving the C-4 canal, and a new Emergency Detention Basin and other structures and facilities, which is used to divert the flow of water toward the Everglades for temporary storage to reduce the potential for flooding during hurricanes or extreme rain events. In this example the urban environment is sending fresh water to the Everglades.

In view of this synergy, it is important to monitor and project future effects on the coupled-system as sea level rise drives salt water infiltration and exacerbates storm surge and coastal flooding during hurricanes. Or when climate change driven drought increases the need for fresh water storage. This synergy merits more attention and continued study.

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A Paired Surface-Water/Groundwater Monitoring Network in the Western Coastal Mangrove Everglades Provides Water Level and Salinity Data for Analysis and Model Validation

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The U.S. Geological Survey (USGS) Land-Margin Ecosystem Study monitors a network of paired surface-water/groundwater gage stations within the western coastal mangrove region of Everglades National Park (ENP). Two 20km-long marsh-estuary transects along the Shark and Lostmans Rivers each contain three primary surface-water/groundwater gage stations: upstream freshwater marsh sites (SH1, LO1); transitional marsh-mangrove sites (SH2, LO2) and downstream mangrove sites (SH3, LO3). These marsh and mangrove forested sites (i.e. not in the rivers or bays) provide paired adjacent surface-water/groundwater water level and salinity data, which combined with existing river stations (NPS and USGS) can assist in the calibration of a coupled surface-water/groundwater model.

The Tides and Inflows in the Mangroves of the Everglades (TIME) is the USGS coupled hydrodynamic surface-water/groundwater transport model. It was developed to simulate the complex hydrodynamics connecting the upstream Everglades freshwater marsh with coastal mangrove estuaries. ENP hydrologists are engaged in a collaborative project with the USGS modelers to use the TIME model for simulating the effects on the environment due to predictions of sea-level rise.

We analyzed ten years of daily, paired surface-water (SW)/groundwater (GW) level and salinity data (2000-2010) collected from the upstream, ecotone and downstream sites from two replicate transects. Median and standard deviation of daily water level (L) and salinity (S) were used to evaluate water differences at each site and between sites along each transect. The greatest salinity variability from both transects was observed at the ecotone sites. On Shark River transect, site SH2 had the greatest variability for salinity as expressed by conductivity (GWS SD=6.26 mS cm^{-2}; SWS SD=10.21 mS cm^{-2}) and a similar pattern was observed at ecotone site LO2 which had the greatest salinity variability (GWS SD=6.86 mS cm^{-2}; SWS SD=12.3 mS cm^{-2}) of the Lostmans sites.

The data on the salinity and the surface -water and groundwater levels can be used to calibrate and verify TIME model results, including the movement of the freshwater-saltwater interface in the coastal Everglades. Comparisons of the field data and model data can improve the TIME model predictive capability to evaluate various restoration and sea-level rise scenarios.

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South Florida Ecosystem Restoration Integrated Delivery Schedule

Stu Appelbaum[1] and *Brian K. Files*[2]
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The goal of the South Florida ecosystem restoration program Integrated Delivery Schedule (IDS) is to identify the optimum sequencing of key hydrologic projects to deliver meaningful restoration benefits to the ecosystem as soon as possible, consistent with law and forecasted funding. The IDS incorporates both Federal and State initiatives. It includes the Comprehensive Everglades Restoration Plan (CERP) and non-CERP projects. The non-CERP projects include Kissimmee River Restoration, Modified Water Deliveries to Everglades National Park, Herbert Hoover Dike Rehabilitation, and ongoing components of the Central & Southern Florida project, as well as the South Florida Water Management District (SFWMD) Northern Everglades Plan and Long-Term Plan for Achieving Water Quality Goals in the Everglades Protection Area projects. Additional projects will be added as necessary. The IDS also includes system operating manual revisions at key points.

The IDS development team consisted of members from the U.S. Army Corps of Engineers, SFWMD, the U.S. Fish and Wildlife Service, Everglades National Park, and the Florida Department of Environmental Protection. The initial IDS is the result of nearly two years of comprehensive interagency and public collaboration. The effort included public workshops and close coordination with the NAS Committee on Independent Scientific Review of Everglades Restoration Progress, the South Florida Ecosystem Restoration Task Force and Working Group, the CERP Quality Review Board, the CERP Design Coordination Team, the SFWMD Governing Board, the SFWMD Water Resources Advisory Commission, and the CERP REstoration COordination & VERification team. Several approaches were used in developing the IDS, including incremental adaptive restoration, priorities based strictly on project authorization and funding, and finally a hybrid of the two. The team developed an interactive tool to depict project sequencing alternatives that considered the status of project planning and design, real estate availability, construction authority, and program funding.

The IDS was developed in response to recommendations provided in the 2007 General Accountability Office report and the 2006 National Academy of Science (NAS) Report to Congress. The IDS allows the Federal and State implementing agencies to provide guidance to decision-makers for scheduling, staffing, and budgeting South Florida ecosystem restoration program efforts. The initial IDS was endorsed by the South Florida Ecosystem Restoration Task Force in September 2008. The IDS is a living document and will be updated as necessary to reflect any major changes in program authorities, funding, or any other significant events.

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Restoration Implications of Recent Ecological Changes in Taylor Slough, Everglades National Park

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Recent vegetation surveys reveal cattail (*Typha domingensis*) expansion in the upper Taylor Slough watershed of Everglades National Park. In addition, sediment surveys suggest total phosphorus enrichment of sediments in that area, although methodological differences confound the analysis of spatial and temporal patterns and trends. Cattail expansion in the Everglades typically is associated with nutrient enrichment, and usually represents the latter stages in ecological changes that come with wetland eutrophication. Other physical and chemical factors may play important roles, and analyses are underway to better understand the causes of this cattail expansion. These analyses are hampered by disparate data collected under widely varying study designs and purposes, short-term data sets, and lack of ecological studies. Currently, surface water flow into upper Taylor Slough is not monitored directly, adding to uncertainty. Despite these problems, initial analyses suggest that the cattail expansion is a result of increased surface water discharges caused by significant changes in basin water management over the last 30 years. Other papers in this session present results of these analyses in more detail. One troubling aspect of this cattail expansion is that upstream surface water quality monitoring over the last few decades did not provide any early warning. For example, water quality monitoring conducted upstream for litigation purposes yielded results that were below water quality targets established for Taylor Slough. We now know that early warning of eutrophication may lie in other, more subtle indicators, such as nutrient content of periphyton and other plants – not in surface water quality changes. The cattail expansion in upper Taylor Slough is troubling when considering other restoration efforts underway or planned for the future that may result in similar water management changes. This unexpected cattail expansion points to the need for careful physical, chemical, and biological research and monitoring before, during, and after implementation of restoration projects in Everglades wetlands so sensitive to nutrients. Restoration of Everglades hydrology may result in unintended impacts if those projects precede restoration of Everglades water quality.

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USDA/Wildlife Services: Tools and Strategies for Burmese Python Control

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The invasive Burmese python *Python molurus bivittatus* has been entrenched in southernmost Florida for a number of years, and the species has received a high media profile recently. Today, the USDA's Wildlife Services (WS) program, the Federal agency with responsibility for resolving conflicts with wildlife, is involved in developing tools and strategies for controlling Burmese pythons in Florida. Based on successful methods development research targeting brown treesnakes *Boiga irregularis* on Guam, we tested acetaminophen and found it to be toxic to Burmese pythons. Also similar to brown treesnakes, commercially available natural bait matrices, such as dead neonatal mice and quail chicks, were well-accepted by the pythons. Other studies have been conducted to identify, design, and test materials for drift fences and to develop traps to be applied in conjunction with drift fences. We have also conducted pilot studies to evaluate python behavior relative to chemical cues, and we have assessed the economic costs associated with the python's predatory impacts on native species. Since our captive pythons are maintained in large outdoor pens, the very cold weather experienced during January 2010 provided opportunity to document python behavior, health, and survival relative to unusually low temperatures. From this experience, we conclude that free-ranging pythons will have difficulty establishing viable populations in north-central Florida, and we suggest that climate extremes are more relevant than averages for assessing potential ranges of invasive reptiles.

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Relations of Seagrass and Physical Trends in Southern Biscayne Bay - Northeastern Florida Bay and Evaluations of the Role of Density in *Thalassia testudinum* Responses to Stressors

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The Miami-Dade County DERM submerged aquatic vegetation monitoring program has established data records within the basins of southern most Biscayne Bay and northeastern Florida Bay dating back to 1993. Relative to this program, a number of specific climatologic events and physical trends have shaped the seagrass community within the northeastern embayments. In the fall of 1995, a large influx of freshwater reduced salinity in the study area to less than 5psu and moderated salinity across nearly all of Florida Bay for well into the following year. At this time *Ruppia maritima* was found in localized high shoot densities within Joe Bay and High Creek and also maintained presences into the more marine eastern basins of the study area. Elevated salinity in 2001 retreated *Ruppia* presence primarily to the receiving basins and salinity values in the 40psu range of 2004-2005 were associated with the loss of *Ruppia* through 2009 in these basins as well. Concurrently, *Halodule wrightii* was initially found with low-moderate shoot densities evenly dispersed throughout the study area. By 2004 *Halodule* distributions were patchier, with moderate-high density in localized areas appearing in response to reductions in either *Ruppia* or *Thalassia testudinum.* The dominant macrophyte of the study area, *Thalassia testudinum*, was found in moderate-high shoot densities across all of the basins (with the exception of the receiving basins). A review of annual mean *Thalassia* density for the study area shows a decreasing linear trend. While low to moderate losses in this seagrass occurred throughout the study area, much of the change associated with the overall trend can be tied to specific event losses in locales which contained some of the highest density. Overarching stressors during this time period are upward trends in salinity and downward trends in dissolved oxygen and redox potential. Discrete loss events observed by this program have indicated that near anoxic and strong reducing conditions play a role. Data will be presented to assess potential role of antecedent *Thalassia* density on sensitivity to stressors, as well as general spatial and temporal patterns of distribution. Additional evaluations will be presented on the relationship of seagrass density with salinity deviation on varying time scales, rate of salinity change, and temperature.

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Everglades National Park and Sea-Level Rise: Using the TIME Model to Predict Salinity and Hydroperiods

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Land-surface elevations are less than 5 feet (1.5 meters) above sea-level in over 250,000 acres (100,000 hectares) of Everglades National Park (ENP). These low-lying areas will be inundated by saltwater if sea-level rise predictions made by the Miami-Dade County Climate Change Task Force are realized by the year 2100. The Intergovernmental Panel on Climate Change estimates slower rates of sea-level rise, but specific areas of the Park in Florida Bay and lower estuaries would see significant changes in the salinity of both surface water and groundwater as well as water depths and hydroperiods.

The USGS has developed a model called Tides and Inflows in the Mangroves of the Everglades (TIME) that simulates major hydrologic processes and salinity variations on localized spatial and temporal scales to evaluate hydrologic changes under several sea-level rise scenarios. The purpose of this investigation is to examine the capability of the TIME model to provide reliable hydrologic information for ecologists investigating ecological responses of unique Everglades flora and fauna to sea-level rise and to develop model scenarios to represent sea-level rise with future water-management schemes.

In order to achieve these goals, calibration runs of the TIME (version 3.5.5) model under operating conditions expressed by the South Florida Water Management Model (SFWMM) version 5.4.1 Alt7r5e have been examined. Output data from the SFWMM model were also used to define the boundary conditions in TIME model along the northern and eastern boundaries which represent future water-management schemes. Downstream boundary conditions defining tidal stages and salinity distribution were incorporated at the outflow boundaries of the TIME model using the EFDC (Environmental Fluid Dynamics Code). Simulated hydropattern and hydroperiod were analyzed for several sea-level rise scenarios that use pre-drainage, current, and future boundary conditions in order to evaluate the model capabilities and develop hydrologic predictions for determining ecologic responses.

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Long-Term Population Trends (1958-2008) of Bald Eagles (*Haliaeetus leucocephalus*) in Florida Bay, Everglades National Park

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The Bald Eagle is one of the most well studied North American birds, and yet despite its status and attention, throughout the 20th century there have been dramatic fluctuations in its populations that continue to this day. Florida currently supports 11% of the nesting population in the lower 48 states, more than any state other than Alaska and Minnesota. In addition, the estimated number of adults in Florida has increased more than 300% during the past three eagle generations as defined as a total of 24 years (FWC, 2008). While Bald Eagle populations statewide have demonstrated a dramatic recovery over the past 25 years, the population of Bald Eagles breeding in Florida Bay, Everglades National Park (ENP) has shown a troubling decrease. Changes in the hydrology of Florida Bay and the southern estuaries of ENP have drastically altered these ecosystems and are listed as key landscapes vital to Everglades restoration. The fish eating birds of Florida Bay and southern estuaries are particularly sensitive to salinity levels and fluctuations in freshwater flows from the Everglades (Crozier and Gawlik, 2003; Lorenz et al., 2009; Frederick et al., 2009). Bald Eagles here have been highly impacted by these changes as well, and should be considered an imperiled species in this region. From the start of ENP monitoring in 1958 through the 1970's, the Bald Eagle maintained a dynamically stable breeding population and was considered to potentially be at carrying capacity (26 active territories) for the Florida Bay system (Ogden, 1975). From 1970-1979, 92.1% $_{+/-}$ 0.02 of breeding territories surveyed were active, however from 1999-2008 only 53.2% $_{+/-}$ 0.03 were active with a record low of only 35.5% in 2001. Changes in breeding activity from historical benchmarks have led us to examine the relationship of Bald Eagle territory location, nesting activity, nesting success, and productivity in Florida Bay for the period 1958-2008.

The significance of this study to the restoration of Florida Bay and the southern estuaries is that:

- There have been negative changes in the nesting activity of Bald Eagles in Florida Bay beginning in the 1980s correlating with documented dramatic hydrologic and ecological changes in Florida Bay.

- Preliminary analysis indicates that nesting activity is driving the decrease in Bald Eagle reproduction in Florida Bay more than nesting success or nest productivity.

- Provides a long-term database of Bald Eagle reproduction that can be used as performance measures for restoration activities of Florida Bay and the southern estuaries.

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Crab Burrows and their Contribution to Surface Elevation in Mangrove Forests of Tampa Bay and Everglades National Park, FL, USA

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Fiddler (*Uca* spp) and mud (*Eurytium* spp) crabs are among the most common and abundant animals in mangrove forests. Their burrows are an important functional component of sediment structure. This study investigates the importance of crab burrows in mangrove forests and their impact on sediment structure. Burrow density and entry-hole diameters were measured from 60 $0.25m^2$ plots. Casts collected from a sub sample of burrows within the plots were used to calculate burrow length and volume. Based on our measurements the volume of crab burrows ranged 3 to 6 l/m^2 in the upper 25 cm of sediment. Density of burrows ranged from 4 to 180 per m^2. Assuming burrow volume represents the total volume of sediment redistributed by crab burrowing activities, and all re-mobilized sediment is available for deposition on the soil surface, the maximum potential contribution of crab burrowing to sediment surface elevation in these mangrove forests is 0.3 - 0.6 cm.

These results raise questions for future research: How long did it take for this volume of burrows to be constructed and what is the potential rate of soil deposition related to crab burrowing activity? What is the rate of burrow turnover? Is remobilized sediment removed from the system by tidal action? What is the influence of burrowing on nutrient availability and hydrology in mangrove forests? Do other species benefit from the crab burrowing activity? and How will burrowing affect sediment elevation in a changing climate? By answering these questions scientists will be able to understand the role of burrowing crabs in mangrove forests.

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Using CERP MAP Data and Ecological Forecasting Methods to Develop an Assessment Protocol for Everglades Restoration

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Ecological forecasting uses scientific data to model how future environmental changes will affect an ecosystem. The predictive power of these models depends on the quantity and quality of the data used to determine the statistical relationship between an environmental driver and the ecosystem response. Ideally this relationship would be determined by looking at replicated study sites over the course of an extended period of time. However, in many cases long-term time-series data are not available. Instead, spatial variation of an environmental driver is used to determine the relationship. Here, we evaluate expanding the use of ecological relationships determined from time-series analysis at fixed sites to broader spatial scales for assessment purposes.

Climate change studies often use a ‘bioclimate envelope’ approach to predict how environmental variables will affect species distribution. This method looks at spatial variation in species distribution, and correlates it with a given environmental factor, such as temperature. Modelers then use this spatial relationship to predict how temporal changes of the temperature within study sites might affect species range. A potential problem of this method is that factors other than temperature (e.g. competition) could be affecting species distribution, and these factors may vary spatially. This could produce a misleading correlation between the target variable and species distribution. In the Everglades System, we are fortunate enough to have high quality data on both temporal and spatial variation. We report a study that uses time-series data from fixed sites in Shark River Slough, Taylor Slough, and Water Conservation Area 3 to predict spatially explicit and extensive data collected for the CERP Monitoring and Assessment Plan (MAP). This analysis allows us to study the validity of substituting spatial relationships for temporal relationships in ecological forecasting studies used for assessing restoration success, and potentially expands the usefulness for CERP MAP data in assessment protocols.

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A Risk Assessment of Methylmercury to Fish in South Florida

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A limited set of studies have evaluated the hazards of methylmercury (MeHg) to fish. The range of lowest effect residues reported was 470 ng/g wet weight (ww) to 12,000 ng/g ww based on tissue burdens, and 567 to 54,000 ng/g based on dietary burdens. The measured endpoints ranged from molecular alterations (e.g., metallothionein and testosterone levels) to reproductive impacts (e.g., sex ratio and spawning success). Biological effect thresholds that were generated for the determination of risk from MeHg ranged from 323 to 529 ng/g ww based on tissue burdens, and from 345 to 718 ng/g based on dietary burdens. Mercury (total mercury - THg) monitoring data for fish collected from south Florida between 1999 and 2009 were retrieved from the South Florida Water Management District's DBHYDRO database for comparison to the effect thresholds. Six different species comprised that data set: bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), redear sunfish (*L. microlophus*), spotted sunfish (*L. punctatus*), eastern mosquitofish (*Gambusia holbrooki*), and warmouth (*L. gulosus*). Approximately 20 percent of the data showed THg concentrations greater than the lowest effect threshold concentration for MeHg (323 ng/g ww). A probabilistic approach to risk analysis, which incorporates Monte Carlo sampling of the entirety of both the effects and monitoring data sets, indicated a relatively low likelihood (3.5%) that any individual fish is at risk from MeHg. Segregating the monitoring dataset by species, year, and location revealed that risk varied with each of these factors.

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A Water Quality Criteria-Based Evaluation of Copper Impacts to South Florida's Freshwater Environment

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The heavy localized use of copper (Cu) in urban areas and citrus agriculture in south Florida has resulted in significant soil and sediment contamination, and a recent prospective ecological risk assessment indicate Cu contamination is cause for concern as regards freshwater ecosystems. In this evaluation, eight years of surface freshwater monitoring data for south Florida were collected from the on-line database DBHYDRO to evaluate the likelihood for impacts due to Cu contamination. The evaluation involved a comparison of water hardness and biotic ligand model (BLM) based surface water quality criteria (WQC) to Cu concentrations reported in the databases. Copper concentrations in water samples from 11.8 percent of the sampling stations exceeded the hardness-based chronic WQC, while concentrations in samples from 1.3 percent of the stations exceeded the BLM-based chronic WQC indicating that the hardness-based WQC is a more conservative estimator of Cu impact. Based on data from approximately 600 water monitoring stations in south Florida, the BLM-based chronic WQC was, on average, 1.8 times greater than the hardness-based chronic WQC for the same location. The vast majority of the WQC exceedances were in residential areas of Palm Beach, Broward, Martin, and St. Lucie Counties indicating that citrus agriculture is not contributing significantly to Cu impacts in south Florida surface freshwaters. A drawback to the practical application of the BLM to water monitoring data in south Florida, and possibly to other municipal and state water monitoring programs, is the paucity of available water chemistry data necessary to support the BLM.

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Bugwood: Resources to Support Invasive Species and Ecosystem Health Education

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The Center for Invasive Species & Ecosystem Health at the University of Georgia (www.bugwood.org) mission is to serve a lead role in development, consolidation and dissemination of information and programs focused on invasive species, forest health, natural resource and agricultural management through technology development, program implementation, training, applied research and public awareness at the state, regional, national and international levels. The Center was formalized in 2008 as an expansion of The Bugwood Network, which is now the information technology component of The Center.

The goals of the Center are:

- To become a preeminent national and international public service and outreach center for invasive species and ecosystem health
- To develop collaboration between UGA and state, university, federal and international partners in these areas
- To integrate and develop information and programs in these areas
- To produce web sites, publications, posters and presentations in these areas
- To serve as a clearing house for information, applied research and training in these areas
- To promote public awareness, education and applied research in these areas.

This poster will introduce The Center, and provide information about: 1) Bugwood Image Database Systems (http://Images.bugwood.org) including ForestryImages and Invasive.org; 2) EDDMapS, The Early Detection and Distribution Mapping System www.eddmaps.org; 3) BugwoodWiki (http://wiki.bugwood.org); and 4) information about other Center projects.

Bugwood web sites received 165 million hits and were accessed by 9.1 million worldwide users during 2009. 110,000 images are available for educational uses through the Bugwood Image Database System. EDDMapS is being implemented and used for invasive plant, animal and biological control projects across the U.S. ranging from Florida, the SE, into the Mid-Atlantic and upper Missouri River areas, and in Alaska. EDDMapS contains 610,000 county reports, 236,000 point reports on 1,728 species and is being used by more than 1,100 Users.

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IveGot1.org – Reporting and Tracking Invasive Species in the Everglades

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IveGot1.org is the portal to EDDMapS in Florida for reporting and tracking invasive species in the Everglades. EDDMapS, the **E**arly **D**etection and **D**istribution **M**apping **S**ystem, was developed to provide a more accurate picture of the distribution of invasive species. It is a tool to develop more complete local, state and regional level distribution data of invasive species, identify "leading edge" ranges of new invasive threats, provide a means of implementing EDRR, and help corroborate threats and refine invasive species lists and management priorities. EDDMapS allows land managers, agencies and others to set priorities for early detection and rapid response (EDRR), and formulate overall invasive plant management action plans. ***IveGot1.org*** was developed through the partnership between the Florida Invasive Species Partnership and the Florida Exotic Pest Plant Council with support from U.S. Fish and Wildlife Service, National Park Service and the Nature Conservancy in cooperation with Florida Fish and Wildlife Conservation Commission and Florida Natural Areas Inventory.

This presentation will highlight new and upcoming features of ***IveGot1.org*** and its integration into the Everglades Cooperative Invasive Species Management Area website (www.evergladescisma.org) and how it is being used to fight invasive species in the Everglades.

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Compliance with the Everglades Forever Act: A Local Government Perspective

Jim Barnes
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The 1994 Everglades Forever Act (EFA) established water quality goals for the restoration and preservation of the Everglades Protection Area. It also identified Basin B within the Village of Wellington as an area that will need to meet the new phosphorus standard by December 31, 2006 for its storm water discharges into the Arthur Marshall Loxahatchee National Wildlife Refuge.

The Acme Basin B Discharge project is one of 55 that comprised the Comprehensive Everglades Restoration Plan (CERP). The Basin B drainage area is part of the Acme Improvement District, which was created by the state of Florida in 1953 to provide drainage for agricultural land in central Palm Beach County. In over 50 years since its inception, land uses within the improvement district have changed dramatically. The Acme Improvement District now serves the Village of Wellington and 60,000 residents. Basin B consists of 8,680 acres of low-density development located in the southern half of the Improvement District. The western boundary of Basin B abuts the Loxahatchee National Wildlife Refuge.

The benefits created by the CERP Acme Basin B Discharge project are largely related to restoration of the natural environment. The health of the Loxahatchee National Wildlife Refuge and the Everglades in general will be enhanced with improved quality and quantity of water generated from within the basin. Specifically, the project proposed to provide the equivalent of 28.5 million gallons of water per day to the Everglades, which, without the project, would be needlessly sent to the ocean via the Lake Worth Lagoon.

The Village worked diligently to arrive at a solution to meet the EFA requirements in an economic and technically feasible manner. The Village evaluated numerous alternatives to meet the Basin B Water Quality requirements.

This presentation will review the Village's history in efforts to comply with environmental mandates and the process by which it achieved the goals set forth as part of the EFA and CERP through a combination of intergovernmental coordination and cooperation, local regulatory programs and the Village's continuing commitment to environmental stewardship.

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Low Impact Development Strategies: Tool and Techniques for Sustainability

Jim Barnes
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Low Impact Development (LID) is an innovative approach to stormwater management that is being implemented by federal agencies, state, and local governments for aquatic resource protection and regulatory compliance. LID is a site level stormwater management design approach with an objective of maintaining the hydrologic cycle or meeting targeted watershed objectives. This is accomplished by a combination of planning and design strategies that use conservation approaches and techniques to reduce site development impacts in combination with Integrated Management Practices (IMPs). IMPs are small scale stormwater management devices that are distributed throughout the site, on buildings, and throughout the infrastructure to meet the control objectives. This includes filtering of pollutants, volume, and timing control. Common IMPs include bioretention, which is the use of the plant soil complex for stormwater management, roof gardens, permeable pavers, and amended soils. The use of LID is being explored by transportation agencies, the Department of Defense, and many large institutions because of the potential life cycle cost savings, superior environmental protection, and ability to leverage funds from other programs, such as maintenance budgets, to construct IMPs. This approach is useful for urban redevelopment, and is also being used in rural and smaller communities for Phase II NPDES permits because of the flexibility in construction and the ability to phase the implementation of the program.

As a decentralized or source control approach to stormwater management that focuses on maintaining or restoring the hydrologic cycle functions in a watershed, the approach is causing many communities and organizations to reevaluate their stormwater programs to see how LID can be used as part of a comprehensive watershed protection and restoration strategy. This presentation will focus on how communities and institutions are using LID techniques to meet a wide range of water resource protection and community development objectives. It will feature communities that incorporate many LID techniques, and highlight other examples of LID designs and projects from throughout the country with specific emphasis on Florida.

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Mangrove Ecosystem Carbon Budgets Using Eddy Covariance and Satellite-Based Products

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Eddy covariance (EC)-based estimates of net ecosystem productivity (NEP) and gross primary production (GPP) determined during 2004 to 2010 in southwestern Everglades National Park were the first of their kind in a mangrove forest ecosystem. These EC fluxes are invaluable for determining physiological responses of mangroves to environmental forcings over hourly to seasonal time scales and for determining functional ecosystem recovery following a major storm disturbance. However, the EC-flux estimates by themselves provide limited spatial representation (1 to 3 km^2). Also, inter-annual variability in carbon assimilation cannot be addressed with ~5 years of EC data. These spatial and temporal limitations can be addressed by estimating GPP and NEP using EC-based information and satellite-based products. The first objective of the modeling studies is to verify that modeled GPP captures seasonal variability in EC-derived GPP at the tower site. The model is then applied as a tool to quantify seasonal and inter-annual variability in carbon assimilation during the period 2000 to 2010, which corresponds to the period of available satellite data. The disturbance to NEP resulting from hurricane Wilma is also quantified immediately following the storm during October 2005 to October 2006. Model estimates include hourly GPP at the EC-tower site derived from satellite-based indices determined during 8-day intervals, including green vegetation (GV) cover and non-photosynthetic vegetation (NPV) cover, along with hourly average climate forcings (e.g., PAR and air temperature). GV and NPV are derived from Relative Spectral Mixture Analysis (RSMA). RSMA utilizes coarse (500 m by 500 m) reflectance products from the Moderate Resolution Imaging Spectrometer (MODIS), and includes data from the EC-tower site. In addition to providing temporally resolved productivity estimates at the EC site, the modeling framework can generate GPP and NEP estimates for mangrove forests along the entire southwest coast of Florida. Model results are discussed within the framework of establishing annual carbon budgets of mangroves within Everglades National Park. In turn, the carbon budgets will serve as the foundation for developing carbon inventories of government-managed lands.

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American Alligator and Selective Faunal Surveys for the Picayune Strand Restoration Project

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A survey of the distribution and abundance of the American alligator (*Alligator mississippiensis*) was conducted in the Picayune Strand State Forest and adjacent conservation lands to expand the existing baseline biological monitoring database for the Picayune Strand Restoration Project. Other concurrent studies include monitoring for terrestrial and aquatic macro-invertebrates, fishes, anurans, semi-aquatic mammals such as Everglades mink (*Mustela vison evergladensis*), and the American alligator.

Seven transects were established within the study area to characterize American alligator distribution across the landscape. Four transects were within the Picayune Strand Restoration Project area and served as "restoration" transects. Three transects were along existing canals and the fourth was conducted along the former Prairie canal that has since been restored. Three additional survey areas were chosen within adjacent conservation lands and served as "reference" transects. Two of the reference surveys were conducted along the boundaries of the Florida Panther National Wildlife Refuge and the Big Cypress National Preserve. An additional transect was conducted within the central slough region of the Fakahatchee Strand State Preserve State Park.

Surveys were conducted during the peak dry down of April and May 2009. Observations were taken at night utilizing hand held spotlights with the exception of the central slough survey of the Fakahatchee Strand which was performed during the day. Measurements were recorded as total length on 0.25 m increments within a scale from 0.25 to 4.0 m. Any alligator observed at 0.25 m was denoted as a hatchling. Juveniles were recorded as between 0.5 -1.5 m and adults as greater than 1.5 m.

Differences were observed in the abundance and size distribution of American alligators within the Picayune Strand Restoration Project area and within the adjacent conservation lands. As a wetland dependent keystone species, the American alligator has significant potential to serve as an indicator for restoration success.

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A Twenty Year Plan to Restore Naples Bay

Michael R. Bauer
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Naples Bay is a relatively narrow, shallow estuary ranging in width from 100 to 1500 feet, and in depth from 1 to 23 feet. The Bay's watershed once drained about 10 square miles, but it now extends to approximately 120 square miles as a result of the construction of the Golden Gate Canal system and its connection to the bay. On average, 200 million gallons of freshwater per day enter Naples Bay from the canal and disrupt the delicate balance of salt and freshwater that estuarine flora and fauna depend upon to flourish. Since 1950, Naples Bay has lost 90% of its seagrass beds, 80% of its oyster reefs, and 70% of its mangrove fringe since 1950. Naples Bay is considered typical of estuarine systems along the coast of Florida that have been heavily altered by drainage and urban development. However, efforts are under way by the City to improve the water quality of the bay and increase the quality and quantity of seagrass, oysters, and mangroves living within it and along its shorelines.

Over the last several years, the City's Natural Resources Division has taken steps to improve the waters and habitats of the Naples Bay estuary. The Division has now developed a twenty year plan to restore the bay based on restoration activities and associated timelines. The first layer is comprised of the subjects of the seven major restoration efforts: improving water quantity, water quality, oysters, mangroves, and seagrasses; creating habitat islands; and trawling to measure success. The second layer addresses the expected direct results at a period five years from now stemming from these endeavors; the conditions ten years from now, a critical point where what amounts to next level derivative outcomes from current actions have occurred; and finally, an expectation as to what conditions will be like twenty years from now, an entire generation away, where our successors will be maintaining the legacy of what has been accomplished as a result of the groundwork we put down now.

Twenty years from now, Naples Bay will look different than it does today. While its commercial working waterfront will have expanded and its shoreline will have remained in residential development, that shoreline will have a fringe of low-lying mangroves around its edge. The water will be obviously clearer. Small islands, oyster bars, and boats fishing its waters will dot its surface, while below, seagrasses will be visible swaying in the current. Fish will be seen jumping and dolphins playing up to and into the Gordon River. The people of Naples will take great pride in their bay and their successful efforts to restore it.

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Lessons Learned at Ten Years into the Picayune Strand Restoration Project

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It is generally recognized that adaptive assessment based on post-construction PSRP environmental monitoring is likely to lead to potential “lessons learned”, including some that could be considered undesirable and need to be addressed with adaptive management. However, over the past ten years there have been other important lessons learned that are associated with the planning and implementation phases of the project.

One of the major lessons learned is that when the planning ends and construction of a project begins, planning staff need to remain involved with the project. This is especially true for projects, such as the PSRP, that are designed primarily to produce onsite restoration. Despite often providing large volumes of information to those constructing the project, the interpretation of the information in those volumes is not always intuitive to individuals unfamiliar with the biology and ecology of an area to be restored. This can sometimes make it difficult for them to come to the correct conclusion as to what actions should or should not be taken in certain circumstances. With planners continuing to be closely involved in restoration projects, they can efficiently address some of these questions and can provide timely input in other situations where some of the work being done is likely to disagree with the intent of the restoration plan.

A second important lesson was the need to have a well thought out and scientifically sound foundation for all aspects of the plan design. This was particularly true for those aspects of the plan where we had to “fill in the blanks” based on extrapolations, sometimes at a significant distance, from available data. An obvious example of this would be the modeling. Everyone knows that models are imperfect representations of reality, and some are more imperfect than others. However, they do represent a synthesis of available information that is organized in an explicit form. Thus, anyone willing to take the time to fairly evaluate these models can interpret for themselves the validity of the conclusions drawn from the models, as well as to suggest ways to further increase the accuracy of the conclusions. When decisions needed to be made, this basic approach provided a strong and defensible foundation for supporting these decisions.

A third important lesson was that as we would complete planning on one project requirement, it seemed that two or three more tasks would appear that needed to be addressed. In some cases, deadlines were extended to allow us to address these new tasks, but in others, they were not, which made for some hectic workdays to meet the deadlines, but more importantly, caused some major headaches at a later date. We hope that many of the lessons we learned while being involved in the PSRP will make the tasks of others working on CERP and other similar projects a little bit easier. The topics we had to deal with can be seen in the Picayune Project Implementation Report (PIR) and other documents we developed in the course of the PSRP.

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The Importance of Treatment Wetlands as Avian Habitat in South Florida

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Over half of the world's wetlands have been lost primarily due to conversion to agriculture. In addition to wetland loss, conversion of wetlands to agriculture has also exacerbated the issue of eutrophication, which is the most widespread cause of water quality problems in the US. The use of constructed wetlands to treat polluted runoff water from a variety of sources has been steadily increasing since the 1950s.

In the Everglades, Stormwater Treatment Areas (STAs) were constructed to remove phosphorous from surface waters. Although the primary purpose of STAs is to improve water quality and habitat conditions in the Everglades, the artificial marshes may provide quality habitat to multiple wildlife groups especially avifauna.

We conducted avian surveys in 6 STAs, the Everglades Agricultural Area (EAA), and in more natural marshes of southern Water Conservation Area 3A (WCA3A). Preliminary results based on the first year of data show that avian abundance and richness were significantly lower in the natural marsh than in the other two land types in all seasons (both tests, $p<0.01$). Avian richness was always greatest in the STAs compared to the other two land types ($p<0.01$); however, an interaction between landtype and season showed that avian abundance in the STAs was greatest in fall and winter, whereas it was greatest in the EAA during summer. The STAs are dominated by waterfowl whereas the EAA and natural marsh are dominated by passerines. Within the STAs, avian abundance and richness were significantly greater in dense submerged aquatic vegetation (SAV) than in emergent vegetation ($p<0.01$). This was especially pronounced during fall and winter.

These results show that the STAs are used heavily by a diverse group of avifauna, particularly wintering species such as waterfowl. The state of Florida is planning to purchase 72,000 acres of EAA farmland to hydrologically reconnect Lake Okeechobee to WCA3A. If the habitat in this new "flow-way" resembles that of the current STAs, it will provide a secondary benefit in the form of a large increase in the numbers of birds, particularly wintering waterfowl.

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Resource Selection Functions as an Empirical Approach to Developing a Wading Bird Habitat Suitability Index (HSI)

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Several White Ibis, Wood Stork and Great Egret population metrics have been recently suggested as vital indicators of Everglades restoration. Ideally, these metrics would be based on a scientific foundation of how hydrologic patterns are mechanistically related to wading bird nesting success in the Everglades through effects on seasonal and annual variation in food availability. Recasting data from rigorous empirical studies into a practical spatially-explicit tool linked to real-time hydrological models and capable of predicting biological responses from physical processes being restored is relevant and desirable for sound wetland ecosystem restoration.

We conducted a landscape scale habitat selection study of two wading bird species (Great Egret, *Ardea alba.* and White Ibis, *Eudocimus albus*) with contrasting foraging strategies to identify key foraging habitat characteristics that were selected and avoided by these species. The study was done in 2006 and 2007, years which contrasted in hydrologic conditions and prey availability. The contrast in species foraging requirements and in years of food availability provided a natural framework for testing the hypothesis that population responses of wading birds in the Everglades is linked to how constrained a species is in its choice of habitats. This study reviews the development of a tool used to provide spatially-explicit management recommendations on the suitability of the landscape for wading bird foraging. Developing models for two species with opposing foraging strategies provided a range of conditions that would be suitable for a suite of wading bird species. In addition, restoration scenarios may also be applied within the GIS framework in order to evaluate their impact on habitat.

The data provided by this tool, combined with other historical distribution data, are also used to develop real-time depth and recession rate criteria as well as determine regulation schedules based on stage. Comparison of these criteria across species will allow the practice of hydrological management to accommodate either the requirements of the most sensitive species or the wading bird guild as a whole.

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An Integrated Approach to Climate Change Vulnerability, Resiliency and Adaptation

Lisa B. Beever[1], *J. Ott*[1], *J. Beever*[2] and *W. Gray*[2]
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The Charlotte Harbor National Estuary Program (CHNEP) adopted a climate change priority action within its 2008 Comprehensive Conservation and Management Plan (CCMP) update. The plan outlined a framework for CHNEP to "build capacity for communities and their local leadership to mitigate and adapt to the effects of climate change through joint efforts." The Southwest Florida Regional Planning Council (SWFRPC) and CHNEP jointly developed an integrated approach to climate change assessment and planning that has allowed a progressive expansion of scope and detail, building on past work with each step. The process has developed frameworks which are being replicated in other locations.

The integrated approach has yielded:

- A presentation regarding climate change and the Southwest Florida Feasibility Study at the 2008 GEER Conference;
- A Southwest Florida Regional Climate Change Vulnerability Assessment;
- A Charlotte Harbor Regional Climate Change Vulnerability Assessment;
- The City of Punta Gorda Climate Change Adaptation Plan;
- Model comprehensive plan and ordinance language to address sea level rise in Punta Gorda;
- The Lee County Climate Change Resiliency Plan;
- Seagrass Responses to Sea Level Rise;
- Climate Change Environmental Indicators;
- A manual to identify actions for improving resiliency in estuarine restoration and protection plans in all coastal communities along the Gulf Coast (spearheaded by Tampa Bay Estuary program and Coastal Bend Bays and Estuaries Program); and
- Salt Marsh Type and Extent Resiliency and Adaptation.

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Selecting Environmental Indicators of Climate Change

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In May 2008, CHNEP updated its list of environmental indicators and issued a survey to prioritize them. At the time, no indicators were included for the newest of the priority actions, SG-Q, related to climate change. Under the Climate Ready Estuaries (CRE) program sponsored by the U.S. Environmental Protection Agency, CHNEP and ICF International developed a method for to select 3-5 meaningful and sensitive indicators of climate change. The step-wise process began with listing all potential indicators of climate change.

As a first step, 172 alternative climate change indicators were identified from several sources. The CHNEP Management Conference was surveyed and 20 indicators ranked toward the top. On January 8, 2010, a subcommittee of CHNEP arrived at consensus on 13 alternative climate change indicators to review in more detail. The indicator "timing of seasonal activities" was expanded to bird arrivals, general phenology, manatee counts, sea turtle nesting, rookery start dates, and pest insect outbreaks, for a total of 18 indicators to consider in more detail.

Respondents were asked about other known monitoring programs, potential new monitoring programs, whether the data set listed is detailed enough, if the indicator is responsive to climate change, if it is useful to managers and for outreach. The respondents also identified the level of relevance of each candidate indicator.

The top ranked indicators include:

- Changes to precipitation trend/patterns, including extreme precipitation,
- Relative sea-level rise,
- Water temperature, and
- General phenology (bird arrivals, butterflies, flowering plants, flowering crops- citrus and mangoes, cypress browning, etc).

A similar process was pursued through CRE by the Long Island Sound Study (LISS) which will be compared.

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Biochemical Markers of the Effects of Canal-Induced Nutrient Gradients on Food-Webs in a Taylor Slough Freshwater Marsh

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The Florida Everglades ecosystem is controlled to a large extent by the interactions between hydrological and biological processes. Climatic factors and Everglades restoration plans will have strong impacts on water flow, nutrient levels, and, consequently, ecosystem productivity. A critical question that remains is how these hydrological changes will affect trophic interactions and community structure. Here, we are applying a lipid biomarker approach to address this question, focusing on the role of nutrient gradients on the quality and quantity of detritus and algae available for primary and intermediate trophic levels. Lipid biomarker analysis relies on specific lipid patterns in basal resources that become transferred to higher trophic levels upon ingestion, thereby providing important insights into food sources and consumer dynamics.

Periphyton, flocculent material (floc), chironomids, amphipods (*Hyalella azteca*), snails (*Haitia spp.*), grass shrimp (*Palaemonetes paludosus*), eastern mosquitofish (*Gambusia holbrooki*), flagfish (*Jordanella foridae*), and dollar sunfish (*Lepomis marginatus*) were collected from a freshwater marsh in Taylor Slough at sites adjacent to and removed from the C-111 canal in January 2010. Although periphyton and floc contained a similar suite of fatty acids, floc was characterized by larger proportions of bacterial (15:0i, 15:0a, 17:0i, 17:0a) and terrestrial (C_{24}-C_{30} saturated) fatty acids, highlighting the heterogeneity of organic matter sources to flocculent material. Floc also contained lower proportions of fresh algal markers (C_{16}, C_{18}, and C_{20} polyunsaturated fatty acids) than periphyton, especially at sites far from the canal, suggesting decreasing quality of organic matter in floc with distance from the canal. In addition, a monounsaturated C_{19} fatty acid was present in floc, but absent from periphtyon, suggesting a potential marker to differentiate contributions of these basal resources to higher trophic levels. Preliminary analysis of amphipods and snails revealed the presence of this marker, implying floc as a food resource for both species. Feeding experiments are presently underway to test basal resource lipid assimilation and metabolism in these primary consumers. Carbon and nitrogen stable isotopic composition of basal resources and consumers will be coupled to fatty acid compositional analysis to further resolve the linkages between hydrology, community assembly, carbon quality and quantity for consumers, and trophic position.

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Microbial Community Responses to Active Management of a Eutrophic Area of the Everglades Determined through Lipid Biomarkers

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Microbial community structure and function, in part, determines the processing rate and fate of autotrophic production in the Everglades. Eutrophication results in a regime shift from a ridge and slough landscape to an emergent macrophyte community that contributes more recalcitrant organic matter (OM), increasing anoxia. Bacterial community structure changes from aerobic, oxidizing species to those that thrive in reducing conditions, slowing the turnover of OM. An applied management strategy (the Cattail Habitat Improvement Project (CHIP)) was utilized to ecologically alter areas where monotypic cattail stands thrive (control plots) by creating an open water "slough" (treatment plots) dominated by submersed aquatic vegetation (SAV) and periphyton. It was hypothesized that the microbial community would shift as a result of increased oxygenation of the water column and inputs of labile organic matter from the SAV and periphyton. Phospholipid fatty acid (PLFA) biomarkers were utilized as a rapid assessment tool to identify functionally relevant microbial groups. Significant changes over the past three years in microbial groups within detrital floc and surface peat were detected in CHIP treatment plots relative to control plots. Total microbial biomass in floc and peat was upwards of 3x greater in treatment plots relative to control plots. Algal biomass in the floc increased by 3-10x as a result of reduced shading by emergent macrophytes. In treatment plots, the ratio of Gram positive bacteria to Gram negative bacteria decreased, indicating increased oxygen availability and improved carbon substrate quality. Improvement in growth conditions for Gram negative bacteria in treatment plots was also indicated by a reduced metabolic stress ratio. Ecologically, the shift to an SAV/algal system has altered the bacterial community suggesting a fundamental change in the oxidative cycling of organic matter within treatment plots.

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Salinity Variation and Ground Water Flows to Biscayne National Park and Southern Biscayne Bay

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Current restoration efforts in South Florida ultimately involve modifying the timing and amount of freshwater inflows from canals into the bay. Closely following salinity trends across the bay is critical to determining and understanding the recent cycle of salinity in Biscayne Bay and how it will be affected by changes in freshwater flow from restoration efforts. Since 2004, CTD measurements have been collected every 15 minutes from 34 surface and bottom station within the central and southern bay by Biscayne National Park (BNP) staff. This information provides us a better understanding of salinity patterns and the current state of canal and submarine ground water discharges in the bay. This information may be used to more closely follow the shape and position of the freshwater-saltwater interface.

Specific station observations indicate that groundwater has an unquantified affect on salinity in Biscayne Bay. We have reviewed the flow to the bay from canals and are attempting to further quantify the effects of groundwater flow on salinity. Observations that indicate an important relationship to groundwater include: the variability of the mangrove coastline north of Convoy Point, which displays some of the highest variability of all CTD stations, even though some are located away from direct canal flow; that the shoreline stations showing the highest individual salinity measurements occurring during the early wet season when the Biscayne Aquifer is seasonally re-filling; and that an estuarine zone appears to develop along the western coast and often persist into the dry season. These factors indicate a significant role for groundwater in maintaining the salinity in Biscayne Bay.

Multivariate statistical analysis techniques including time series analysis, cluster analysis and principal components are currently being employed on the salinity data to group stations presenting similar characteristics. This allows us to examine the relationship between salinity and other environmental factors, including ground water flow measurements, sampled during this period. Thus far, our results are showing convincing evidence that groundwater may play a larger role in bay salinities than was previously thought, and its distribution and discharge needs to be considered further before finalizing any restoration efforts. As fresh groundwater discharge may represent the most available source of freshwater input for benthic habitats, it is important that its effects on salinity first be understood before implementing additional changes in flow or discharge to Biscayne Bay.

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Hydrologic Information of the Western Tamiami Trail and the Ten Thousand Islands to Monitor Downstream Effects of the Picayune Strand Restoration Project

Andrew Erickson and ***Marcia Berry***
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In 2006, the U.S. Geological Survey (USGS) initiated the first of three studies to describe the effects of the Picayune Strand Restoration Project (PSRP) on freshwater flows across the Tamiami Trail (US-41) to the Ten Thousand Islands (TTI) estuary. Through this effort, the USGS has established a total of 19 monitoring stations at a variety of locations, including bridges along the western reach of US-41, dredged canals and boat basins, tidal rivers, and estuarine bays. All stations provide salinity and temperature data, and most stations include water-level and flow data. These data can be used to develop and calibrate hydrodynamic and water-quality models of the area, as well as integrate biological response models to changes in hydrology. The studies are being conducted as part of the USGS Greater Everglades Priority Ecosystems Science (GEPES) initiative, National Park Service Critical Ecosystem Studies Initiative (CESI), USGS Sirenia Project Manatee Research, and in cooperation with the U.S. Army Corps of Engineers and South Florida Water Management District. All data generated by these studies will be available through the USGS South Florida Information Access (SOFIA) web page at http://sofia.er.usgs.gov/. Real-time water-data for Florida is available from the USGS National Water Information System at http://waterdata.usgs.gov/fl/nwis/rt.

Assuming that (1) the completion of the PSRP will extend the hydroperiods of areas north of US-41, and that (2) the addition of culverts under US-41 and plugs in Tamiami Canal have changed the spatial distribution of freshwater flow to marshes and estuaries to the south, the data collected from these studies will provide insight about ecosystem responses to the restoration by providing:

- Hydrologic information describing the magnitude of pre, present, and post restoration freshwater flow and distribution along US-41 to marshes and estuaries to the south.
- Long-term flow monitoring method for bridges and culverts under US-41 between County Road 92 and State Road 29.
- Hydrologic information describing flow, salinity, and temperature characteristics of tidal rivers and estuaries of the Ten Thousand Islands.

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An Assessment of an Integrated Participatory Scenario Development Framework that Addresses Climate Impacts on South Florida Water Resource Management

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Projections of climate change and decadal scale climate variability impacts are plagued with uncertainty. These uncertainties further complicate already complex decision environments, causing difficulties for resource managers who are charged with making high stakes future planning decisions. The identification of robust water management strategies that perform well across a range of potential climate impacts has emerged as a goal in response to deep uncertainty. This research presents and assesses a stakeholder driven research agenda to identify robust water management strategies by incorporating available climate information with additional socio-economic stresses into an integrated system dynamics water model.

Scenario development results are presented and methods to incorporate qualitative scenarios into a stakeholder based system dynamics model are discussed. Stakeholder feedback on the scenarios and on model design and utility was elicited during a model simulation workshop. In the workshop, three sets of regional water management strategies are tested under four different future scenarios that were developed for this project, using the integrated water model. These policies include (1) residential conservation policies; (2) water reuse policies; and (3) agricultural irrigation efficiency policies. The model simulations explore the robustness of planned management strategies against a range of projected impacts of climate and socioeconomic change.

After the simulation workshop, the stakeholder participants were interviewed to qualitatively test the effectiveness of this research approach on learning and systems thinking. The findings from this work produce implications for the sustainability of currently considered water resource management strategies, and identify how policies might be adjusted to be more robust. This research also leads to greater understanding of the societal impact of participatory scenario development and model building. The constraints and aids influencing the incorporation of information are discussed.

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Herbert Hoover Dike Rehabilitation Program Management

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The Herbert Hoover Dike Rehabilitation program is a nationwide priority for the Corps of Engineers and has significant impacts to the South Florida Ecosystem Restoration program. With multiple components all moving at the same time and various interrelationships, innovative approaches to managing the program are being implemented.

The Herbert Hoover Dike (HHD) Branch is tasked with carrying out the rehabilitation of Herbert Hoover Dike, a 143-mile series of levees and structures surrounding Lake Okeechobee. HHD Branch is tasked with managing and executing the HHD Rehabilitation in accordance with the Corps of Engineers Project Management Business Process. The HHD Rehabilitation project consists of five parallel activities that are combined into one overall project:

1. Construction of cut-off wall and landside rehabilitation and structural features.
2. Design of rehabilitation features in current and future segments (reaches) of HHD.
3. Compliance with National Environmental Policy Act (NEPA) requirements associated with the rehabilitation both within and outside the Federal right-of way.
4. Completion of supporting documentation that will recommend solutions, address risk assessment and systems based solutions for future reaches of HHD Rehabilitation through completion of Major Rehabilitation Reports.
5. Coordination with the state of Florida, local communities on project progress, possible land acquisition needs and solutions to existing structures that are currently located in HHD and are required to be brought up to current dam safety standards.

The HHD Project Branch maintains close coordination and communication with other internal Jacksonville technical offices such as Engineering, Planning, Contracting, Corporate Communication, Construction, and Operations while maintaining a presence (HHD Project Manager forward) in the local project area to communicate regularly with local communities and the construction field offices regarding project updates and problem solving.

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Discharge and Water Quality Trends, Southwest Coast of Everglades National Park, 2001 to 2009

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Anthropogenic changes to the hydrology of the Everglades began over 125 years ago with the construction of canal and drainage systems, railroads, and roads. A large portion of the Everglades historic sheetflow is now distributed via a system of canals managed by the South Florida Water Management District and the U.S. Army Corps of Engineers. Hydrologic information throughout the Everglades ecosystem is crucial to the development of restoration strategies and for future evaluation of restoration results.

Discharge and water quality fluctuations along the southwest coast of Everglades National Park are monitored as part of the U.S. Geological Survey's Priority Ecosystems Science Initiative (GEPES) and in support of the Comprehensive Everglades Restoration Plan (CERP). Locations include North River, Shark River, Harney River, Broad River, Lostmans River, Onion Key Pass, Chatham River, New River, Lopez River, Turner River, and Barron River. Data collection includes water level, salinity, and temperature. Additionally, discharge is calculated for all stations except Barron River, Turner River, and New River. Discharge is computed using empirical calibration ratings for velocity and cross-sectional area. Hydrologic data collected through this study (15-minute time-series data) is transmitted via GOES satellite every hour and stored in the USGS database. Historical data and recent provisional data can be accessed via SOFIA data exchange – http://sofia.usgs.gov/exchange/zucker_woods_patino/hydrology_data.php

These data provide information on the quality, quantity, timing, and distribution of water discharge along the southwest coast of Everglades National Park on a continuous basis, and will assist in evaluating changes in flow and water quality due to the implementation of restoration projects. Additionally the data can be used in investigating the influence of both short and long term climate events, such as tropical storms, hurricanes, climate change, and sea level rise, and their effect on local hydrology.

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Water Quality Monitoring at McIntyre Creek, J. N. "Ding" Darling National Wildlife Refuge

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Increased rainfall amounts during the 2004 and 2005 hurricane seasons resulted in large freshwater outflows from the Caloosahatchee River and its tributaries to San Carlos Bay, Pine Island Sound, and adjacent estuaries, including the J. N. "Ding" Darling National Wildlife Refuge (DDNWR). Following these events, the refuge experienced an extensive algae bloom. While the source of the bloom is not fully understood, it has been suggested that the releases from the Caloosahatchee River basin at control structure S-79 contributed to the bloom. This study will provide basic information on water quality trends at the mouth of McIntyre Creek, a key entry point to the DDNWR.

Data collection at the U.S. Geological Survey (USGS) McIntyre Creek monitoring station includes water level, discharge, salinity, temperature, dissolved oxygen (DO), pH, turbidity, chlorophyll, cyanobacteria, and colored dissolved organic matter (CDOM). Discharge will be computed using empirical calibration ratings for velocity and cross-sectional area. Hydrologic data (15-minute time-series data) collected through this study is transmitted via GOES satellite every hour, stored in the USGS database, and can be accessed on a provisional basis via internet at the USGS real-time web page http://waterdata.usgs.gov/fl/nwis/uv/?site_no=02293249.

These data provide information on the quality, quantity, and timing of water entering the DDNWR on a continuous basis, and will assist in determining effects that large volume freshwater releases at control structure S-79 may have on the overall environmental health inside the refuge.

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The Importance of South Florida for Wintering Wood Storks (*Mycteria americana*)

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Prior to Everglades drainage and impoundment, the majority of Wood Stork (*Mycteria americana*) nesting in the southeastern U.S. occurred south of Lake Okeechobee. Following the widespread hydrological alteration of the region, including the loss of many short-hydroperiod marshes, nesting by Wood Storks in South Florida (SFL) declined by more than 90% and nesting shifted northward. On the basis of this decline, Wood Storks were declared endangered in 1984 and recovery guidelines for the species called for reliable nesting by at least 2500 pairs in SFL. Everglades recovery goals also include increased nesting by Wood Storks and changes in the timing and location of colonies. Recent demographic studies indicate that, due to the late initiation of nesting in SFL, the region is currently functioning as a population sink for the species. Any focus on increasing nesting is counterproductive if Wood Storks do not reliably nest by early January. Due to this dynamic, managers have questioned whether recovery guidelines specific to SFL are still warranted for the Wood Stork. Here we show that while nesting in SFL may be unimportant for species recovery goals and may actually act to their detriment, SFL wetlands are still of paramount importance for the Wood Stork. We used satellite telemetry to record the movements of adult and juvenile Wood Storks captured across the Southeast since 2004. Approximately 28% of locations occur in SFL (Broward, Collier, Dade, Hendry, Lee, Monroe, and Palm Beach counties). Here we focus on Wood Stork activity in SFL in October-January, during the early dry season prior to the start of nesting. Wood Stork activity in SFL increased steadily over that period, peaking in January. Hendry and Lee counties attracted the highest number of birds, with the majority of locations occurring in Hendry county. Hendry and Collier counties had the highest home range overlap, with the lifetime home ranges of 23 out of 47 birds overlapping in northern Collier county. The majority of early dry season locations in these two counties occurred in forested wetlands (35%), emergent wetlands (26%), agriculture (25%), and developed areas (6%) and were recorded from birds that were captured in FL, GA, and MS. When we quantified habitat use in SFL as a whole, the majority of locations were in marine wetlands (primarily mangrove swamps, 25%), forested wetlands (22%), emergent wetlands (19%), agriculture (18%) and developed areas (9%). We used these locations to model habitat suitability for the Wood Stork in SFL during the dry season based on habitat type and other environmental variables and to identify areas of particular importance during the non-breeding season. We also mapped likely habitat loss under current sea-level rise scenarios.

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Modeling Trophic Linkages with Wading Bird Prey Concentrations: Turning Ecosystem Attributes into Wading Bird Food

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The key trophic hypothesis underlying the Everglades restoration is that restored hydrology will produce higher wading bird prey availability leading to higher nesting effort. Prey availability is not just fish population size. It also incorporates factors that reorganize fish populations in to small patches of dense prey and make them vulnerable to capture by wading birds.
We measured prey concentrations throughout the Everglades (9759 km^2) during the dry seasons of 2005-2009, which differed in hydrological conditions and levels of wading bird nesting. We collected prey at 442 random sites in a multi-stage design, and 94 wading bird foraging sites opportunistically, using a 1-m^2 throw-trap. We captured 106,024 prey animals representing 54 species. Rain during the 2005 dry season caused wading bird nest abandonment. Conversely, the 2006 and 2009 dry seasons had high peak water levels, steady recessions and strong wading bird nesting. Drought conditions led to poor wading bird nesting in 2007 and 2008. Mean prey biomass (g/m^2) at random sites was significantly lower in 2007 and 2008 than 2006 (8, 18, and 48, respectively), likely due to low wet season water levels which may have constrained the growth of prey populations. Favorable hydrologic conditions preceding and during the 2006 dry season fostered the highest prey biomass of the four years, and 2006 had high wading bird nesting. 2009 was a banner year for wading birds; however, prey biomass averaged across all samples was not correspondingly high (24 g/m^2). Only crayfish biomass increased considerably in 2009, and it did coincide with large numbers of White Ibis nests. However, this is the first time in five years that total prey concentrations did not track overall wading bird nesting. We suspect that in 2009 wading birds responded to the extremely large portion of the landscape that became available throughout the dry season, rather than the quality of individual patches.
We used a model selection approach to identify factors associated with wading bird prey concentrations and found that prey concentrations increased with increased microtopography, rapid recession rates, and a higher biomass of fish the preceding wet season. Microtopographical relief creates shallow depressions that allow fish to concentrate before the marsh dries completely. The receding water is a mechanism that distributes fish and macroinvertebrates into depressions as the seasonal drying front moves through the landscape from higher to lower elevations.

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Effects of Lake Stage and Marsh Elevation on Wading Bird Nesting Effort at Lake Okeechobee

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Aerial wading bird surveys of the lake have been conducted from 1957-1960, 1971-1972, 1974-1975, 1977-1992, and from 2005 through the present to monitor timing and nesting of wading birds. Historically, approximately 10,000 birds a year nested at Lake Okeechobee until the regulation schedule increased water levels in 1978. Thereafter nest numbers declined, likely because wading birds need shallow marshes to access their prey. Today, the Lake operates under a schedule which tries to minimize extreme high lake stages and allows for recessions in the interior marsh during the dry season.

Past research has focused on the stage level in reference to both wading bird nesting and foraging. Although very important, this does not take into effect the actual topography of the lake bottom. In this study, we used lake stage levels and an interpolated predictive surface of the littoral zone to develop predicted water depths. We estimated the daily availability of habitat in the littoral zone using depths found in the literature to be suitable for wading bird foraging. Habitat was unavailable if it was too deep or dry. We examined the relationship between monthly nest effort for three species, the Great Egret (*Ardea Alba*), Snowy Egret (*Egretta thula*), and White Ibis (*Eudocimus albus*), and predicted available habitat 2006-2009.
We detected a total of 10176 and 6116 nests in 2006 and 2009, respectively. In contrast, we detected only a total of 550 and 20 nests in 2008 and 2009, respectively. Average daily available habitat for each season was higher in good nesting years of 2006 and 2009, at 600.6 km^2 and 671.0 km^2 respectively than in the poor years of 2007 and 2008, at 160.1 km^2 and 84.5km^2 per day respectively. There was a high correlation ($r=0.78$, $p<.01$) between monthly nest effort and average daily area of habitat per month between February and May. Plotting lake stage against available habitat showed a quadratic function that coincided with a peak area at 3.91 m NGVD88 (approximately 14 ft msl). This coincides with reported high nest efforts historically at moderate lake stages of 3.77 m to 4.36 m. Future research is aimed at refining a habitat suitability model that incorporates other environmental factors.

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Legacy P and Its Impact on Restoration Efforts

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The amount and spatial distribution of legacy phosphorus that has built up in the soils due to past anthropogenic activities will significantly affect the efficacy of various restoration approaches. A discussion of the findings from a recent legacy P study will be presented. Estimated quantities of legacy P and its distribution throughout the northern Okeechobee basins will be presented. The potential benefits of various abatement strategies, including farm/field level BMPs and sub-regional and regional (near Lake) wetland and/or chemical treatments, will also be presented as to their cost effectiveness. Cost estimates for total restoration to meet current proposed TMDL levels will be summarized.

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Resource Partitioning among Five Mesopredators in the Upper Shark River Estuary

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Mesopredators play an important role in influencing the structure and function of natural ecosystems. Their adaptive foraging behavior is known to significantly affect not only the abundance of their prey, but also other ecosystem-level processes such as patterns of plant diversity and productivity, trophic transfer efficiencies, organic matter decomposition rates, and nutrient cycling. To this end, mesopredator species will utilize a subset of the resources available to minimize competitive interspecific interactions, potentially routing energy flow through multiple pathways.

In Everglades National Park, distinct hydrologic seasons influence the spatial distribution of mesopredators. In the dry season, freshwater marshes dry, forcing fishes, including large-bodied mesopredators, into the deepest habitats in the landscape, such as tidal creeks at the marsh-mangrove estuary ecotone. At the same time, ecotonal abundances of estuarine transient mesopredators, dominated by snook (Centropomus undecimalis*)* triple, likely in response to increased freshwater prey abundance. Our main objective in this study is to document how spatially co-occurring freshwater and estuarine mesopredators partition resources. Thus, we examined resource use by the five the most common mesoconsumer species found in the upper Shark River: largemouth bass (Micropterus salmoides*), Florida gar (Lepisosteus platyrhincus*), bowfin (Amia calva*), American eel (Anguilla rostrata*), and *snook.*

We combined stable isotope techniques and gut content analyses in our research approach. We collected fishes from first and second order creeks in the Rookery Branch headwaters of the Shark River using a boat-mounted, generator-powered electrofisher (two-anode, one cathode Smith-Root 9.0 unit). Stomach contents were removed via gastric lavage for all species except American eel, and fin clips were taken from each of the five species caught. We also collected prey identified in the stomach contents via electrofishing and minnow traps and analyzed them for C and N stable isotopes. Results from the 2010 early dry season show that there is significant partitioning of prey among mesoconsumers, even among the freshwater taxa. Mesopredators seem to fall into two broad categories with some being strictly *piscivorous* while others consumed a mix of macroinvertebrates and fish prey. For some of the species, we also detected evidence of a degree of specialization at the individual level. Supporting the stomach content data, C and N isotopes show differences in trophic niche width among consumer species, however, ultimate resource pools appear to be similar. The question remains as to how temporally-stable this resource partitioning is. We hope that further repeated sampling throughout the seasons will answer this question, and provide us with a greater understanding of how ecotonal fish communities respond in a trophically-mediated manner to seasonal and longer-term (i.e., from restoration) hydrological variation.

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Diet Composition of White Ibis Chicks in Loxahatchee National Wildlife Refuge: Crayfish, Crayfish and more Crayfish

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While the ecological goals of Everglades restoration have been identified for some time now, the prey types capable of supporting large populations of nesting White Ibis have been unclear. The main objective of this study was to quantify and compare White Ibis diets in Loxahatchee National Wildlife Refuge (Lox) throughout the 2008 and 2009 nesting seasons. Water levels were relatively higher and stable and the total nesting numbers were lower in 2008 than in 2009. We collected 105 boluses in 2008 and 146 in 2009 from the largest nesting colonies in Lox. Boluses were collected during 5 and 4 weeks of the provisioning period each year. Boluses were sorted and analyzed in the lab; all prey were identified and their sizes (g dry mass) were estimated using regressions and comparisons with whole animals. The food types were categorized into 8 groups based on habitat and taxonomy for multivariate analyses. The groups were crayfish, small fishes (mosquitofish, killifishes, flagfish), large fishes (mostly sunfishes), grass shrimp, aquatic insects, terrestrial insects, vertebrates, and garbage (mostly rotten meat or dog food).

The mean total biomass per bolus in 2008 was 1.46 g (SE = 0.23) and in 2009 it was 1.68 g (0.17) and did not differ between years. Crayfish biomass dominated the diets (>50%) in both years and were present in 80-85% of all boluses indicating that crayfish are a heavily used prey type over all water conditions during these years in Lox. Fish biomass made up 0% to 36.2% of all prey biomass across collections in 2008 and 0.8% to 27.4% in 2009. Terrestrial prey and garbage use was highest when water depths were highest.

The contribution of crayfish biomass to overall similarity of boluses for any collection in both years ranged from 66% to 100%; crayfish typified the diets. Multivariate analyses of prey biomass composition within years revealed no significant variation between collections (weeks) in 2008. In 2009 prey composition did vary by date; in general the biomasses of both small- and large- bodied fishes increased and crayfish biomass decreased in collections at the end of 2009 (shallower landscape water depths) compared with collections earlier in the season. Our results indicate that crayfish are a dominant component of White Ibis diets in Loxahatchee. The good nesting in 2009 was probably caused by greater crayfish availability with continuous recession.

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A Preliminary Examination of the Influence of Canal Inputs on Ambient Surface Water Chemistry at the Tamiami Pilot Swales Sites

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The Florida Coastal Everglades is one of the most hydrologicially regulated wetland systems in North America. The Comprehensive Everglades Restoration Plan (CERP) aims, in part, to restore the Everglades eco-region to a flow regime more characteristic of historical patterns. As part of this plan, sections of Tamiami Trail, a main east-west highway, will be bridged, allowing water from the Tamiami Canal to flow freely into Everglades National Park. Here, we examined the influence of Tamiami Canal outflows on ambient surface water chemistry at 36 pilot transect sites located downstream of four culverts providing flow from Tamiami Canal into the park. Preliminary results from December and January sampling events indicated that ambient water chemistry at the transect sites was more similar to that of surrounding sites located to the north and south of the canal than to the chemistry of canal waters. The dissimilarity of canal water chemistry to transect water chemistry was much more pronounced during low water levels in January, with significantly elevated DOC concentrations being observed in the canal. Additionally, proximity of the transect sites to the canal had no significant influence on the similarity of transect site and canal water chemistry. These results suggest that the influence of canal inflows on downstream water chemistry is mitigated by other factors. However, the temporal variability of our preliminary data illustrates the potential importance of hydrological factors in predicting the relative importance of canal inputs to Everglades water chemistry.

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Episodic Use of Tarpon Bay, Shark River, in Everglades National Park as Nursery Habitat for Common Snook: Was Hurricane Wilma Responsible?

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Adult common snook (*Centropomus undecimalis*) are routinely captured by both anglers and scientists in tidal waterways of Everglades National Park and Florida Bay. However, despite all the scientific monitoring effort within Everglades National Park, early-juvenile snook have rarely been captured there. As a result, details of their early life-history in ENP are unknown. Early-juveniles in other estuaries within south Florida typically use a variety of subtidal estuarine habitats including tidal creeks, ponds, small embayments, ditches, and canals. These habitats are abundant within the park so it is surprising that early-juvenile snook have not been successfully captured there in the past.

In January 2006 as part of ongoing research, the US Geological Survey began seining along the shorelines of Tarpon Bay to collect fish and invertebrates for food web analysis. As part of this effort we collected approximately 100 YOY (young-of-the-year) and age-1 snook during six sampling trips between January 2006 and April 2007. This unexpected result led us to believe that a more thorough investigation of snook nursery habitat use within Tarpon Bay was warranted. Therefore, we applied for and received a Park Oriented Biological Support grant to collect young of the year snook throughout Tarpon Bay and to assess their ecological status.

We conducted 89 random seine hauls during six sampling events between February 2008 and April 2009, but only collected three juvenile snook. These results were entirely different from what we observed during 2006. We developed several hypotheses to determine what factors might have caused the difference in habitat use by juvenile snook between the two nonconsecutive recruitment years.

We hypothesize that the timing and strength of the tidal surge produced by landfall of Hurricane Wilma on October 24, 2005 directly facilitated the delivery of competent snook larvae or juveniles into Tarpon Bay. We review the hydrological details of this hurricane and compare snook recruitment patterns 2006-2010 in Shark River and other estuaries in south Florida. We also consider how Everglades restoration might affect habitat quality of Tarpon Bay for common snook and other estuarine gamefish.

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Amphibians and Muskrats as Potential Indicators of Ecological Change

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Ecological indicators that span a range of spatial and temporal scales from landscapes to sites are important for tracking system-wide and site specific responses to management. Site specific indicators linked to system-wide indicators maximize value of information obtained from monitoring programs. In addition, indicators linked to models allow for conducting management in a continuous feed-foward loop of planning (forecasting using models), doing, and learning (monitoring and assessment). A challenge is to develop monitoring programs that have clearly defined protocols that are comparable across sites and spatial scales and have strong linkages to key management issues and actions. Hydrology, water quality, and invasive species are key management challenges throughout the Everglades ecosystem including the Arthur R. Marshall Loxahatchee National Wildlife Refuge (LNWR). Here we explain how we are developing information needed to use amphibians and muskrats as site specific indicators with links to broader spatial scales.

Amphibians are sensitive to hydrology, habitat, and water quality, have been identified in conceptual ecological models (CEM) for the Southwest Florida Feasibility Study (SWFFS), and have established protocols and metrics developed by the USGS Amphibian Research and Monitoring Initiative (ARMI). Amphibians also are embedded within the aquatic fauna component of the Greater Everglades CEM. An amphibian stressor response model developed for the SWFFS is currently being adapted for use in the Greater Everglades. Building off of this information we are collecting data that will help to refine the model for LNWR and at the same time examine anuran occupancy rates (using proportion of area occupied (PAO)) in relation to hydrology and invasive species control efforts. Because we are using established protocols our results can be integrated with amphibian surveys being conducted at broader spatial scales.

The round-tailed muskrat (*Neofiber alleni*) is dependent on wetlands for survival and has been identified in a recent FWS Southeastern Region Biologists Conference as a potential "umbrella" or indicator species of freshwater emergent marsh communities. They are known to occur at the LNWR, but no systematic surveys have been conducted to determine distribution and abundance. Generally, the status of Everglades' muskrat populations is unknown. However, recent inventories have shown compelling evidence for decline of muskrat populations in southern Everglades habitats. Hypotheses for the decline include alterations in hydrographic patterns, changes in habitat, predation by invasive Burmese pythons, or some combination of factors. Protocols for surveying for muskrats that have been used elsewhere are not applicable to LNWR; therefore, our first step in exploring feasibility of muskrats as an indictor was to establish a protocol that is comparable to methods in other areas. In the process of developing this protocol, we have collected preliminary data on muskrats in LNWR and will use this information to develop a CEM to guide future work.

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Hurricane Impacts and Colonization of *Lygodium microphyllum* on Tree Islands of the Arthur R. Marshall Loxahatchee National Wildlife Refuge

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Hurricanes have powerful effects on ecosystems resulting in a mosaic of microhabitats favoring establishment of native pioneers and invasive species. In the Florida Everglades, invasive exotic plants are prevalent and *Lygodium microphyllum* is one of the most serious threats to the ecosystem. In 2004 and 2005 three major hurricanes struck southeast Florida causing impacts to natural communities. We conducted a series of studies to: assess impacts to tree islands; assess colonization of *L. microphyllum* post-hurricane; relate patterns of colonization to both hurricane impacts and environmental factors.

Spatial extent of *L. microphyllum* and magnitude of hurricane impact were examined by sampling 73 tree islands and recording density of *L. microphyllum* and hurricane impact class based on type and quantity of impact to trees and amount of canopy openness. Tree islands were resampled one year later. On eight additional tree islands, we measured location, height, and area of all *L. microphyllum* patches along transects sampled biannually for 2.5 years. Hierarchical models were used to identify spatial and temporal factors related to patch parameters. We also compared *L. microphyllum* colonization in treefall and non-treefall areas and in 1 m^2 plots in open and closed canopy areas on 12 tree islands.

All sampled tree islands showed hurricane impact ranging from defoliation to uprooted trees. Tree islands that experienced heavy impacts had greater *L. microphyllum* cover one year post-hurricane than tree islands that experienced light impacts. Number and occurrence probability of patches logarithmatically increased over time. Lower water depth was associated with larger number of patches while higher depth was associated with greater mean patch height. Patches spread from outer areas of tree islands to the interior. Occurrence probability was lower in sawgrass-dominated locations at island edges compared to locations dominated by woody plants. *Lygodium microphyllum* was present in significantly more treefall plots (76%) than non-treefall plots (14%). Presence in treefall plots was significantly related to canopy cover and presence of water. We also observed a significant difference in presence of *L. microphyllum* in canopy gaps compared to closed canopy areas.

These results suggest that colonization and growth of *L. microphyllum* are related to extent of impact, location on a tree island, water depth, and time. Disturbances, such as hurricanes, that result in canopy openings and creation of disturbed areas with standing water contribute to the ability of *L. microphyllum* to invade natural areas.

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Planning for Climate Change in South Florida: Climate Envelope Modeling for Threatened and Endangered Species

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Climate change will affect our natural resources in direct (e.g., changes in temperature and precipitation) and indirect (e.g., changes in land use and water availability) ways. Some species and habitats may thrive while others may shift in distribution or disappear. Maintaining landscapes suitable for sustaining fish, wildlife, and plant populations in the face of these challenges requires that we think proactively about where suitable conditions may be in the future and how sensitive species are to not only changes in climate variables, but also changes in land use. A part of assessing responses of species to climate change is development and application of climate envelope models.

We are developing climate envelope models for 21 threatened and endangered terrestrial vertebrates in South Florida. We will use these species to develop methodologies and recommendations for implementing a comparable approach for climate envelop modeling across multiple taxa and broader and different geographic areas. Key elements of our project include: (1) identifying limiting climate factors for species; (2) developing user friendly databases; (3) explicitly addressing uncertainties for decision making; (4) using a multi-model approach; and (5) presenting information in formats that are easily accessible to decision makers.

Our products will be useful as inputs for efforts to assess species vulnerability, update recovery plans and other U.S. Fish and Wildlife Service planning documents, update State Wildlife Action Plans, inform biological planning, and develop long-term monitoring programs.

We have conducted extensive literature searches and compiled databases of traits that will inform our selection of parameters to use in the climate envelope modeling and provide basic information for conducting vulnerability assessments and updating species/habitat models. We are in the process of working with potential users of the databases to make sure the information is easily accessible for their needs.

We have developed prototype distribution models for several species including the American crocodile. We used contemporary historic WorldClim data and future climate projections at a 1km x 1km resolution to develop our models. We used these prototypes to explore alternative modeling approaches, identify limitations of each approach, examine tradeoffs of each approach as related to potential management decisions, and conduct preliminary examination of species distributions under projected climate conditions. Our projections of future climate envelopes can be linked with projections of land use and habitat to provide a more comprehensive picture of future potential habitat for each species.

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An Assessment of Biscayne Bay's Water Quality Properties and Trends: A Contribution to Nutrient Criteria Development.

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Anthropogenic drivers have a significant influence on water quality conditions and on the fate of natural resources in south Florida estuaries, and especially in Biscayne Bay (BB), for more than a century. Climate variability and change coupled with an intensely managed conveyance system of canals, urban development, land cover/use changes, and recreational usage of natural resources have contributed to mold the dynamics and existence of BB ecosystems and their biotic constituents. Given the imminent promulgation of water nutrient criteria for south Florida's estuaries by January 2011, we characterized south and central BB waters by using statistical clustering methods. We delineated eight water classes with distinct biogeochemical properties and geographical settings extending south from Rickenbacker Causeway to Manatee Bay. We confirmed previous reports of east-west gradients with more adverse impacts close to shore and lesser impacts in the open bay; north-south variability linked to water residence time as well as to P-rich canal discharges in north-central BB (urban source?) and to N-rich canal discharges in south and south-central BB (agricultural sources?). Spatially, the statistically derived subdivisions mimic very closely the bay bathymetry, the circulation and salinity patterns, and the spatial distribution of benthic communities and fish biodiversity.

These results highlight two fundamental characteristics of BB: first, its bay-wide oligotrophic nature, and second, a differential response of the bay's subbasins to nutrient loads. The waters of BB are P-limited and phytoplankton readily respond to even small increases in TP at this lower end of the concentration range. General productivity appears to be less sensitive to nitrogen species. As such, BB and the other south Florida estuaries integrate a water quality end-member that deserves special consideration when defining nutrient criteria intended to protect their outstanding oligotrophic character.

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Linking the Everglades and the Netherlands: DOI Florida-Holland Connection Team Report

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On May 3-7, a team of US Department of Interior personnel and DOI partners travel to the Netherlands to take a look at what the Dutch are doing in water, climate change and growth stewardship (how urban areas inter-relate with natural systems). Similarities between Florida and The Netherlands include large areas near and, for them, below sea level, intense system of canals, levies and water control methodologies, ecosystem declines due to man-made systems to mitigate flooding and development. This presentation will highlight findings and recommendations for future collaboration and exchange between Florida and the Dutch.

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Epifauna Community of South Biscayne Bay in Relation to Salinity

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South Biscayne Bay's western shoreline will be the first ecosystem to change when the Biscayne Bay Coastal Wetland Project of the Comprehensive Everglades Restoration Plan (CERP) is implemented. As part of RECOVER's Monitoring and Assessment Plan (MAP), we are developing a dynamic characterization of the epifaunal community and its variation along the shoreline to provide baseline information for evaluating the ecological effects of CERP-associated water management changes. Our objectives are to characterize the epifaunal community, determine salinity affinities, and develop species-based and community-based performance measures. We now have 3 yr of MAP data (sites 1-72) and 2 yr of pre-MAP (sites 1-47) data for two seasons, dry (January-February) and wet (July-August). Our data come from three 1-m^2 throw-trap samples collected at each site. Caridean shrimp (at least 13 species) and rainwater killifish were the dominant taxa in our samples; however several other species made up a substantial component of the fauna, and the pink shrimp was well distributed across sites. Adding a year of data improved our estimates of faunal-weighted-salinity, a promising means of characterizing species according to halo-habitat. We calculated this value for each species, standardized the value by subtracting from it the average salinity at all sites during sampling, and summarized the data for all years and seasons into a plot of mean density-weighted-salinity values, sorted from highest (positive) to lowest (negative). Positive values indicate an association with higher-than-average salinity across all sites, and negative values indicate an association with lower-than-average salinity across all sites. Confidence intervals (CIs), indicating the uncertainty around the mean, decreased with the addition of another year of data, yielding several species with short CIs that were both on the same side of the zero (center) line, eliminating ambiguity. Species can potentially be characterized by halo-habitat with this approach. Salinity was an important variable explaining species density in multiple-regression models for both seasons, significant in eight of the nine dry-season species models and seven of the 10 wet-season models. In the dry season, the correlation with salinity was positive for four species (blue crab, caridean shrimp, pink shrimp, and Gulf toadfish), and negative for four species (clown goby, rainwater killifish, goldspotted killifish, and Gulf pipefish). In the wet season, the correlation with salinity was positive for three species (caridean shrimp, code goby, and gulf toadfish) and negative for four species (blue crab, clown goby, rainwater killifish, and Gulf pipefish). Dry-season fish species richness had a significant negative relationship with salinity—the lower the salinity the greater the number of species. Temperature, depth, seagrass canopy height, seagrass species, and mangrove predator density were other variables tested. Our working hypothesis was that large discharges of fresh water from canals interrupt salinity patterns along the shoreline, creating disruptions in habitat that affect species composition and cause dissimilar species composition at nearby sites. Adding another year of data and combining our data for the three MAP years enabled us to see more similarity of species composition at nearby sites (sites 1-47) in dry season than in wet season, supporting our hypothesis.

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The Effects of CERP, Increasing Freshwater Flows in to the Oligohaline and Mesohaline Areas of Northeastern Florida Bay

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This presentation will review water resources practices of the past 20 years and relate them to observed effects on the oligohaline, mesohaline, and polyhaline zones of Northeastern Florida Bay. These will be used to help forecast water needs for this area.

At present, salinity in Florida Bay (FB) is strongly correlated to rainfall. This poses two (2) problems, hypersalinity in FB proper and devastation of the upstream low salinity habitats in the marshes, and creeks . While not seagrass habitats these do contain submerged aquatic vegetation (SAV) and are significant habitat for many species. They provide rearing habitat for many minnows and young of the estuarine fishes. Similarly, these are rearing places for neonate crocodiles. To maintain these areas, sufficient water is required to create SAV oligohaline to mesohaline salinity conditions in these creeks and marshes. One of the goals of CERP is to increase freshwater flows to restore these habitats by improving quantities, quality, timing, and distribution of these flows.

Reduction of these habitats has contributed to the decline of SAV communities with commensurate decline of avian bird populations that forage upon these species. . Upstream of these bays are the marshes and creeks that provide oligohaline to mesohaline conditions for estuarine fishes and neonate crocodiles. An abundance of water in the wet season creates connectivity to these SAV habitats . During the period between 1955 and 1999, hypersalinity (greater than 40 psu) occurred most frequently in the eastern area (centered on the Nest Keys), and even, at times, in the upper estuaries (Long Sound, Joe Bay, and Little Madeira Bay). During this same period water management practices changed significantly.
One important factor affecting this area was the construction the C-111 project and the deliveries of water through the headwaters of Taylor Slough and the C-111 Canal system. Flows through Taylor Slough Bridge (TSB) and the C-111 Canal were low in the period 1970 – 1981 (25%) relative to the flows after 1981. Changes in water management activities resulted in up to a four-fold increase in water delivery into this area. TSB was not affected by this increase until about 1993. After 1993,annual discharges were up to 100,000 acre-feet (80 X 10^6 m^3 /year), averaging approximately 50,000 acre-feet (40 X 10^6 m^3/year) from 1991 through 2009. In 2001, the bridge was raised to permit larger quantity deliveries of water.

Salinity studies have shown a reduction of hypersalinity events in all areas of Florida Bay following 1999. After 2004, reduction in rainfall and drought conditions reduced flows significantly through TSB. Annual flows were well below 25-year averages. This reduction in flows marked hypersaline events in FB. This clearly shows the potential for stabilization of salinity in Florida Bay through increased freshwater deliveries through Taylor Slough. This provides a hydrologic marker for effects that be employed in the adaptive management process. Several system-wide modeling updates of these areas have been produced since 1999. These coupled with the hydrologic and ecological data can provide valuable insight into the future, be employed to forecast changes, and effectuate adaptive management decisions as CERP is implemented.

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The Effects of CERP, upon Submerged Aquatic Communities in Lake Okeechobee

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The Lake Okeechobee (LO) littoral zone is on the western shore of Lake Okeechobee and hosts both emergent and submerged aquatic vegetation communities . This comprises diverse communities of native and exotic plants in an area larger than 400 km2. It serves as nesting habitat and food resources for many important game fishes, wading birds, migratory waterfowl, alligator, and the endangered Everglades snail kite. Littoral vegetation structure is influenced both by hydro-period and phosphorus loading from the lake's eutrophic pelagic region. (Havens et al 2005) Approximately 50 % of the littoral zone is comprised of Submerged Aquatic Vegetation (SAV). This area will be the focus of this presentation.
A wide body of published research documents the benefits of seasonally variable water levels within the range of 12.5 ft (June-July low) and 15.5 ft (November-January high) on the plant / animal communities of Lake Okeechobee. Falling water levels in late winter to spring benefit wading birds by concentrating prey resources in the littoral zone where those birds forage, water levels near 12.5 ft benefit submerged plants and bulrush by providing optimal light levels for photosynthesis in the summer months and variation in the prescribed range results in annual flooding and drying of upland areas of the littoral zone, which favors development of a diverse emergent plant community.

The stage envelope was the basis for the Restoration Coordination Verification program (RECOVER) system wide performance measure LO-3. This performance measure is a depiction of all possible hydrologic stages on a graph. Ecologically based depths are depicted over a calendar year. Deviations from this stage are measured in terms of foot months or weeks. This system permits quantification (in hydrologic units) of deviation from optimal ecologic conditions.

This presentation will attempt to relate the positive effects of ecological stage management with areal extent of SAV. SFWMD measures total acres of SAV in LO. This is measured in August of each year and data exists back to 2000. A regression of SAV and the weekly compliance with the ecological stage envelope was attempted. Several regressions were prepared of various antecedent stage conditions. The best fit of the regression was based upon 6 month conditions prior to the August measurements of Total areal extent of SAV. A regression equation of a high R2 value was prepared.

CERP is planned and adaptively managed to improve system wide ecology. This depends upon forecast modeling of entire system. These forecast models are updated in response to changes in land use, structure operations, and increase in historical period. Several system-wide modeling updates of these areas have been produced since 1999. These coupled with the hydrologic and ecological data can provide valuable insight into the future, be employed to forecast changes, and effectuate adaptive management decisions as CERP is implemented. This equation was used to determine affects of various CERP scenarios to relate to hydrologic and ecological effects upon LO.

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Forecasting Effects of Nutrient Loading and Availability of an Ecosystem Restoration in the Caloosahatchee and St. Lucie Estuaries of Florida

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The magnitude, timing and distribution of freshwater inflow to the St. Lucie River Estuary (SLE) and the Caloosahatchee River Estuary (CRE) have been disrupted by anthropogenic alterations over the course of Southern Florida history. These include over drainage of coastal watersheds and artificial connections to Lake Okeechobee (LO). This has affected nutrient loads as well as the relative availability of nutrients. Comprehensive Everglades Restoration Program (CERP) projects are proposed to achieve a more ecologically suitable pattern of freshwater inflow to these systems. This will similarly affect nutrient loads and availability.

Nitrogen: phosphorus stoichiometry in primary producers has served as integrators of ecological processes. Restoration of sea grass communities (in estuarine components) of the Everglades is one of the goals of CERP. The “Redfield ratio” facilitates understanding of nutrient dynamics and further serves as an evaluation method of the relative availability of nutrients in estuarine plant communities. This has been used as a surrogate for relative nutrient availability for sea grasses, macro-algae and phytoplankton. An idealized succession of phytoplankton to *Thalassia* spp. occurs from Redfield gradients of 16 to 30, respectively. Similarly, high Redfield’s (above 30) create similar create phosphorus limitation of sea grasses.

Regulatory releases provide significant loads to the SLE and CRE. According to the South Florida Water Management District, 83 MT of TP and 881 MT of TN are contributed annually to the SLE from Lake Okeechobee. Similarly, 65 MT of TP and 1584 MT of TN are contributed annually to the CRE from Lake Okeechobee. These have Redfield ratios of 23.4 for SLE and 53.7 for CRE. These vary significantly from theoretical sea grass ratios of 30 and favor blue green macro-algae. Since Lake Okeechobee contributes significant nutrient loads to the both the CRE and SLE estuaries, these loads and ratios will be effected by the construction and operation of CERP Reservoirs and Storm water Treatment Areas (STA’s). Moreover, they can be isolated from the effect of other non-CERP programs such as BMP’s, land use changes, TMDLs, and basin run off controls.

Conceptual ecological models require further development in order use the South Florida Water Management Model (SFWMM) output to evaluate restoration effects. For this reason, CERP regional evaluations, CERP updates and other forecasting techniques have not employed these models. This poses a dilemma as the ecological effects of CERP can not be examined in regional evaluations. To address this dilemma, an interim methodology is proposed that employs SFWMM output and uses structure nutrient data to forecast the effects of CERP on seagrass nutrient availability. This presentation will present this methodology.

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Program Management Support Contracts and Everglades Partners Joint Venture

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This presentation will discuss the potential services provided to organizations by program management support contracts. Program management is the process of managing multiple, interdependent projects. It has become more and more common in both the public and private sectors for program management activities to be contracted to consultants. The contractor enhances or compliments the client staff providing a wide variety of support capabilities, including planning, scheduling, budgeting, interagency coordination, regulatory compliance, design, construction management, operations and maintenance, logistical support, and information systems.

As an example, Parsons is part of a joint venture of consultant companies providing multi-disciplinary professional services for the Comprehensive Everglades Restoration Plan (CERP) through a program management support contract with the Jacksonville District, United States Army Corps of Engineers (USACE). CERP provides a framework to restore, protect and preserve the water resources of central and southern Florida, including the Everglades. It is one of the largest ecosystem restoration programs ever undertaken and has been used as a model for other large-scale water resource and ecosystem restoration projects in the United States and other nations.

Joint venture staff performs many of the activities necessary to manage individual projects on a daily basis as well as coordinate the program as a whole. Project level support includes meeting coordination, development and tracking of key project documents, schedule analysis and quality control of project deliverables. Program-level activities include information and data management, financial reporting, other performance metrics reporting, science research, and facilitation. The program management support contract has provided the USACE staff timely and effective program/ project assessments, injected technical expertise when required and allowed critical in house staff to focus on key technical and policy issues related to their projects.

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CERP Adaptive Management Program Implementation

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The Comprehensive Everglades Restoration Plan (CERP or Plan) provides a framework to restore, protect and preserve the water resources of central and southern Florida, including the Everglades. Congress authorized the use of an adaptive management (AM) approach for CERP (*Water Resource Development Act [WRDA], 2000*) to allow the Plan to proceed in the face of complexity and incomplete scientific data (uncertainties). A comprehensive AM program in support of a system-wide ecosystem restoration program at the size and scale of CERP has never been successfully implemented. This presentation details the status of the CERP AM Program development and implementation.

Though many components of the CERP AM Program have been developed since CERP was authorized in 2000 (*e.g.*, creation of a monitoring and assessment plan as well as performance measures, conceptual ecological modeling, development of interim goals and targets, etc.), the specific documents describing the AM Program have only recently been developed. These include the CERP AM Strategy and the CERP AM Integration Guide. The CERP AM Strategy is a framework for seeking a better understanding of the South Florida ecosystem and using new scientific/technical information to improve the Plan. The CERP AM Integration Guide provides the details on how to integrate AM into the U.S. Army Corps of Engineers (Corps) six-step planning process, which governs the planning and implementation of CERP projects. Other CERP AM program accomplishments include: the development of project-level AM plans for several CERP projects; the initiation of an active AM field test; an effort to compile new scientific and technical knowledge gained over the past decade; and a workshop to detail the process by which new information from monitoring and assessment will be incorporated into CERP decision making.

Key messages relevant for Everglades restoration managers include:

- Until recently CERP projects have used AM in various ways. The AM Integration Guide provides guidance to help project teams apply AM consistently while tailoring to the specific scientific, technical, and/or policy aspects of the project.

- CERP is transitioning from planning to implementation and AM provides a structured approach for gathering new information and identifying issues. A formal process for incorporating that information into decision making is necessary, and is evolving as CERP progresses.

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RECOVER and the Role of Science in Everglades Restoration

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REstoration COordination and VERification (RECOVER) is the system-wide component of the Comprehensive Everglades Restoration Plan (CERP or Plan) responsible for linking science and the tools of science to a set of system-wide planning, evaluation and assessment tasks. Everglades restoration is science-based; the role of RECOVER is to ensure that the best available science continues to guide the Plan's implementation and that a system-wide perspective is maintained throughout the restoration process. This includes using applied science to optimize the design, sequencing and operations of CERP projects. RECOVER also supports the application of adaptive management (AM) to CERP, advocating the use of a scientific process that promotes and applies learning, reduces uncertainty and increases the chances of CERP success.

RECOVER executes its activities through three general mission areas: (1) Planning; (2) Evaluation; and (3) Assessment. RECOVER is guided by the RECOVER Leadership Group, which includes membership from 12 agencies including six federal agencies, four state agencies, and two Native American Tribes. RECOVER members are scientists, modelers, planners and resource specialists who organize and apply scientific and technical information in ways that are most effective in supporting the objectives of CERP. RECOVER uses multi-governmental and interdisciplinary collaboration to foster inclusiveness, cooperation, transparency, and universal access to tools and data. RECOVER works with the CERP projects to relate system-wide goals and objectives to project design and performance and to help integrate both system-wide science and AM into the project planning process.

Recent RECOVER products include: the 2009 Monitoring and Assessment Plan (MAP); the 2009 System Status Report, which uses monitoring data to assess the status of the Everglades and South Florida ecosystem; the 2015 Band 1 Report, which predicts and evaluates the performance of 10 initial CERP projects by simulating projects and associated operations; regional evaluations that evaluate and account for system-wide changes attributed to implementation of project alternatives and project contributions to achieving overall restoration; development of system performance measures that guide the evaluation of project designs and reporting of CERP performance; and development of the CERP AM Integration Guide, which details an AM program for both project-level implementation and system-wide application of AM principles.

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Do Wading Birds Nest near Alligators by Choice? Testing the "Nest Protector" Hypothesis

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Wading birds often nest over water inhabited by alligators, sometimes in apparent preference. This potential association has been noted in the field as well as in the more artificial setting of alligator farms. Many ecologists hypothesize that the alligators benefit the nesting birds as deterrents to mammals and snakes that may otherwise prey on wading bird nests. However, this potential interaction has not been experimentally examined. We are using several approaches to test selected predictions of this hypothesis using small willow-dominated colonies of little blue herons (*Egretta caerulea*) and tri-colored herons (*Egretta tricolor*) in the central Everglades as experimental units. First, to determine if the spatial relationship between nesting wading birds and alligators is nonrandom, we are comparing alligator densities near suitable, but previously unoccupied, wading bird nesting sites with densities near sites birds nested on in previous years. Second, we are manipulating densities of alligators and wading birds using an experimental array of 200 alligator and 400 bird decoys to determine if either species is attracted to the other via visual sensory cues. Third, we are quantifying mesopredator presence. Fourth, we are measuring the potential benefit alligators may derive from dropped food and chicks by using throughfall traps under nests. The strength and vectors of this potential mutualism will be evaluated in relation to results obtained from these ongoing studies.

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The Federal Civil Works Program and the Restoration of Lake Okeechobee

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Due to its size, central location, and current condition, Lake Okeechobee presents uniquely difficult challenges as an integral part of the overall South Florida Everglades Ecosystem Restoration Program. The Army Corps of Engineers' cost-shared federal civil works program, including the Central and Southern Florida Project and the Comprehensive Everglades Restoration Plan, contains several projects focused on the rehabilitation of the dike surrounding the lake and restoration of ecological functions within the Lake and its watershed and downstream areas impacted by deliveries of water. The Corps also has responsibility for operations decisions affecting ecological conditions in the Lake and downstream areas and the availability of water for municipal, agricultural, and environmental water supply purposes.

To date, implementation of projects and modifying operational plans affecting Lake Okeechobee and the surrounding region have proven to be difficult, resulting in significant delays affecting the recovery of ecological functions and resources. These difficult issues revolve around water resources planning and policy issues including cost-share requirements, recent trends and current water quality conditions in Lake Okeechobee and regulatory requirements, technical analysis tools and uncertainties, the distribution of and potential tradeoffs between benefits and impacts and the views of agencies and stakeholders, and project costs, budgeting rules, and funding capabilities.

This presentation will provide an overview of the linkages between these intertwined issues and current information on project implementation schedules.

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South Florida Ecosystem Restoration Issue Resolution and Change Control

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The South Florida Everglades Ecosystem Restoration (SFER) program includes multiple projects with an overall estimated program cost of approximately $20 billion involving all phases of project implementation, from initial planning and design through construction and long-term operations and maintenance and repair. To manage this enormously complex program, the Jacksonville District Corps of Engineers and the South Florida Water Management District have developed and implemented several program-specific management tools and procedures. This presentation will focus on two important elements of program and project management—issue resolution and change control.

At the heart of project implementation is the Project Delivery Team or PDT. The PDT is an interagency team charged with implementing the current phase of the project, whether it is planning, design, or construction. The PDT is led by Project Managers from the two sponsoring agencies; for SFER projects these are usually the Jacksonville District, U.S. Army Corps of Engineers (USACE) and the South Florida Water Management District (SFWMD). Issues are best resolved at the PDT level by team members most familiar with the project. If interagency issues can not be resolved by the PDT, they are presented to the Design Coordination Team (DCT) for resolution. The DCT consists of senior leadership from the USACE, the SFWMD, and the Florida Department of Environmental Protection, as well as regularly invited representatives from Department of Interior. Issues not resolved by the DCT may go to the Joint Project Review Board (JPRB), if only the USACE and the SFWMD are involved, or the Quality Review Board (QRB), if other agencies are involved. The JPRB and QRB membership includes executive level representatives from the respective agencies.

Like issue resolution, change control includes a hierarchical process for communicating impacts to projects, specifically scope, schedules, and budgets. As Project Managers recognize changes in their projects, they need to determine the impacts if any. Negative impacts should be mitigated to the extent possible. However, it is sometimes necessary to update the project scope, schedule, and budget. Often these changes mean delays in project deliverables or additional costs to the agencies. The change control process is used to elevate these changes and inform leadership of the impacts. A Change Control Request (CCR) is prepared by the Project Managers with an explanation of the change and the impacts. The CCR is routed to the various technical organizations of the agencies for coordination and approval. It is ultimately approved by senior leadership. Only then are the project schedule and budget baselines changed to reflect the change.

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Fate of Seasonally Deposited Mercury in the Florida Everglades

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The Florida Everglades, a subtropical freshwater wetland ecosystem, receives mercury (Hg) input primarily through atmospheric deposition, but elevated levels of Hg have been documented in fishes and wildlife. Constructing a mass budget for newly deposited Hg would be helpful to identify the ecosystem components (e.g., surface water, soil, periphyton, macrophyte, and fish) where Hg will be retained. Through constructing Hg mass budgets, we can predict the fate of newly deposited Hg after entering this system. Mass budgets for total Hg (THg) deposited during the 2005 dry and wet seasons and for methylmercury (MeHg) produced from the seasonally deposited Hg were established for the entire Everglades and for the four management units, namely the Water Conservation Area 1 (WCA 1), WCA 2, WCA 3, and the Everglades National Park (ENP), based on the USEPA Regional Environmental Monitoring and Assessment Program (R-EMAP) phase III data. About 75-80% of newly deposited THg during the 2005 dry or wet season is entrapped in soil. For MeHg produced from the newly deposited Hg, the fraction retained in soil is also about 80%, except for WCAs during the wet season where the contribution of soil storage is much less(48-68%). Accordingly, flocculent detrital organic matter (floc) can retain a considerable fraction of MeHg (about 16%). Distinct spatiality in THg and MeHg cycling between management units was observed, in particular between ENP and WCA 3. MeHg fluxes to soil, water, floc, macrophyte, and mosquitofish were 52, 1.4, 16, 13, and 3.4 ng/m^2/season in WCA 3 while they were 81, 0.38, 1.9, 5.8, and 1.5 ng/m^2/season in ENP during the wet season. These data suggests that less MeHg was retained in soil while more MeHg was transported into water, floc, macrophyte, and mosquitofish in WCA 3, in comparison to ENP. The differences in ecological and biogeochemical conditions (e.g., water depth and floc abundance) between ENP and WCA 3 played an important role in the disparity of MeHg cycling between these two management units.

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Anthropogenic Resource Utilization in the Diet of the Sacred Ibis, *Threskiornis aethiopicus*, a Non-Native Wading Bird in Southeastern Florida, USA

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The sacred ibis, *Threskiornis aethiopicus*, is a non-native wading bird in the Western Hemisphere. It is believed that in North America the sacred ibis escaped captivity from zoo aviaries and private collections following the destruction caused by Hurricane Andrew in 1992. Sightings of the species were restricted to urban areas until 2005 when breeding birds were detected in wading bird colonies in the Everglades region. There was concern that the establishment in the Everglades by this large wading bird would put pressure on the larger bodied endangered Wood Stork (*Mycteria American*), and the smaller bodied White Ibis (*Eudocimus albus*), through chick predation and resource competition. An eradication program was initiated by a consortium of government agencies in Florida in 2008 to avoid a case of exponential population growth of the Sacred Ibis as was seen in Europe. This study investigated the degree to which the population of sacred ibis in South Florida consumes anthropogenic food items, which may have contributed to its population expansion. Morphometric measurements, the first such data for this species in North America, were obtained for 8 adult males and 5 adult females. The contents of the esophageal tract and gizzards were used to classify ibis diets as being of anthropogenic origin if they contained cheese, meat, paper pulp, and/or pellet meal. Diets were comprised of predominately anthropogenic items (58% of the cumulative biomass). Ibis utilizing anthropogenic resources consumed more biomass (26.99g ± SE 5.35g) than birds utilizing natural resources (8.74g ± SE 2.21g) ($H = 8.05$, d.f. = 1, $p < 0.01$). Natural diets, on average, contained a significantly greater percent vegetative matter (63% ± SE 12%) than anthropogenic diets (8% ± SE 3%) ($H = 8.44$, d.f. = 1, $p < 0.01$). Novel organic and inorganic items found in anthropogenic diets included bacon, glass, hot dog, pellet meal, and plastic. The notion that some species of birds can adapt to newly available anthropogenic resources has wide support, and the impacts these resources have on avian ecology and physiology are becoming apparent through multiple studies. The ability of this species to heavily utilize anthropogenic resources may have helped it become established in South Florida, as it has helped the bird invade parts of Europe. However it is not clear whether this species prefers anthropogenic resources or whether they simply serve as a buffer when natural resources are scarce. Further investigation, of ecologically similar species, may elucidate linkages between resources in urbanized areas and impacts in nearby natural habitats.

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Projects and the Role of Science in Everglades Restoration- A Closer Look at C-111 Spreader Canal and its Objectives

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The CERP Projects are the tangible outcome of a symphony of science, policy, planning, engineering, and innovation that encompass Everglades Restoration. The projects attempt to link scientific restoration objectives with practical, cost effective solutions, while balancing numerous environmental, legal, social, cultural, and financial constraints. The CERP projects have specific, scientific objectives, which their proposed solution will attempt to obtain. The C-111 Spreader Canal project (C-111 SC) is one such project. This project addresses the need to restore ecosystem function in Taylor Slough and Florida Bay within the Everglades National Park, the adjacent Southern Glades, the Model Land, and other associated wetlands and estuarine systems. C-111 SC employs the concept of seepage management in order to improve flows and salinity regimes in Taylor Slough and Florida Bay.

The components of the C-111 SC Western PIR were designed for maximum restoration during the first phase of the project. The Frog Pond Detention Area and Aerojet Canal facility will work in unison to create a hydraulic ridge just east of Everglades National Park. The hydraulic ridge will decrease seepage out of the Park, thereby improving the quantity, timing, and distribution of water delivered to Florida Bay via Taylor Slough. Hydroperiods and hydropatterns within the wetlands of the Southern Glades and Model Lands will be improved by the construction of a new operable water control structure in the lower C-111 Canal, incremental operational changes at existing structure S-18C, changes in operations at the existing S-20 structure, construction of a plug at existing structure S-20A, and the installation of ten earthen plugs in the C-110 Canal. The features of the proposed project will also serve to return salinities to more natural levels in portions of Florida Bay and its associated estuaries. Ecologically damaging flows through the C-111 Basin to Barnes Sound will be eliminated and functional quality of wetland habitat will be improved.

Current Status:
The USACE and SFWMD agreed to use a dual PIR/EIS approach in an ultimately successful effort to expedite the construction of the C-111 SC Western PIR. The groundbreaking for this project occurred on January 26, 2010, six weeks after the PIR successfully went through the Civil Works Review Board process.

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Above- and Belowground Biomass and Net Primary Productivity Landscape Patterns of Mangrove Forests in the Florida Coastal Everglades

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Spatial and temporal patterns of mangrove vegetation in the Florida coastal Everglades (FCE) reflect a major interplay of resources, regulators and hydroperiod gradients. These gradients offer a unique opportunity to test hypotheses assessing the allocation of biomass and net primary productivity (NPP) of mangrove forests as response to the degree of interaction among factors such as salinity, nutrient availability, and hydroperiod. This complex interaction results in distinct riverine and scrub mangrove ecotypes at the same latitudinal gradient across the FCE landscape. We investigated landscape patterns of above- and belowground biomass and NPP of mangrove sites along two FCE estuaries: Shark River estuary (SRS-4, SRS-5, SRS-6) and Taylor River Slough (TS/Ph-6, TS/Ph-7, TS/Ph-8). We tested the hypothesis that the allocation of belowground biomass and NPP relative to aboveground is greater in the Taylor River region compared to the Shark River region, as a result of nutrient limitation and longer hydroperiods. The average biomass root: shoot ratio was 17 times higher in Taylor River relative to Shark River indicating that scrub mangroves allocate a larger proportion of their total biomass to belowground. Root: shoot ratios ranged from 0.33 ± 0.04 to 0.17 ± 0.01 in the Shark River sites, and from 1.92 to 9.75 ± 1.0 in the Taylor River sites. Aboveground NPP (ANPP: litterfall and wood) ranged from 322 g m^{-2} yr^{-1} (TS/Ph-6) to 1398 g m^{-2} yr^{-1} (SRS-6) across all sites, with average ANPP 3.4 times greater in the Shark River sites (1154 ± 127 g m^{-2} yr^{-1}) compared to the Taylor River sites (344 ± 17 g m^{-2} yr^{-1}). Litterfall production was the highest contribution to the total ANPP accounting for 75-85% of the total ANPP in Shark River and Taylor River, respectively. Total NPP ranged from 785 g m^{-2} yr^{-1} (TS/Ph-7) to 1867 g m^{-2} yr^{-1} (SRS-6) across all sites, with higher rates in all Shark River sites compared to Taylor River sites. Average total NPP was twice in Shark River (1680 ± 95 g m^{-2} yr^{-1}) compared to Taylor River (829 ± 29 g m^{-2} yr^{-1}). Litterfall production accounted for 51% (Shark River) and 34% (Taylor River) of the total NPP, while wood production only contributed 17% (Shark River) and 8% (Taylor River). Total root production ranged from 407 ± 23 g m^{-2} yr^{-1} (TS/Ph-7) to 643 ± 93 g m^{-2} yr^{-1} and made a significant contribution to total NPP accounting for 32% (Shark River) and 58% (Taylor River). The contribution of fine roots (<2 mm diameter) to the total NPP was 50% of the total root production estimated for both Shark River and Taylor River estuaries. Our results indicate that scrub mangroves of Taylor River have adapted to P limitation and longer hydroperiods by allocating more biomass and production belowground relative to aboveground. This information on how mangrove biomass and NPP are distinctly allocated between above- and belowground in response to environmental gradients across the FCE will be used to develop carbon budgets (storage, production and allocation) before and after major disturbances (i.e., hurricanes) and to improve our understanding of carbon dynamics in neotropical mangrove forests.

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An Update on the Biological Monitoring of the Lake Trafford Restoration Project, Collier County, Florida

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Lake Trafford is a shallow, subtropical lake that was subjected to increasing anthropogenic nutrient loading over several decades. Excessive growth of the invasive exotic aquatic plant *Hydrilla verticillata* choked out native aquatic plants and negatively impacted sport fisheries. Herbicide treatments for *Hydrilla* removal were successful but the eradication led to accumulation of a deep organic muck layer throughout the Lake and since then Lake Trafford has been a phytoplankton dominated lake with frequent algal blooms and fish kills. As a direct result of a grass roots initiative, the Big Cypress Basin of the SFWMD implemented a restoration project that involves hydraulic dredging of muck sediments from the lake. The removal of over 4 million cubic yards of sediments was completed in 2008. Additional de-mucking is currently underway with an expected completion date of April 2011. Natural recruitment of native aquatic macrophytes has been hindered by turbidity and reduced water clarity from remaining muck being easily re-suspended in the water column from wind generated waves. As the remaining muck is removed from Lake Trafford exposing a sand and shell/clay bottom, we expect to see dramatic shifts in water clarity, phytoplankton/zooplankton communities, and sedimentation rates.

A primary restoration goal is to return Lake Trafford to a mesotrophic, native macrophyte dominated lake with a stable sport fishery. The following monitoring plan elements are proposed to document the post-muck removal lake conditions of Lake Trafford –and- track performance measures of restoration success: 1) seasonal diurnal zooplankton surveys; 2) biweekly chlorophyll, phytoplantkton, and PhytoPam analysis for rapid light curves (RLC) and photosynthetic efficiency of the three major groups (Chlorophyceae, Bacillaryophyceae and Cyanophyceae); 3) annual SAV surveys and Lake Vegetation Index (LVI); 4) benthic and littoral zone macroinvertebrate community assessments; 5) littoral zone fish community structure; 6) sediment surveys and sedimentation rate monitoring; 7) weather station installation and monitoring; 8) modified water quality monitoring plan; and most importantly 9) develop a *Lake Management Plan* in cooperation with FDEP, SFWMD, FFWCC, USFWS, ACOE, and Collier County.

To enhance the restoration of Lake Trafford, a series of native planting projects have been proposed for both submergent and emergent species including eelgrass (*Vallisneria americana*), pondweed (*Potamogeton illinoisensis*) and bulrush (*Scripus validus*) in cooperation with the South Florida Water Management District and Florida Fish and Wildlife Conservation Commission with support from the USFWS.

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Setup, Formulation and Validation of a Spatially Explicit Hydrodynamic and Surface Water Chloride Concentration Model

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This poster focuses on the development and application of linked, spatially explicit hydrodynamic and water quality models for the Arthur R. Marshall Loxahatchee National Wildlife Refuge. The Refuge is a 58,000-ha remnant of the northern Everglades. The spatially explicit MIKE FLOOD and ECO Lab modeling frameworks were used to simulate the hydrodynamics and chloride transport within the Refuge. This MIKE FLOOD model dynamically links a one-dimensional MIKE-11 channel model with the 400*400 m two-dimensional MIKE-21 overland flow model, and allows for exchange of water and constituent between the two systems. Chloride is modeled as a conservative constituent. Through calibration, the chloride model helps to suggest and identify spatial patterns of roughness linked to vegetative cover, as well as requisite dispersive parameters. We conclude that chloride modeling provides a level of spatial information supporting hydrodynamic and transport model development that, in practice, could not be matched using direct measurements of discharge and velocity, and/or artificial tracer studies. The graphical and statistical comparisons of stage, depth, discharge, and concentration demonstrate that this coupled model can provide reliable predictions of the hydrodynamics and water constituent (chloride) movement in the Refuge. This modeling provides a better understanding of the impacts of contaminants and nutrient loading, and quantifies benefits of management alternatives.

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Bone-Rich Anthropogenic Sediments on Everglades Tree Islands

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The heads of Everglades tree islands are well known to be phosphorus hot-spots in the generally phosphorus-limited wetland. Proposed mechanisms of phosphorus concentration on the tree islands include contributions from atmospheric and groundwater sources, as well as guano deposits. Archaeological excavations of ~1-2 m deep peat deposits on the heads of several large teardrop-shaped tree islands in Shark River Slough revealed a 40-75 cm thick indurated mineralized layer at about 40-60 cm below the surface, composed primarily of calcrete (calcium carbonate) but including pockets of phoscrete (calcium phosphate). These layers are underlain by artifact-bearing peats/black earth middens that indicate human use of tree islands even in the earliest stages of Everglades wetland formation. Alkaline local soil water conditions generally inhibit the decomposition of bone materials and render bone-phosphorus largely immobile and relatively inaccessible for vegetative uptake, essentially trapping the phosphorus on the tree island heads. However, our geochemical and petrological analyses reveal evidence of calcium carbonate and phosphate dissolution and reprecipitation suggesting that bone and bedrock are local sources for the minerals forming the indurated layer. Fluctuating water tables and locally variable soil water chemistry driven by high rates of organic matter decomposition create conditions within the rooting zone where bone material is dissolved and reprecipitated, thus becoming sporadically accessible for vegetative uptake. At the same time, high evapotranspiration rates under the mature forest canopies promote the precipitation of calcium carbonate within the rooting zone leading to the formation of mature calcretes directly within the peat profile. Our work documents calcrete and phoscrete formation and diagenesis via X-Ray Fluorescence and electron microprobe analyses. We discuss the relevance of fluctuating water tables and chemistry and high rates of organic matter decomposition and evapotranspiration to new theories of teardrop-shaped tree island formation and the emergence of a regional-scale patterned landscape in Shark River Slough.

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Application of an Individual-Based Model of Roseate Spoonbills to Ecosystem Restoration

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We report on recent advances in the development of a generic multi-level modeling framework for ecological modeling. This modeling approach supports the linking of hydrologic models and ecologic models in a manner that facilitates modeling processes at multiple scales, from individual organisms to landscapes. The modeling framework is used to implement an open source decision support platform based on JGRASS that couples hydrologic model output from the Tides and Inflows in the Mangrove Ecotone model to the ALFISHES model, a model for assessing the impact of changes in hydrology on fish biomass. The output of the fish model is then coupled to an individual-based model (IBM) of Roseate Spoonbills (*Ajaia ajaja*) in order to assess the impact of restoration scenarios on Spoonbills, a key indicator species.

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Flow and Pattern in the Ridge-Slough Mosaic: Predictions of Two Alternative Mechanisms for Landform Development

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Landscape pattern development in peatlands occurs in response to the spatial interactions between local positive and distal negative feedbacks. The ridge-slough mosaic in the Everglades is a charismatic example of such self-organized patterning, and the persistence and loss of pattern represents a potentially useful indicator of target hydrologic conditions for restoration. The characteristic bi-modal pattern and pronounced patch elongation are thought to emerge from a) interactions at the local scale (among peat accretion, hydroperiod and vegetation) that create two alternative ecological configurations to achieve the same net peat accretion rate, and b) spatial coupling among patch types that create a distal feedback that anisotropically inhibits patch expansion. While local interactions that control the point-scale carbon budget can plausibly explain the presence of two alternative patch types, the mechanisms underlying patch geometry (patch elongation, pattern wavelength) are less clear. The clear flow-oriented elongation of patches has led to the predominant hypothesis that sediment redistribution (from sloughs to ridges) due to differential velocity is responsible for the historical pattern, and that the contemporary declines in velocity are responsible for the recent declines in pattern integrity. An alternative hypothesis, also dependent on flow but, crucially, not on velocity, has also been proposed. This mechanism, which has been referred to as the self-organizing canal hypothesis, starts with the observation that sloughs control landscape discharge competence due their greater depth and flow velocity. Lateral expansion of ridges constrains discharge competence, leading to extended hydroperiod, which ultimately precludes ridge expansion. The process is thought to work in reverse as well: lateral expansion of sloughs increases discharge competence, leading to reduced hydroperiod and thus conditions unfavorable for sloughs. Moreover, longitudinal expansion of either patch type would be neutral with regard to specific discharge (though secondary effects on water displacement and thus hydroperiod would still occur), which could lead to the observed elongation of patches. We note that these hypotheses are not mutually exclusive, but that discerning the relative importance of each is profoundly relevant to the particulars of hydrologic restoration. This talk will describe the two hypotheses in detail, and discuss possible empirical predictions that can be used to discriminate between them. Specific discriminatory predictions derive from evaluations of a cross-sectional water balance at contemporary vs. elevated velocities, emergent soil characteristics that are predicted in response to sediment redistribution, and comparative geometric characteristics of contemporary and historical landscape patterns.

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The Development of a Macroalgal Indicator of Salinity Patterns in Biscayne Bay

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The coastal ecosystems of the world, including those of South Florida, have experienced intense modifications caused by a combination of natural and human disturbances. The hydrology of South Florida has been significantly modified by the construction of a large water management system that has altered the natural flow of freshwater across the landscape and into coastal bays. In an attempt to recover lost natural drainage conditions, the Comprehensive Everglades Restoration Plan (CERP) will implement a series of engineering projects aimed at improving the quantity, quality, and delivery patterns of freshwater into Florida Bay and Biscayne Bay. However, the ecological consequences that this project may have on the abundance, diversity, and distribution of benthic organisms in littoral environments are not known.

While macroalgae are prominent components of benthic habitats of Biscayne Bay, limited information is available on their diversity and distribution in relationship to physical parameters. Our study was designed to determine the: (1) seasonal and spatial patterns of macroalgal community composition and abundance; and (2) relationships between macroalgae and physical parameters at Black Point, Biscayne Bay, an area presently influenced by the pulsed-release of freshwater from Black Creek. Surveys of physical parameters and macroalgae species were conducted from March 2008 to February 2009. Macroalgal species composition and distribution were determined and correlated to environmental parameters in search of species associations that could be used as indicators of salinity patterns.

A total of 31 species of macroalgae were documented in Black Point. The high variability in salinity appears to be shaping the distribution of macroalgae and seagrasses into three distinct communities: (1) a low salinity community dominated by *Chara hornemannii*, *Halodule wrigthii*, and puff (i.e., cyanobacteria-diatom-filamentous algae mix); (2) a brackish community dominated by *Penicillus capitatus*, *Batophora oerstedii*, and *Acetabularia shenckii* ; and (3) a marine community dominated by calcareous greens such as *Halimeda incrassata* and *Penicillus capitatus*, and *Thalassia testudinum*. Results of this study show that structural attributes of macroalgal communities can provide highly dynamic indicators of changes in water quality in Biscayne Bay that can be used as part of an adaptive management framework to provide both early targets of restoration and dynamic metrics to assess restoration success.

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Multi-Scale Characterization of Biogenic Gas Dynamics in Peat Soils Using Hydrogeophysical Methods: Implications for Biogenic Gas Distribution and Carbon Fluxes

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Peatlands are a major component of the Earth's carbon cycle, containing about one third of the carbon in the pedosphere and influencing climate by sequestering and releasing carbon dioxide and methane to the atmosphere. Ground penetrating radar (GPR) is a geophysical method based on measuring the travel times of continuous high-frequency electromagnetic (EM) waves between a transmitting and a receiving antenna. Velocity of this EM wave is primarily controlled by changes in water content and thus is very sensitive to variability in free phase gas content. The method has been effectively applied as a non-invasive technique for investigating biogenic gas dynamics in peat soils over a wide range of spatial scales with minimal disruption to the *in situ* gas regime. Several applications of GPR at both the laboratory and field scale are presented here in order to further investigate the spatial distribution and temporal dynamics of biogenic gases in peat soils. Laboratory measurements on samples extracted from both northern peatlands (from Maine and Minnesota) and subtropical peatlands (from the Everglades) are shown and compared here. Several field-scale applications of the technique in northern peatlands are described, and the potential implementations of the technique to research in the Everglades are discussed. We conclude with some further recommendations for future applications of GPR for investigating gas distribution and dynamics in peat soils.

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Analysis of the USGS Coastal Gradient Real-time Gaging Network

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The ideal data collection network would provide a spatially and temporally extensive record of the interactions between natural and societal systems for a region of interest. With the realities of funding and logistical challenges in maintaining gaging networks, there is a need to evaluate networks to understand the uniqueness of the gaging information that they provide. Two analytical approaches were applied to evaluate four years (2004-2007) of data from the U.S. Geological Survey's Coastal Gradient Network. One approach utilized time-series clustering techniques that groups hydrologic time series of similar behaviors. Cross-correlation matrices were generated for water-level, salinity (specific conductance), and discharge time-series. The Pearson coefficients were clustered using a k-means routine group time series with similar behaviors. After the initial clustering of the data by groups, the technique was then repeated on each sub-group to determine and rank the uniqueness of each gage/parameter within the group.

The second approach utilized a number of multivariate statistical approaches including fuzzy clustering, multi-dimensional scaling, k-means clustering, and principal components analysis (PCA). These techniques were used on a cross section of observations of the data chosen at time intervals such that the number of sampling sites included in the analyses was maximized. Fuzzy clustering was first employed to determine the appropriate number of clusters. The factor loadings of the PCA were then used to study the strength of association of sites along a number of principal components axes. The number of axes was based on an analysis of the eigenvalues to identify the number of significant factors needed to explain the majority of statistical variability in the data. The additional multivariate techniques were utilized as a comparison to the results of the PCA.

Results from the two approaches were similar and generally confirmed the rankings determined from each approach. The results were combined in a matrix for the network by parameter and provide a baseline of how each gage dynamically relates to other gages in the network for the period 2004- 2007. To detect changes in the hydrologic response of the system in the future, the analysis can be repeated to evaluate if there has been significant changes in the relationship between gages.

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Conceptual Components for the Coastal Everglades Depth Estimation Network (Coastal EDEN)

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The Everglades Depth Estimation Network (EDEN) has provided principal investigators and other water-resources managers with quality-assured water levels for 247 stations for the period January 1, 2000 to the present for the freshwater portion of the Everglades. In addition, EDEN provides ground elevation and water-level data on a 400-meter grid. Daily water-surfaces are generated and posted on the web and a set of applications (EDENapps) are provided that allow users to interrogate the water-surfaces and water-depths for locations of particular interest to a user. A similar portal for quality assured data and derived products is needed for the coastal areas.

The principal focus of "Coastal EDEN" will be the oligihaline/mesohaline zone in the Southern Everglades. These coastal areas, or specifically the Coastal Oligohaline Wetlands Zone (sometimes referred to as "the coastal fringe" or the "zone of change"), are critical in evaluating the hydrologic and ecological response to modifications of the water delivery system for restoration and future climate change. Hydrologic changes, either from flow alterations or climate change, will first be manifested along the coastal fringe. These areas experience tidal backwater conditions and increases in flow and/or sea-level rise may move this area inland. Coastal areas will probably exhibit larger relative changes in hydroperiods as compared to inland areas.

Various data and information products are being considered for Coastal EDEN to characterize the coastal fringe of the Everglades. One product would be to delineate the coastal fringe based on elevation intervals. The plant communities of the Everglades are a manifestation of the hydrologic history and hydroperiods, are the principal driver for many aspects of their ecological response. The EDEN water-surface and digital-elevation models would be extended and daily, weekly, monthly, and annual hydrographs would be generated to show changes in water depths for elevation intervals with the coastal fringe. A second product for Coastal EDEN would be current and recent hydrologic and salinity conditions maps. Water level, flow, salinity, and temperature data would be displayed with color codes for ranges of conditions for current real-time conditions or average conditions over the recent past (7-, 14-, 28-day). The data could also be displayed in tabular format. The third product would be a web accessible database of the Coastal EDEN stations. The data portal would allow users to download quality assured-historical data from various agencies for user-defined periods.

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Development of Empirical Hydrologic and Water-Quality Models of Loxahatchee National Wildlife Refuge using Data-Mining Techniques

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The Arthur R. Marshal Loxahatchee National Wildlife Refuge is the last of the low specific conductance, soft-water ecological systems in the Everglades. Historically, the ecosystem was driven by precipitation inputs to the system that were low in conductance and nutrients. With controlled releases into the canal that surrounds the Refuge, the transport of canal water with higher conductance and nutrient concentrations could potentially alter critical ecosystem functions of the interior marsh. With potential alteration of flow patterns to accommodate the restoration of the Everglades, the Refuge could be affected not only by changes in the timing and frequency of hydroperiods**,** but also by the quality of the water that inundates the Refuge.

Data-mining techniques were applied to 13 years of historical data to systematically synthesize and analyze the data set to enhance the understanding of the hydrology and water quality of the Refuge. From the analysis, empirical models, including artificial neural network (ANN), were develop, to answer critical questions such as relative impacts of controlled releases, and precipitation, and meteorological forcing on water level, conductance, and phosphorous. To make the models directly available to all stakeholders, an easy-to-use decision support system (DSS) was developed as an MSExcel[3] spreadsheet that integrates the historical database, ANN models, model controls, streaming graphics, and model output. The DSS also includes a visualization worksheet to provide three-dimensional graphical displays of spatial and temporal variability of water level, specific conductance, and total phosphorous in portions of the Refuge. The DSS will allow Refuge managers to easily execute the water level, conductance, and phosphorous models to evaluate various water-resource management scenarios.

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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Development of Inferential Sensors for Real-time Quality Control of Water-level Data for the EDEN Network

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The Everglades Depth Estimation Network (EDEN) is an integrated network of real-time water-level gaging stations, ground-elevation models, and water-surface models designed to provide scientists, engineers, and water-resource managers with current (2000-present) water-depth information for the entire freshwater portion of the greater Everglades. The U.S. Geological Survey Greater Everglades Priority Ecosystems Science program provides support for EDEN with the goal of providing quality-assured hydrologic data for the U.S. Army Corps of Engineers Comprehensive Everglades Restoration Plan. The generation of EDEN water-level surfaces is dependent on high quality real-time data. Real-time data are automatically checked for outliers using minimum and maximum thresholds for each station. Smaller errors in the real-time data, such as gradual drift of malfunctioning pressure transducers, are more difficult to immediately identify with visual inspection of time-series plots and may only be identified during on-site inspections of the gages. Correcting smaller errors in the data often is very time consuming and water-level data may not be finalized for several months. 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 missing or erroneous water-level data.

A technology often used for industrial applications is "inferential sensor." Rather than installing a redundant sensor to measure a process, such as an additional water-level gage, an inferential sensor, or virtual sensor, is developed that makes very accurate estimates of the process measured by the hard sensor. The inferential sensor typically is an empirical or mechanistic model using inputs from one or more proximal gages. The advantage of an inferential sensor is that it provides a redundant signal to the sensor in the field but without the environmental threats (floods or hurricanes, for example). In the event that a gage does malfunction, the inferential sensor provides an accurate estimate for the period of missing data. The inferential sensor also can be used in the quality assurance and quality control of the data. The virtual signal can be compared to the real-time data and if the difference between the two signals exceeds a certain tolerance, corrective action can be taken. Inferential sensors for gages in the EDEN network are currently (2010) under development. The inferential sensors will be automated so that the real-time EDEN data will continuously be compared to the inferential sensor signal and digital reports of the status of the real-time data will be sent periodically to the appropriate support personnel. The development and application of inferential sensors is easily transferable to other real-time hydrologic monitoring networks.

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Hindcasting Water-Surface Elevations for Water Conservation Area 3A South

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There is interest among principal investigators and water-resource managers for the Everglades Depth Estimation Network (EDEN) project team to generate water-surface and water-depth maps for periods prior to 2000. These maps would provide hydrologic data previously unavailable for assessing biological and ecological impacts over longer time periods. As one moves back in time, the quantity and quality of available data diminishes. An objective of the EDEN hindcasting effort will be to identify periods and regions where long-term hydrologic time series will support hindcasting. One approach for generating water-surface maps prior to 2000 is to hindcast particular sub-domains of EDEN where data supports multi-decadal hindcasting rather than the entire freshwater EDEN domain.

This approach was applied to Water Conservation Area 3A South (WCA3AS). Thirty-one stations from the EDEN network were used to generate water-surface elevation maps for WCA3AS using a sub-domain of the EDEN water-surface model. One important difference in the sub-domain model is that only measured canal data are used, rather than using the additional interpolated canal data that the EDEN model uses. Using a day in the current EDEN database (2000-present), the EDEN sub-domain model for WCA3AS was statistically compared to the current (2010) EDEN model for October 1, 2003. The sub-domain model had a lower cross-validation root mean squared error than the same sub-area of the EDEN model (13.74 and 39.75 centimeters [cm], respectively) and a lower mean error (0.12 and 0.33 cm, respectively).

To generate hindcasted water-surface maps prior to 2000, a database was built with the measured and hindcasted data and used as input for the sub-domain model. Thirteen of the 31 EDEN stations used for the sub-domain model were hindcasted back to 1990 using data-mining techniques including artificial neural network models. The hindcasted water-surface map enables the analysis and integration of historical hydrologic and ecological interactions.

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EverVIEW: Bringing Ecological Modeling, NetCDF Data Manipulation and Visualization to the Natural Resource Manager's Desktop

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Natural resource managers in the Greater Everglades have expressed their need to view and manipulate ecological modeling data on their desktop computers. Managers not only want to view model output on their desktops, but also to run ecological models, adjust model parameters when assessing alternative restoration plans, and have a spatially explicit visualization environment for comparing these alternatives. Working through the USGS Priority Ecosystem Science (PES) program, the National Wetlands Research Center has created EverVIEW to help address the needs of resource managers.

EverVIEW is a desktop application developed in Java for multiple operating systems. The application was designed in a framework which facilitates deploying functionality as tools or plug-ins. EverVIEW exposes tools to the user through various toolboxes such as the Data Manipulation Toolbox and the Modeling Toolbox. Tools can be incorporated into EverVIEW, the umbrella application, or downloaded and run as stand-alone executables.
The Greater Everglades modeling community is progressively moving to NetCDF as the default data container for modeling inputs and outputs. EverVIEW is designed to view NetCDF data in a spatially-explicit environment but also allows the user to view other local or web mapping service (WMS) enabled spatial datasets. The "NetCDF Slice & Dice Tool" from the Data Manipulation Toolbox was the first tool released. This tool allows the end-user to create subsets of NetCDF files through user-defined filters. Users can filter data using desired date ranges, seasons, spatial envelopes or polygon geometry, and other ranges of data values.

A unique feature of EverVIEW is an ability to instantiate multiple mapping panels, each of which can be populated with different datasets allowing the end-user to spatially compare modeling inputs and outputs. Users are able to download models from the Modeling Toolbox and view inputs and outputs on map panels arranged on the screen simultaneously. For example, after downloading the spoonbill habitat model, users can choose to view salinity, water depth and nest location inputs in separate map panels, and the resulting habitat suitability output in another panel.

The Greater Everglades management community can finally perform side by side model comparisons on their desktops using that information to make better informed decisions. EverVIEW will continue to evolve to maintain its relevance in meeting the needs of natural resource managers.

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The Mexican Bromeliad Weevil (*Metamasius callizona*): Changing Florida's Canopy

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The Mexican bromeliad weevil, *Metamasius callizona*, is an invasive bromeliad-eating weevil in Florida. The weevil arrived on ornamental shipments of bromeliads that came from Mexico and was first discovered in a grower's greenhouse in Broward County in 1989. An attempt was made to eradicate the weevil but it was too late – the weevil had already become established on nearby, native bromeliad populations. Since then, the weevil has spread to fill its new potential range in south and central Florida and, along the way, has destroyed native bromeliad populations. Twelve of Florida's 16 native species of bromeliads are susceptible to attack by the weevil. In North America, these 12 species are restricted to Florida and the greatest number and diversity are found in south Florida in the Everglades. All 12 species are epiphytic and are an important part of the canopy ecosystem. Several of Florida's bromeliads hold water in their leaf axils which functions as a water source for canopy animals and as the basis for aquatic ecosystems that support predictable flora and fauna. Other arthropods and canopy organisms, such as reptiles, birds, and small mammals, rely on the bromeliads for nesting sites, hunting grounds, and places of refuge. Left unchecked the weevil could potentially destroy up to 27 species (12 species of bromeliads and 15 species of invertebrates that rely on the bromeliads for survival), remove habitat and water sources from the canopy, and alter nutrient cycles. A biological control program, aimed at controlling the weevil, was started in 1991. In 1993, a potential biological control agent, a tachinid fly, *Lixadmontia franki*, was discovered in Honduras on a related species of bromeliad-eating weevil. The fly is a specialist parasitoid of bromeliad-eating weevils and was shown to parasitize *M. callizona* in the laboratory. Beginning in 2007, fly releases were made at several locations in the Everglades, including Loxahatchee National Wildlife Refuge, Fakahatchee Strand State Preserve, and Collier Seminole State Park, as well as other locations in Florida. Results show that the fly can survive in Florida but there has yet been no evidence of the fly being established or having an effect on wild weevil populations.

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Use of Hydrological Modeling for Selection of the Recommended Picayune Strand Restoration Plan

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The Picayune Strand Restoration Project (PSRP) was developed based on the combined planning efforts of ecologists, land use planners, engineers, and hydrologic modelers. This paper focuses on the hydrologic/hydraulic modeling that was conducted over the duration of the planning and design process. Key factors that were evaluated at each step are identified that led to either more modeling, more data collection activities, and ultimately design activities.

The PSRP is located in the Big Cypress Basin in southwest Florida just east of Naples. There are extensive wetlands throughout the Big Cypress Basin, and flood waters during the summer wet season often cross basin divides. The PSRP is bisected by four main north-south canals that were dredged during the 1960s. The four canals drain an area known as Southern Golden Gate Estates, which is located between U.S. 41 and I-75. This area was sparsely developed due to significant flooding of the area during the wet season. Two of the four canals (Faka Union and Miller Canals) extend 15 miles north of I-75 and pass through North Golden Gate Estates, a rural residential area. It was decided that the wetland restoration would not extend north of I-75 due to the numerous homes that would have to be purchased. This decision imposed the first major constraint on the project, which was to make sure that the wetland restoration of the southern half of the watershed did not cause further flooding problems in Northern Golden Gate Estates.

The first models developed of the area were separate surface and ground water models that addressed flooding and water supply issues. Once the restoration objective was established, the modeling effort switched to integrated surface/ground water issues due to the complex nature of the watershed. Calibration was the first challenge, and numerous data gaps were identified. The first version of the model was developed and was used for the initial alternatives analysis, which confirmed that flood control measures were probably necessary components of a restoration strategy. Data gaps were filled, and the model was re-calibrated, and another round of alternatives analysis was conducted. The alternatives included limited restoration with no upstream flooding or more extensive restoration with pumps and/or gates to maintain upstream flood protection. Many alternative scenarios were evaluated, and the modeling results were linked to ecologic response to help guide decision makers. Once engineering design tasks were initiated, another level of model development and calibration was conducted to support more design-level questions. This paper will highlight key issues at each step in the planning/design process.

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Relating Observed Extreme Salinity Events in Florida Bay to Physical and Hydraulic Conditions Simulated Using the FATHOM Model

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FATHOM is a spatially explicit model designed to simulate the movement of water and solutes in Florida Bay in response to runoff, climate, tides and the topography of the bay. The model maintains a mass-balance of water, salt, nutrients (N and P), dissolved oxygen, and heat (temperature) in each of 54 basins bounded by the shallow shoals that dissect the bay. Fluxes across the shoals driven by differences in water surface elevation on either side. Water velocity on the shoals is calculated as a function of bank width, depth of flow, and bottom roughness using Manning's equation for friction flow. Calculated velocities are used with cross sectional areas of water on the shoals to give water fluxes. Solute fluxes are then calculated from solute concentrations. Model input includes monthly climate data from the mainland and the Keys, estimated average monthly evaporation, monthly coastline runoff, and hourly tide stages along Gulf and Atlantic boundaries of the model. Monthly changes in mean sea level at the boundaries and long-term trends in annual average sea-level are added to the tide data. Bathymetry data are derived from a combination of NOAA charts for Florida Bay and bathymetric data collected in Florida Bay by the US Geological Survey. The roughness coefficient for Manning’s equation was derived from flume studies conducted in the northwestern area of the bay. FATHOM simulations of monthly salinity in Florida Bay have been compared with observed monthly salinity data from a long-term monitoring program conducted by the Southeast Environmental Research Center. For the period 1991 - 2002, simulated salinity accounts for greater than 75% of the variation in observed monthly salinity for the 12 years at 20 sites within Florida Bay.

In addition to simulated salinity values, FATHOM outputs include time-series estimates of physical and hydraulic conditions in Florida Bay. Within each of the 54 basins, the model provides monthly simulated values of residence times, water depths, wetted surface areas, and water volumes. For each shoal the model provides monthly average cross-sections of exchange between basins, monthly gross and residual fluxes of water and solutes across each shoal, and velocity profiles. It is reasonable to expect that there may exist important relationships between these physical and hydraulic conditions in the bay and occurrences of hyper-saline and/or hypo-saline episodes. We used the simulated physical and hydraulic outputs of FATHOM and the observed salinity data for 20 locations in the bay for the period 1991-2002 to develop empirical relationships for predicting extreme salinity events. The model outputs were used individually and in various non-dimensional combinations. The relationships are based on water budgets in each of the 20 individual basins for which observed data are available. Results show that the relative importance of the different physical and hydraulic characteristics varies across the bay in a manner consistent with published classifications of water quality regions within the bay.

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Bone Phosphorus Dominates Fixed Tree Island Soil in the Everglades WCA3

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The amount of phosphorus in fixed tree island soils is higher than in the surrounding waters and subaqueous soils. Soil phosphorus levels vary across the Everglades, as do the theories of the sources of the phosphorus and the modes of accumulation. Published theoretical sources of soil phosphate include guano, phosphatic dustfall, concentration from groundwater, and release from weathering of bone fragments. In 2008, we conducted a thorough study of the soil properties on Gumbo Limbo Island in Water Conservation Area 3 along with the soil water, slough water, and guano. The soil on the island summit is a very deep kitchen midden Mollisol with a continuous petrocalcic horizon at 47 cm, an apparent pre-habitation subaqueous soil surface at 190 cm and limestone bedrock at 202 cm. Soluble phosphorus was measured in soil and slough water and in bird guano droppings on plant leaves. Total phosphorus in bulk (unsieved) soil and water-washed sand (< 2mm) fractions were determined by HCl digestion. Results show that the slough water had almost no detectable soluble phosphorus, while soil water (0.11 ppm) and bird guano had a small amount (34.41 ppm). Bones > 2mm were identified in significant concentration in all horizons down to 190 cm, where a distinct decrease in bone volume and sharp increase in silt and clay occurred. Burned bones and artifacts were found in all horizons down to 190 cm, supporting human habitation and contribution to soil accumulation. Total phosphorus was 93,500 ppm in the surface and fluctuated irregularly between 56,900 and 114,400 ppm below the surface, with a distinct decrease to 38, 200 ppm below 190 cm. Preliminary sand grain counts indicate that much of the sand is made of bone, shell fragments, and cemented soil. The ratio of total phosphorus in the sand fraction versus the bulk sample of the A horizons (by weighted average) was 0.87, 0.40 in the horizon just above the petrocalcic surface, and 1.13 below the petrocalcic (by weighted average). These results show that the sand fraction provides higher contribution of total soil phosphorus from sand-sized particles below the petrocalcic than above, and very little from the sand just above the petrocalcic. Chemical weathering of phosphorus and plant uptake may explain the distribution. Soil water percolates through the rooted surface layers and may perch above the petrocalcic where roots concentrate, but underneath the petrocalcic there are few roots and a fluctuating high water table that prevents removal of weathered phosphorus. The calcium carbonate content is distinctly high just above the petrocalcic and below 190 cm. Soluble phosphorus would be immobilized as calcium-phosphate quickly in the soil since there is a significant calcium source and a pH of 8 throughout, making upward or downward movement of soluble phosphorus in this soil unlikely. Further investigation of petrocalcic horizon surface topography and extent along with a soil water sampling study are needed to further explain these data. However, phosphorus released by bone fragment weathering in each horizon sufficiently explains the source and quantity of total phosphorus throughout the soil, although minor additions from the other sources are possible. Soil data combined with archaeological evidence have preserved a record of island-building, climatic change, and chemical weathering.

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The Effect of a Preconditioning Salinity on Survival and Growth of Postlarvae and Juvenile Pink Shrimp

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The pink shrimp (*Farfantepenaeus duorarum)* is an ecological indicator species being used to evaluate changes in freshwater flow to Florida Bay and adjacent southwest coast ecosystems as part of the Comprehensive Everglades Restoration Project (CERP). The pink shrimp, like other penaeid species, tolerates a wide range of salinities from slightly brackish to hypersaline. It has been established that postlarvae of some penaeid species osmoregulate better than adults and that the salinity of prior-conditioning (long-term acclimation) during postlarval stages may modify the subsequent tolerance limits and growth. Our observations of field collections suggest that postlarvae enter Florida Bay nursery grounds between PL10 and PL20 (number indicating age or days as postlarvae). To determine whether the salinity tolerance range of pink shrimp is affected by the salinity at which postlarval stages are preconditioned, we conducted a series of laboratory survival trials with postlarvae of different ages, different conditioning periods, and two conditioning salinities, 15 and 35. Survival rates were determined between 0.5 and 144 h of exposure to 5, 10, 15, 25, 35, 45, 55 and 60 ppm salinity. The first two trials were conducted with postlarvae PL30 and PL40 (age at the end of preconditioning period) preconditioned to a salinity of 35 for 15 d and 30 d respectively in a recirculating system (28 ± 2.5^0C). The third and fourth trials were conducted with postlarvae PL50 preconditioned to salinities of 15 and 35 respectively at 25 ± 1.0^0C for 30 d. A subsequent growth experiment was conducted with PL90 juveniles previously conditioned to 15 and 35 ppm. Juveniles conditioned at 15 were tested at 5, 15 and 25, and those conditioned at 35 were tested at 25, 35 and 45. Pellet food was offered twice daily for 30 d. Results indicated similar survival rates for PL30 and PL40 preconditioned at 35--over 80% at salinities between 10 and 45, decreasing to 50% at 5 and 55, and less than 10% at 60. All PL50 preconditioned at 35 died at salinities of 5 and 10 after 6 h of exposure; however, survival was over 90% at salinities between 25 and 45. PL50 preconditioned at 15 did not survive more than 12 h at any salinity >35, but their survival at salinities 5 to 25 was over 96%. Survival results suggested that the tolerance range (homeostatic range) of postlarvae preconditioned at 15 and 35 shifted proportionally with the salinity of conditioning, or by 20 ppt. Growth results indicated that shrimps pre-conditioned at 15 grew faster at 15 and 25 than at 5 and those preconditioned at 35 grew faster at 25 and 35 than at 45; but differences were not significant. These results support our hypothesis that the salinity of prior-conditioning of postlarvae determines future tolerance range and the salinity most favorable for growth.

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Apocnemidophorus pipitzi (Coleoptera: Curculionidae), a New Candidate for Biological Control of Brazilian Peppertree, *Schinus terebinthifolius* (Anacardiaceae)

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Brazilian peppertree, *Schinus terebinthifolius* Raddi, was introduced into Florida, USA, from South America as an ornamental in the 1840s. It eventually escaped cultivation and has become an aggressive invader of disturbed and natural areas in peninsular Florida. Brazilian peppertree is a serious threat to the state's biodiversity, especially over large areas of the Everglades where it is displacing native vegetation. In the 1980s, this invasive weed was targeted for classical biological control because of the extent of the infestation and the absence of native congeners in the continental USA. In March 2006, a survey for new natural enemies of Brazilian peppertree was conducted in the Itapúa Province in southeastern Paraguay. A stem broing weevil identified as *Apocnemidophorus pipitzi* (Faust) was collected from the plant at several locations. Adults resemble bird droppings and feed mainly on the upper surface of subterminal leaflets, where they produce a characteristic notching pattern. Adults were transported under permit to the Florida Biological Control Laboratory in Gainesville and caged on potted Brazilian peppertree plants for biological and host range studies. A laboratory colony of the weevil *A. pipitzi* was established in April 2007 by caging the adults on cut branches of Brazilian peppertree supplemented with leaf bouquets. Females deposit eggs in the twigs and larvae feed under the bark where they damage the vascular cambium. A new generation of the weevil is produced in ~ ca. 3 months. Host specificity tests were conducted with 77 plant species in 39 families and 7 orders. The results of the multiple choice tests showed that *A. pipitzi* can reproduce only on Brazilian peppertree and the congeneric Hardee peppertree, *Schinus polygamus* (Cav.) Cabrera, which is invasive in California. The stem boring habit and results of laboratory host range tests indicate that A. *pipitzi* is a *Schinus* specialist. A petition to release this insect in Florida for biological control of Brazilian peppertree is in preparation.

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Integration of Ichnology, Cyclostratigraphy, Hydraulic Well Testing, and Lattice Boltzmann Methods for Carbonate Aquifer Characterization: A Case Study at the L-31N (L-30) Seepage Management Pilot Project

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Recent hydraulic testing in the Biscayne aquifer indicates that stratiform bioturbated zones, which are vertically constrained by upper and lower high-frequency cycle boundaries, can stack vertically to form an extremely transmissive aquifer over a substantial lateral distance. A thick stack of macroporous aquifer zones composed of *Ophiomorpha*-dominated ichnofabrics within the limestone of the Biscayne aquifer extend over a lateral distance of at least 8.4 km along the L-30 levee. Research is being conducted to understand the controls on the extent and hydraulic properties of these highly permeable zones to produce a predictive conceptualization of carbonate aquifer properties beyond the aquifer-test scale.

The focus of this study was to employ a combination of diverse tools—ichnology, cyclostratigraphy, hydraulic well testing, and Lattice Boltzmann methods—to characterize the hydraulic properties and distribution of macroporous aquifer zones chararcterized by *Ophiomorpha*-dominated ichnofabrics in the Biscayne aquifer. In 2008, open-hole, step-drawdown and 3-hour duration constant rate pumping tests were conducted on two coreholes that fully penetrate the carbonate rocks of the Biscayne aquifer along the L-30 levee within the area of the L-31(L-30) Seepage Management Pilot Project. Based on water-level measurements recorded during recovery from the constant rate pumping tests and corrected for background groundwater levels, a Theis method produced estimates of transmissivity values for the coreholes that are approximately 10 to 20 times higher than values from tests by Fish and Stewart (1991; Table 5) for the Biscayne aquifer, and 3 to 7 times higher than other previous tests that were reported by Fish and Stewart (1991, Table 3). The percentage of net thickness of hydrostratigraphic zones characterized by *Ophiomorpha*-dominated ichnofabric and related macroporosity is as high as 77% of the total aquifer thickness for four coreholes in the study area that fully penetrate the Biscayne aquifer. It is noteworthy that permeability values derived from the Theis method fall within a span of values (1.5×10^7 to 3.5×10^9 mD) calculated using Lattice Boltzmann methods (LBM) for outcrop and core samples, which are comprised of macroporosity principally related to an *Ophiomorpha*-dominated ichnofabric and collected from limestone of the Biscayne aquifer. The permeability values derived from both the recent hydraulic testing and LBM are very high—emphasizing the potential for extremely large flows, even for relatively small hydraulic gradients, related to *Ophiomorpha*-dominated ichnofabrics in the Biscayne aquifer, and other Middle Jurassic and younger carbonate aquifers, the generally accepted age range of *Ophiomorpha*. Macroporosity related to *Thalassinoides* burrow traces within the Cretaceous carbonates of the Edwards-Trinity aquifer system of central Texas serves as a comparative example. Results from this study are being integrated into planning of the L-31N(L-30) Seepage Management Pilot Project—a critical part of the Comprehensive Everglades Restoration Plan.

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Modeling Apple Snail Population Response to Hydrologic Change in the Everglades

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Apple snails (*Pomacea paludosa*) are a critical component of Florida wetland food webs. All size classes from 4 mm hatchlings to 30^{+} mm adult snails are targeted by aquatic predators ranging from crayfish to alligators, with avian predators, especially limpkins (Aramus guarauna) and endangered snail kites (*Rostrhamous sociabilis plumbeus*), foraging on adult-sized snails. The majority of the kite population is restricted to the Greater Everglades Ecosystem, and their intra-system distribution depends largely on finding sufficient snail densities and flooded marsh conditions to support their exclusive *Pomacea* diet. Consequently, understanding how hydrology impacts snail densities directly affects our understanding of how hydrology impacts the kite and other snail predators.

Several studies conducted in the last 12 years have quantified snail demographic response to environmental metrics including hydrology and plant community composition. These studies revealed that hydrology directly affects apple snail movement, survival, and recruitment. In addition, specific snail densities have been associated with kite foraging, including how density affects snail capture rates by kites. Sufficient empirical data now exist to support a simulation model of apple snail population response to hydrology. Model output can be used to evaluate faunal response to hydrologic scenarios related to restoration and management in the Everglades.

The purpose of the model is to describe the dynamics of an apple snail population at a scale of 500 m x 500 m cells that represent south Florida wetland habitats. The numbers of snails in a range of size classes is simulated at a daily time step. Environmental input data are daily water depths and air temperatures. Model parameterization is based on empirical data and includes 1) size-class dependent survival rates in dry down and flooded conditions, 2) temperature/seasonal based patterns of egg cluster production, 3) the effects of water depth on egg cluster production, 4) incubation and hatching rates, and 5) the effects of submersion on egg survival. The model is in development and we anticipate providing preliminary output for our presentation at the GEER conference. The model is designed to use a wide range of hydrologic scenarios. We anticipate incorporating other environmental effects (e.g., dominant emergent vegetation and submerged aquatic species) in future iterations of the model. In addition, the model output will eventually be linked to EVERKITE, a model simulating snail kite demography.

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Effects of Sea Level Rise (SLR) and Storm Surge Events on Coastal Vegetation Communities

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One consequence of sea level rise will be changes in coastal vegetation due to inland intrusion of high-salinity water, both from the average rise in sea level itself and from storm surges. In the coastal zone of southern Florida, mangrove vegetation is slowly encroaching on freshwater vegetation, such as hardwood hammocks. Using a spatially explicit mechanistic model, MANHAM, we have previously demonstrated that a large salinity change in the vadose zone, for example from a storm surge, could trigger a vegetation regime shift over a large area of inundation. However, this model makes a number of simplifying assumptions. The revised model described here improves on the model's realism.

The revised MANHAM model utilizes two overlapping coordinate systems. One coordinate system is a grid-based three-dimensional soil space using several stacked layers with N x M horizontal cells and several soil layers. Each cell or pixel represents 1*1 m^2 segment within a landscape that has a topography that increases along one horizontal dimension. This coordinate system is used to simulate hydrology, salinity and root distribution, which depends on vegetation distribution. Another coordinate system has the same area and shape as the first coordinate system, but it has a two-dimensional continuous surface. This coordinate system simulates the vegetation distribution. The reason for the two systems is that it is difficult to consider individual tree interactions in the grid-based system. The specific technical aspects of the model are as follows. An individual-based model is used to describe the dynamics of three tree types; hardwood hammock, mangrove, and buttonwood. Light and salinity limitation are modeled as multipliers. Tree-to-tree competition is modeled. Water movement and salinity in the soil vadose (unsaturated) zone are modeled at fine vertical resolution. Root distribution is modeled, which interacts with soil salinity and water uptake. Intertidal dispersal processes of mangrove propagules are included in an approximate way.

We have performed simulations using the revised MANHAM model. In the absence of disturbances, any initial distribution of mangroves and hammocks will self-organize into a pattern with sharp boundaries along a gradient in salinity. Mangroves occupy the low elevation, high salinity side, whereas hammocks occupy the high elevation, low salinity area. However, a large inundation from a storm surge event or a series of smaller inundations can cause a large-scale shift in the boundary. Threshold values for regime shifts under various conditions are presented and discussed. The MANHAM model will be combined with a model of landscape freshwater flows (BISECT model) and a storm surge model to investigate possible vegetation regime shifts.

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Hydrodynamic Modeling to Assess Factors Affecting Thermal Properties of a Passive Thermal Refuge in Southwest Florida

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Everglades restoration activities may cause changes to temperature and salinity stratification at the Port of the Islands (POI) marina, which could affect its suitability as a cold-weather refuge for manatees. To better understand how the Picayune Strand Restoration Project (PSRP) may alter this important resource in western Collier County in southwestern Florida, the USGS has developed a three-dimensional hydrodynamic model for the marina and canal system at POI.

The Environmental Fluid Dynamics Code (EFDC) simulator was used to produce a 10-14 m grid cell size model of POI to represent temperature and salinity transport. Boundary inputs were generated using a larger 500 m grid cell size 2D model constructed with the Flow and Transport in a Linked Overland-Aquifer Density Dependent System (FTLOADDS) simulator. Empirical data from POI suggest that manatees aggregate at the site during winter because of thermal inversions that provide warmer water near bottom. These thermal inversions, however, only appear to form in the presence of salinity stratification. Model results for a representative 9-month period (Sept. 2004 – May 2005) match observed trends in salinity and temperature fluctuations and produce temperature inversions with magnitudes and durations similar to observed values. Modified boundary conditions, representing proposed PSRP hydrologic restoration alterations, were also tested to examine how these alterations may affect the distribution and stratification of salinity and temperature inversions throughout POI. Periods of the restoration simulation show a reduction in salinity stratification and a subsequent reduction of the temperature inversion compared to the existing-conditions simulation. This may have an effect on POI's suitability as a passive thermal refuge for manatees and other temperature-sensitive species.

The model was also used to simulate three other scenarios that demonstrate the physical relationships relevant to the POI's suitability as a refuge. The first scenario simulated the area without the density effects of salinity within POI, and the results showed a substantial reduction in the system's ability to maintain a temperature inversion. Next, the simulated bottom elevation of the POI was increased, effectively deepening the port, resulting in increased salinity and temperature gradients. Lastly, the freshwater inflow volume and temperature were varied. The results indicated that increasing freshwater inflow increases the salinity stratification during the dry season. This only occurs if there is a temperature inversion and the inflow water temperature is not low enough to upset the existing stratification. This situation can happen if inflow temperatures closely mimic air temperatures during a cold front.

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Developing Genetic and Molecular Tools for Assessing and Controlling the Invasive Potential of *Lantana camara* and Protecting Native Lantana

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The Greater Everglades is home of many rare and endangered species. One of this species is *Lantana depressa*. It has been under the threat of genetic contamination and displacement by its invasive relative, *Lantana camara*. Natural cross-pollinations between the two species have resulted in hybrid plants that resemble the native species and can be easily misidentified as native plants. To overcome this difficulty, we have cloned and sequenced 384 DNA fragments from the Lantana genome, identified 225 sequences containing simple sequence repeats (SSRs), and developed 86 highly specific molecular (DNA) markers. These markers have been used to analyze the DNA fingerprints of 56 lantana accessions. Clear differences in DNA fingerprints have been observed between *L. depressa* and *L. camara*. Based on these fingerprints, we have identified two accessions that appear to be *L. depressa* in morphology, but are mostly likely cryptic interspecific hybrids. Pollination studies have been performed to assess the invasive potential of 10 commercially available *L. camara* varieties. Broadly four groups of varieties are recognized: (1) male- and female-fertile and able to cause genetic contamination as a pollen donor or receiver, (2) male-fertile but female-sterile and invasive as a pollen donor, (3) male-sterile but female-fertile and invasive as a pollen receiver, and (4) male- and female-sterile and non-invasive to *L. depressa*. New sterile (male and female) *L. camara* lines have been generated through ploidy manipulation. In conclusion, our results indicate the necessity of caution in selecting lantana accessions for ecological restoration or native landscape planting, and genetic and molecular tools can play powerful roles in assessing and controlling the invasiveness of exotic species and protecting the natives.

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Anuran Use of Natural Wetlands, Created Pools, and Existing Canals within the Picayune Strand Restoration Project

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The Picayune Strand Restoration Project (Picayune) is a major hydrologic/habitat restoration project in Collier County, Florida that is being conducted as part of the Comprehensive Everglades Restoration Plan (CERP). This study was designed to evaluate the success of the restoration activities within the Picayune by obtaining and analyzing anuran species richness and relative abundance in relation to various restoration phases. The restoration phases included two "treatments" (i.e., restored canal and un-restored canal) and a "reference" (i.e., natural wetland depression). Anuran observations were conducted using nocturnal audible call surveys, polyvinyl chloride (PVC) pipe refugia sampling, and dip netting. Based upon the audible call sampling and dip netting, the results indicated that the lowest species richness and relative abundance values occurred within the un-restored canal, then there was an increase in the restored canal, and highest values were in the natural wetlands. Also, the audible call sampling showed distinct groupings and similarities of anurans within each restoration phases and also identified significant differences in the distribution of anuran species relative to the different restoration phases. Specifically, *Gastrophryne carolinensis*, *Hyla femoralis*, and *Rana sphenocephala* were only documented in the natural and restored areas and *Hyla cinerea* and *Hyla squirella* preferred the natural areas the most followed by the restored areas; therefore, they appear to be "indicator species" of restoration success. These findings serve as an implication that the restoration activities within the Picayune are effective and that anurans are biological indicators of restoration success.

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Linear Man-Made Structures, Hydroscape Domestication, and Ecological Consequences

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Levees, canals, and roads have been identified as major structural stressors of the Everglades ecosystems. However, it is unclear via what mechanisms these structures influence ecological processes and patterns at various spatial-temporal scales. The mechanistic understanding is critical for restoration design. This presentation reviews the general effects of these linear structures on ecological systems and the mechanisms that generate the effects.
First, levees, canals, and roads interrupt natural physical and chemical processes of hydroscape, particularly hydrology. The most conspicuous impacts on hydrology include: alteration of the natural distribution and timing of presence, depth and flow of water, and the changes in the states of physical conditions, chemistry, dissolved matters, and sediment. Consequently, changes take place in the physical regime at each location, the geomorphic configurations of hydroscape, and the spatial-temporal characteristics, movements, and fates of the particles, chemicals and organisms in water. Secondly, the physical alterations influence populations and communities, and change the ecosystem functions of the hydroscape, because of a) blockage of the movement and dispersal of organisms, b) creation of new habitats, c) creation of travel lanes, particularly for exotic species, d) edge effects, and e) alteration of ecological and hydrologic connectivity. These influences alter spatial compositions, temporal patterns, and spatial processes of meta-populations, meta-communities, and ecosystems. They lead to decreases and extinctions of endemic populations, invasions of exotic populations, distortion of critical links in natural food webs, decreases in native biodiversity, degradation of ecosystem functions, and losses of ecosystem services. Thirdly, levees, canals, and roads facilitate landscape domestication, and increase human activities. These activities generate severe impacts. The most significant impacts of hydroscape domestication are probably the indirect effects of increased human social-economic activities, including alternation of land cover, agriculture, industrialization, pollution, and urbanization. Measurements of critical mechanisms and processes should be considered in the development of restoration performance measures.

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Wetland Drying has Substrate- and Species-Dependent Effects on Crayfish (*Procambarus* spp.) Populations.

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Wetland drying can be a severe disturbance for aquatic animal communities that provide prey for seasonally nesting wading birds. However the disturbance levels of wetland drying, measured as population reduction, and the net impact on animal densities will be context dependent. I conducted a 2 month experimental dry-out to compare burrowing success and survival (i.e., drying resistance) of two species of crayfish (*Procambarus fallax* and *Procambarus alleni*) in three common south Florida wetland soils (sand, marl, and peat). Throw trap density data taken from WCA 3A and Loxahatchee from 2005-2009 were used with local hydrologic covariates (modeled using EDEN water surfaces and local depth measurements) to consider the net effects of low water and drying on crayfish densities.

Burrowing observations when the water first dropped below the sediment surface indicated that the two species burrowed equally well in peat while *P. alleni* burrowed more successfully in the heavier marl and sand substrates. Survival after two months depended on species and substrate conditions. Survival was low for both species in sand and no *P. fallax* survived in that substrate. Survival was high for both species (~66%) in peat. *P. alleni* survived better than *P. fallax* in marl substrates. Both species experienced loss of body mass from initial conditions although *P. fallax* tended to lose more than *P. alleni*. The difference in survivorship of the two species in the marl was greater in this study with a 2 month drought than in an earlier experiment with a 3 week long drought. These results explain in part why *P. alleni* comes to near complete dominance in temporary marl wetlands while *P. fallax* can persist and maintain their densities in temporary wetlands with peat substrates and moderate drying.

Hydrologic covariates at six sites sampled through time in Loxahatchee explained little of the temporal and spatial density variation; *P. fallax* were abundant in Loxahatchee (3.75-9.75/m^2 averaged for each site over time) and seem able to re-grow quickly even following dry events of up to 10 weeks. While densities tended to be lower in central WCA 3A (2.2-4.7/m^2) densities were generally higher when water levels over the past year approximated conditions found in Loxahatchee. Taken together the results of these studies suggest *P. fallax* are resilient to moderate drying in wetlands with peat substrates and may achieve higher densities in response to moderately low water depths.

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Assessing Project Effects on Wildlife in Picayune Strand Restoration Project

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Assessment of effects of the Picayune Strand Restoration Project (PSRP) on fish and wildlife includes consideration of state and federal listed species, migratory birds, and natural resources that provide habitat to upland, freshwater wetland and estuarine species. Regulation and guidance is provided by the Endangered Species Act of 1973, (87 Stat. 884; 16 U.S.C. 1531 *et seq*.), the Fish and Wildlife Coordination Act (FWCA) of 1958, as amended (48 Stat. 401; 16 U.S.C. 661 *et seq*.) the Migratory Bird Treaty Act (16 U.S.C. 703-712), and applicable state and local jurisdiction. On-site and adjacent state and federal land management objectives such as endangered species recovery, timber harvest, exotic and nuisance plant management and public recreation also affect restoration objectives and fish and wildlife resources. Assessment includes prioritization of individual species in balance with ecosystem restoration, consideration of short and long-term effects of restoration activities, water management, and the range of predicted natural conditions.

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Tree Island-Grass Coexistence in the Everglades Freshwater System

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Mosaic freshwater landscapes in many wetland ecosystems exhibit tree-dominated patches interspersed in a background of marshes and wet prairies. In the Florida Everglades, tree islands provide habitat for a variety of plant and animal species and are hotspots of biodiversity. Even though the emergence of tree islands has been associated with climate histories, fluctuating hydrologic conditions, and internal feedbacks, a process-based quantitative understanding of the underlying dynamics is still missing. Here we develop a mechanistic framework that relates the dynamics of vegetation, nutrients and soil accretion/loss through ecogeomorphic feedbacks and interactions with hydrologic drivers. We show that the stable coexistence of tree islands and marshes results as an effect of their both being (meta-) stable states of the system. However, tree islands are found to have only a limited resilience, in that changes in hydrologic conditions or vegetation cover may cause an abrupt shift to a stable marsh state. The inherent non-linear and discontinuous dynamics determining the stability and resilience of tree islands should be accounted for in efforts aiming at the management, conservation and restoration of these features.

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Making Sea Level Rise Projections Actionable For Engineering

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As adaptation to sea level rise moves from discussion to action in south Florida, the role of projections in supporting engineering design is brought into question. In south Florida projections of sea level rise are available from many sources and in many forms. However, there is often a gap between the information provided by these projections and the actionable information required for design of coastal infrastructure. Given that adaptation planning for sea level rise is in a nascent form, the improvements in projections that would be produced by iterative feedback during their application, has been limited. Projections originally crafted to support discussion of adaptation options, the initial step in the adaptation process, are in many cases insufficient for subsequent engineering in their present form. Common limitations can be overcome by including:

- Local, not global, projections
- Projections given relative to specific, standardized tidal and geodetic datums
- (e.g. Mean Higher High Water and North American Vertical Datum of 1988)
- Specifying a reference period (e.g National Tidal Datum Epoch 1983-2001)
- Specifying a base year for the start of the projection
- Clear quantification and communication of uncertainty
- Integration of the projections into the context of tides, extratidal high water events, and storm surge

Additional improvements come from the recognition that sea level projections may not be the final decision support product, but are an input to other engineering-related processes such as statistical evaluations, modeling, or economic analyses. The projection's format can be reformulated to ensure compatibility with these secondary processes. Finally, in a region with multiple projections in use, the projections must be designed to allow intercomparison if integrated adaptation of complex, dependent systems is to occur.

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The Sea Level Projections of USACE EC 1165-2-211 in Context

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In 2009 the United States Army Corps of Engineers (USACE) released updated guidance on how to incorporate sea level rise considerations into civil works projects. The guidance was given in the form of an engineering circular, EC 1165-2-211, and it includes a methodology for calculating sea level rise projections. The method is an update of sea level rise recommendations from the National Research Council (NRC) in 1987. Given the age of the NRC's original report and that an abundance of research has taken place since, one may wonder how the USACE sea level rise projections compare to the latest scientific literature. Additional questions may arise regarding how the USACE projections compare with other projections in use in the region. To address these types of concerns, and place the USACE sea level rise projections into greater context, projections for various locations in south Florida are derived using the USACE's methods. The results are then evaluated with respect to: i.) the latest developments in the scientific literature, ii.) other projection methodologies, including those already in use in the region, iii.) greenhouse gases emissions scenarios, and related temperature change, associated with each sea level rise scenario, iv.) related effects of climate change including ocean acidification, storminess, and precipitation change, v.) utility and limitations of the sea level rise projections in decision- support.

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Mercury Concentrations and Stable Carbon and Nitrogen Isotopes in Fish along the Freshwater to Estuarine Transition in Eastern Florida Bay

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Fish were collected and analyzed for mercury and the stable isotopes of carbon and nitrogen along two gradients from coastal wetlands to the estuarine environment of eastern Florida Bay. The collections were conducted in parallel with collections of water and sediments for total mercury and methylmercury analysis. The purpose was to determine where methylmercury was entering the eastern bay and where it was entering the food web. Eastern Florida Bay had previously been identified as a “hot spot” for methylmercury bioaccumulation.

The fish collected included representatives of gamefish, intermediate sized fish, and small forage fish. The most abundant species among gamefish were largemouth bass, peacock bass, crevalle jack, and gray snapper, Mayan cichlids were the only abundant intermediate size fish collected. Abundant forage fish included mosquitofish, mojarra, and silversides. Most species were either freshwater or estuarine in their habitat preferences, but silversides, gray snapper, and crevalle jack were found distributed between brackish water and estuarine water salinities throughout the mangrove ecotone connecting the land and estuarine environments.

The stable carbon isotope signature (δC^{13}) can clearly distinguish feeding in freshwater and mangrove habitats (<-21.5‰) from feeding in bay habitats (>-17‰). Fish collected from the mangrove habitat had δC^{13} values covering nearly the full range of the freshwater and bay habitats, -30.6‰ to -12.0‰. A few marine fish such as crevalle jacks and snook found in the mangrove habitat had acquired δC^{13} values indicating that they had been resident in freshwater or mangrove habitats for much of their lives. These and some other marine fish had δC^{13} values that identified them as part time residents of the mangrove habitat. No freshwater fish had δC^{13} values indicating any residence in the bay and only a few, such as inland silversides, had values indicating residence in the mangrove habitat.

Across habitats, gamefish had higher average nitrogen isotope signatures (δN^{15}) and mercury concentrations than intermediate and forage fish. Among individuals within any species, these parameters increased with fish size, as expected.

In complementary studies, total mercury and methylmercury concentrations in water were observed to be highest in the mangrove habitat. There were no significant differences in mercury concentrations within any species across habitats. Factors than total mercury and methylmercury concentrations in water must be driving mercury bioaccumulation in fish in eastern Florida Bay. Temporary or transient utilization of the mangrove habitat may be part of the explanation. Differences in the bioavailability of methylmercury in water or differing food webs are other possibilities. In one exception, mercury concentrations in silversides roughly tracked the seasonal cycle of methylmercury concentrations in the waters of the mangrove ecotone, highest concentrations in the late summer to early fall period of maximum temperatures and freshwater inputs. The more rapid turnover of mercury in forage fish such as silversides than in larger, longer-lived gamefish may allow bioaccumulated mercury to better track changes in mercury concentrations in the water.

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Landscape-Scale Trends and Patterns of Ghost Tree Islands in the Everglades

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Tree islands in Water Conservation Area 2A (WCA-2A) have been significantly degraded due to water management practices initiated early to mid 20th century. Many of the islands have disappeared completely from the landscape and are now known as “ghost” islands. We surveyed the microtopography of ten tree islands across WCA-2A (8 “ghost” islands, one “live”, and one “transitional” island). Over 20 km of east-west transects were established across all islands to identify the patterns of peat and bedrock microtopography between the island and surrounding marsh. Peat elevation was assessed every 10 m along three transects (head, middle, neartail) on each island; bedrock depth was assessed at 20 m intervals along the same transects.

A review of aerial imagery over the last 6 decades showed the significant and consistent loss of island extent across WCA-2A. Island extent decreases occurred 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. Five of the islands sampled appear to have developed over pinnacle rock at the head while four islands appear to be over the flat bedrock surface, and one island appeared to have developed in a bedrock depression. On some of the island heads, pinnacle rock would extend up to 1 m from the surrounding bedrock; however, on the island where the head was over a depression, the bedrock depression was only ~30 cm. The shallowest soils were observed the northern part of WCA-2A while the deepest soils were encountered in the southern part of the Conservation Area. Peat topographic variability was greater within the head of the island relative to the middle or neartail transects. Bedrock topographic variability was not related to the peat microtopography although changes in elevation were greater within the bedrock relative to the peat.

Three hypotheses of island formation (i.e. islands formed over pinnacle rock, over bedrock depressions, and from pop-up formations implying no bedrock formational features (i.e. flat surface) proposed by Sklar et al. (2002) appear to have been supported in this study. Landscape-level peat thickness on the islands appeared to be controlled more by surficial drivers (e.g. duration and depth of flooding) rather than bedrock depth. There was a greater degree of variability in hydrology of the southern WCA-2A relative to the northern part of the WCA. The seasonal annual drydown most likely contributes to shallower peat depths (due to greater peat oxidation) as well as the difference in elevation between the slough and island. Any of the islands that have persisted to date in the southern part of the WCA should have adapted to these extreme hydrological fluxes. Deeper peat depth in southern WCA 2A is probably a result of slower oxidation under deeper water levels. Islands in the northern part of WCA-2A do not encounter the extreme seasonal changes in water level and therefore have less variability between the island and slough.

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The Influence of Tree Island Size and Hydroperiods on Two Common Everglades' Rodents: *Sigmodon hispidus* and *Oryzomys palustris*

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Rodents are thought to be the most widely distributed mammals throughout the Everglades, but little is known about the life history and ecology of even the most abundant rodents in the Everglades. A first and fundamental step to understanding the role of small mammals in the Everglades ecosystem is to investigate how rodents are influenced by the most salient characteristics of Everglades, namely its tree islands and hydrology. We use mark-recapture data collected between February 1994 and December 2005 on 16 tree islands at Rock Reef Pass, Everglades National Park, Homestead, Florida to investigate the influence of water levels, rainfall, and density within tree islands on the survivorship of the marsh rice rat (*Oryzomys palustris*) and the hispid cotton rat (*Sigmodon hispidus*) found on those islands. We also examined indirect indicators of female fitness and reproduction and related them to tree island size. We used an information-theoretic model selection approach to assess the relative support by the data of models that included hydrology and species' variables. The models best supported by the data not surprisingly included water level and intraspecific adensity and rainfall. The estimated monthly survival for both species was higher and more constant than expected for a small mammal. The expected survival of *O. palustr*is was minimally affected by water level while rainfall had a pronounced effect on expected survival of *S. hispidus.* Expected survival of species was greatly influenced by intraspecific density within tree islands. *O. palustris* and *S. hispidus* adult females preferentially used larger tree islands and juvenile density were positively correlated with tree island area and was greater on large tree islands than on medium and small tree islands. These capture results indicate that large islands are important sources of new recruits for both *S. hispidus* and *O. palustris*. Our results also provide evidence that changing water levels are likely to have an indirect effect on survivorship of both *S. hispidus* and *O. palustris* by altering interspecific density within tree islands. We suggest that the loss of larger tree islands has an adverse impact on both *S. hispidus* and *O. palustris* and that the increased distance between tree islands as a consequence of hydroperiod and water level modification reduces the resilience of these rodents to local changes in conditions.

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Bioenergetics as a Unifying Concept in Environmental Restoration Planning

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All other things being equal, including niche width, in intra-or inter-species competition, an organism that is capable of more efficient access to, availability of or use of the matter and energy at its theoretical disposal in its niche will have more matter and energy for predation, predator avoidance, growth, and reproduction, be more reproductively successful, and eventually outcompete and displace those less capable from the niche. One can infer from this that an ecosystem that is composed of such bioenergetically efficient niches is maximizing the capture, storage, and use of solar energy to convert less to more complex forms of matter and energy at each successive trophic level with the least entropy production. In addition to its general diagnostic value, the concepts, principles, and practices of mass and energy balances in the form of bioenergetics accounting has practical applications in testing hypotheses regarding food web statics and dynamics, the management of resource utilization for maximum sustainable yield, and for quantifying bioaccumulation/biomagnifications in aquatic and terrestrial ecosystems for ecotoxicological risk assessment (ERA). One practical application of bioenergetics to ERA involved testing the claim by third parties that attaining the proposed total phosphorus (TP) water quality standard of 10 ppb would result in such an ecotoxicologically significant increase in methylmercury concentrations in the aquatic food web due to a loss of phosphorus-mediated biodilution that it would threaten the reproductive success of fish-eating wading birds, including the endangered wood stork (*Mycteria americana*) and protected migratory birds such as the great blue heron (*Ardea herodias*) feeding in areas now at much higher TP concentrations. The empirical models used by the third parties to infer these unacceptable risks were unconstrained by mass or energy balance requirements. To remedy this deficiency, I developed a spreadsheet model of a wetlands unit world, where the coverages, densities, primary productivities, and refractory and decomposable fractions of algae and macrophyte species were dictated solely by the TP concentration in the water column. The equation for each was derived as empirical relationships from published studies conducted by others. The food chains included both autotrophic and saprotrophic pathways. To fully initialize the model, assumptions were made about foraging preferences and the fraction of carbon routed to the detrital pathway at each trophic level. The trophic transfer efficiencies of carbon and methylmercury were obtained from the literature for representative Everglades species, but where such data were unavailable, to the most similar species for which data were available. The carbon transfer model was calibrated to reproduce the observed aquatic plant and animal species densities reported by Trexler and co-workers at a representative unimpacted site in Water Conservation Area 1. The methylmercury transfer model was calibrated with data collected at the same site by or for SFWMD. The results of the calibrated model indicated a 2.5 to 3.5-fold increase in methylmercury exposure at U3 when TP concentrations decreased from 70 ppb to 10 ppb., not the 15-fold increase predicted by the empirical model. The next step is to reinitialize the model with the most recent Everglades data and compare the results of and conclusions from the original and revised models.

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A Time-Dependent, Multi-Trophic Level Model of First-Flush Methylmecury Bioaccumulation. Part 2. Model Application to Time-Dependent Ecotoxicological Risk Assessment

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Monitoring results of a first-flush methylmercury (MeHg) anomaly in one treatment cell of a constructed wetland in South Florida were used to develop a time-dependent, multi-trophic level mathematical model of MeHg bioaccumulation. The model simulates predator-prey relationships for the trophic level 2 (T2) fish, the mosquitofish (MF), *Gambusia holbrooki*, based on its physiology, foraging preferences, and prey preferences with prey switching. Model development is discussed in Part 1 of this series. The best-fit model for the MF was then modified to add representative T3 and T4 fish, the bluegill sunfish, *Lepomis macrochirus*, and largemouth bass , *Mircopterus salmoides*. The model assumes T4 fish forage includes small T3 fish, T2 fish, small crayfish, and a periphyton grazer, T3 fish forage includes T2 fish, small crayfish, a benthic macroinvertebrate, and both include incidental ingestion of sediment. However, there were too few total mercury (THg) as MeHg T3 and T4 concentration data to rigorously calibrate the model for the higher trophic levels; nevertheless, the modified model yields reasonable results when literature coefficients values are used. The modified model was then used to generate MeHg exposures for top-predator fish-eating birds, such as the great blue heron (*Ardea herodias*) and bald eagle (*Haliaeetus leucocephalus*). The time-integrated ecotoxicologcal hazard quotients (HQs) calculated using the time-dependent exposure model were then compared to HQs calculated using a more traditional, steady-state approach published in the peer-reviewed literature. The results of the comparison suggest that the steady-state approach can underestimate the cumulative exposures and associated ecotoxicological risks when prey MeHg concentrations peak in the period immediately preceding egg laying and/or persist through to fledging of exposed chicks. This is true even when probability density functions (pdfs) are substituted for single -value prey MeHg concentrations, because the pdfs are still centered on the averages or geometric means of the forage MeHg concentrations for the exposure period, even if the pdfs are skewed by the MeHg anomaly. The longer the exposure period considered, the more likely the effect of first-flush peak MeHg concentrations will be numerically diluted out by more typical concentrations. To identify such situations, the screening-level pdfs should be centered on the average of peak prey MeHg concentrations for the exposure period.

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A Trophodynamic Model of Methylmecury Bioaccumulation following a First-Flush Anomaly in a Constructed Wetland in South Florida: Part 1. Model Development Using Structural Sensitivity Analysis

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Stormwater Treatment Area (STA) 2 is one of six constructed wetlands complexes in South Florida for nutrient removal to support Everglades restoration. The first, second, and third floodings of Cell 1, an unfarmed parcel used as a hunting preserve, resulted in unprecedented first-flush methylmercury (MeHg) anomalies peaking at 4.8, 7.2, and 20 ng/L in unfiltered surface water in 2000, 2001, and 2002, respectively. The anticipation of progressively worsening first-flush events following successive dry-out and rewetting cycles prompted an intensive study of the third, involving inflow, interior, and outflow surface waters and interior marsh soil, pore water, periphyton, plants, and fish. The results were used to develop, calibrate, and apply a time-dependent, multi-trophic level mathematical model of methylmercury bioaccumulation consisting of a series of one-compartment uptake and depuration models linked to simulate predator-prey relationships. The time-dependent forcing functions were surface water, wet soil, periphyton, and macrophytes using observed MeHg concentrations with linear interpolation between measurements. The largemouth bass forage consisted of macroinvertebrates, mosquitofish, sunfish, and incidental ingestion of hydric soils; sunfish consisted of the same less sunfish, and mosquitofish that of a periphyton grazer with incidental ingestion of periphyton and a benthic macroinvertebrate with incidental ingestion of soil. The model differential equations were solved using a 0.1-day time step and a 4^{th}-order Runge-Kutta integration scheme. Following the pioneering work of Nordstrom and co-workers, the fish growth rate was an allometeric function of species and size, the fish forage rate was proportional to bioenergetic demand, which was proportional to growth rate plus active metabolic rate, the dissolved oxygen (DO) demand was proportional to the active metabolic rate, and the gill uptake efficiency of the truly dissolved fraction of MeHg was proportional to that of DO. To initialize the model, the MeHg bioaccumulation kinetics of the benthic macroinvertebrate were based on the freshwater mudworm, *Lumbriculus variegatus* and the periphyton grazer was assumed to have a depuration rate coefficient equal to ½ that of the mudworm. The mosquitofish feeding and DO consumption rate functions were adapted from literature values. The fish gill and gut uptake efficiencies were initially set at 20% of DO and 50% of theoretical, respectively. When the model would not calibrate to the observed mosquitofish data, the gill uptake efficiencies were reduced to 2% and the depuration rate coefficients of macroinvertebrate and grazer varied. The mosquitofish fit improved substantially but still overestimated the first-flush peak, then underestimated the declining profile therafter. The best fit was achieved only when mosquitofish prey-switching was invoked, assuming the macroinvertebrate population developed first and the grazer later. The experience from this exercise suggests several areas for subsequent research, including the assumption that all mosquitofish THg was MeHg and the influences of dissolved and forage organic carbon on the efficiencies of MeHg uptake via gill and gut, respectively. Also of interest are the effects of time-dependent MeHg recycling and prey switching on ecotoxicological risk assessment.

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Unifying Concepts for Interdisciplinary Planning for Environmental Restoration Programs

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Overreliance on a reductionist approach represents an unacceptable likelihood of missing, oversimplifying, or misrepresenting critical system components, stressors, or their interactions that are required for robust problem-solving. This can result in unexpected unintended adverse consequences, including potentially irreversible damage to the target resource. Examples include an overfocus on restoring a more natural Everglades hydroperiod as the primary means of restoring a more natural Everglades structure, function, and throughput, while ignoring or underestimating the significance of water quality stressors in general and nutrients, sulfate, mercury, or pesticides stressors in particular. The purpose of the session is to identify unifying concepts, principles, and practices in science, engineering, information management, and quality assurance/control that facilitate robust, interdisciplinary, environmental problem-solving in the face of uncertainty with acceptable Type I and II errors while avoiding unintended irreversible and minimizing reversible adverse consequences. This applies to one or more of each step in the problem-solving process: formulation of the questions to be answered by the study and the associated decision-making and data quality objectives; a summary of relevant monitoring, research, and modeling results to date; conceptual representation of the system of interest and its interactions with and responses to stressors of concern; hypothesis formulation; experimental design; selection of appropriate methods and procedures; and data analysis, integration, and synthesis, including empirical and mechanistic mathematical modeling within a mass and energy balance framework. Examples of substantial errors of omission or commission, their problem-solving consequences, and their interdisciplinary detection and corrections are also solicited. The session is intended to provide a forum for interdisciplinary generalists whose primary interest is designing, planning, and implementing ultimately successful environmental restoration and protection programs. Unifying concepts, principles, or practices appropriate for this session are:

- Mathematics
  - Symmetry
  - Chaos Theory, Game Theory, or Information Theory
- Complex Systems
  - Analog vs. Digital Representation
  - Conceptual, Statistical or Mechanistic Models
  - Systems Analysis or Operations Research
  - Interpolation, Extrapolation & Scaling
- Physicochemistry
  - Mass & Energy Balance
  - Principle of Indeterminacy or Least Action
  - Nonlinear Thermodynamics & Kinetics
- Ecology
  - Bioenergetics
  - Stoichiometrics
  - Stochastic Dynamics
- Diagnostics
  - Uncertainty/Sensitivity Analysis
  - Quality Assurance/Quality Control

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Management Issues And Long-Term Phosphorus Trends For Lake Istokpoga And Its Watershed – Are We Moving In The Right Direction For Lake Okeechobee?

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Istokpoga, Florida's 5th largest lake at 27,609 acres, is at the center of one of the most contentious ecosystem discussions in Florida. Since 1963, the lake has been effectively managed as a flood control and water supply reservoir, its watershed has been converted from open lands to agriculture. Nationwide, ecosystem restoration focuses on where problems are expressed, not where they originate; Lake Okeechobee and the Everglades are no exception. In 2003, Istokpoga was been described by the South Florida Water Management District as an uncontrolled source of phosphorus to Okeechobee, based on a three fold increase in annual phosphorus loading during the 1990s. From 1995 to 2004, Istokpoga consumed the lion's share of state funding to attempt *Hydrilla* eradication, but the realization that *Hydrilla* must be managed have curtailed that substantially. Looking upstream, phosphorus loading from Arbuckle Creek, its main tributary, increased from an estimated 19 mtons in 1994, to 124 mtons in 2003, but dropped back to 19 mtons in 2009. Since 1996, in-lake nutrient concentrations averaged 16 ug/L higher on the north half (71.6 ug/L) than the south (55 ug/L), though since 2006, lakewide concentrations have declined to 1997 levels. For several years, Istokpoga has absorbed as much as 50 mtons of phosphorus without exporting it downstream to Lake Okeechobee, but it was projected to be saturated by 2020 unless loads were reduced. Layered on top of this is the 2006 – 2008 drought that reduced flows to Istokpoga. For years, the lake and its watershed were going in the wrong direction to meet restoration goals for phosphorus loads to Okeechobee. Several projects, from restoring residential canal depths, distributed water storage and retention and wetlands restoration upstream, to reducing phosphorus loads through aggressive implementation of BMPs by farmers and residents are in various stages of completion or implementation. Is this watershed-wide effort reversing the loading trends both two and from Istokpoga of the past two decades? Is the Istokpoga watershed actually meeting the goals for restoration of Lake Okeechobee?

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Fire History in Everglades National Park and Big Cypress National Preserve

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Over the past several decades, the staffs of Everglades National Park (EVER) and Big Cypress National Preserve (BICY) have recorded a substantial amount of wildfire history data in the form of paper records, tabular data, hand-drawn burn perimeters on 1:24,000 scale USGS topographic maps, and more recently, Global Positioning Systems burn perimeter data. 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 include ongoing fire management activities, fire ecology studies as well as a variety of resource management issues related to the Comprehensive Everglades Restoration Plan. We document how these data have been incorporated into a user-friendly Geographic Information System geo-database. The database is explained and initial analyses of fire history in EVER and BICY are presented.

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Picayune Strand Restoration: Alternatives Evaluation and Selection of the Recommended Plan

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The Picayune Strand Restoration Project (PSRP) study produced one of the first Project Implementation Reports completed, approved, and authorized in the CERP program. The PSRP will restore to more natural conditions a 59,000 acre area that was overdrained by four large canals. The canals' drainage effects and construction of an extensive grid of roads resulted in significant changes to vegetation and wildlife in the area. The restored Picayune Strand will be a critical link between several existing state and federal parks and preserves in eastern Collier County.

The team developed alternatives of different features and sizes. Some initial alternatives focused mainly on inland restoration, some mainly on estuary restoration, and some on both. We added variations to some alternatives to ensure that existing level of service for flood protection was maintained.

The project delivery team used multiple methods to analyze the ecological benefits for inland and estuary areas, off-site impacts to multiple natural and human resources. Many of these methods relied on the output of hydrologic modeling. These effects were combined with costs to screen out all many alternatives. The remaining alternatives underwent cost effectiveness and incremental cost analysis for each of the benefit categories. While no plan performed best for all outputs, Alternative 3D performed near the top for each analysis and was selected as the Recommended Plan.

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Opposite Seasonal Patterns in *Chara* and *Halodule* Communities in the Mangrove Lakes and Estuaries of the Coastal Everglades: Relationships to Environmental Variables

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The Mangrove Lakes region of the coastal Everglades is a focus of the Comprehensive Everglades Restoration Plan (CERP). Extensive submerged aquatic vegetation (SAV) beds, supporting large populations of wading birds and wintering waterfowl, once characterized these areas. Present SAV, waterfowl, and wading bird abundances are all greatly reduced from historical (1931 - 1946) levels. These reductions are coincident with increased salinities, and possibly nutrients, in this region caused by diminished freshwater inflows due to water management practices. With a management goal of restoring historic SAV abundances, increased deliveries of freshwater to these mangrove estuaries are proposed to maintain lower salinities as part of CERP. *Chara* and *Halodule* communities are structured seasonally by environmental variables, some of which may change with restoration actions. It is necessary to understand seasonal SAV/water quality relationships in order to predict possible community changes and to restore the critical seasonal energy sources for wildlife provided by these communities.

The focus of this investigation was to describe the seasonality of the SAV communities in the Mangrove Lakes region and to relate the observed seasonalities to seasonal changes in environmental variables (i.e., salinity, temperature, nutrient concentrations, light availability, and phytoplankton abundance). Two distinct SAV communities were observed. The alga *Chara hornemannii* is dominant in the upstream brackish "lakes" while the vascular macrophyte *Halodule wrightii* is dominant in the downstream coastal embayments. Differences in mean salinity, light availability, and sediment thickness further distinguish these communities. Interestingly, seasonal patterns of abundance within these communities are opposite from each other. Peak *Chara* abundances are observed in the dry season while *Halodule* experiences peak abundances in the wet season. Little seasonality was observed in nutrient concentrations and phytoplankton abundances, but pronounced seasonality was observed in salinity, temperature, light availability, and water level. Multivariate analyses were employed to determine the strength of these environmental variables in explaining the seasonal variation of these communities. These functional relationships will provide resource managers with some key decision-making tools in the restoration efforts of the Mangrove Lakes region.

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Wading Bird Nesting as a Tool for Understanding Everglades Ecology: A Keystone Integrator and Generator of Trophic Hypotheses

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Declines in wading bird nesting numbers and nesting success have been linked in the public mind to Everglades degradation for decades, and this intuitive perception has resulted in the longest running biotic monitoring program in south Florida (>100 yr). This monitoring program has served as an early warning of several types of unanticipated ecological relationships and environmental change, and has generated several major hypotheses about how hydrology and community ecology are linked in the Everglades ecosystem. In this talk, I review the history of wading bird nesting in south Florida, and detail how this century-old monitoring program has led to key insights into the functioning of the Everglades ecosystem, many of which are central to current restoration hypotheses.

The first was an early warning of the collapse of productivity in the estuary as freshwater flows were reduced. Continued monitoring with Roseate Spoonbills has provided an especially clear example of how and why productivity is enhanced with temporary restoration of freshwater flows, providing a strong basis for the larger prediction that rewatering the coastal zone will lead to higher productivity and larger populations of wading birds and other piscivores there. The second insight has been that prey availability, foraging ecology, wading bird nesting numbers and nest success are tightly linked – this has previously been an untested assumption based on little evidence, and exploration of these relationships has generated detailed predictions and allowed spatial modeling of these linked processes. Variation in responses among avian species generated by monitoring has also led to specific predictions about how prey availability and community ecology have shifted over time, and how this function might be restored. Third, wading bird monitoring has also revealed a pulsed response in nesting following periods of droughts that has generated several testable predictions about the mechanisms of that relationship, and the role of cyclic disturbance as a driver of aquatic community ecology. Bird monitoring has also demonstrated the sudden emergence and decline of mercury contamination during the 1980s and 1990s. This has generated research that details how mercury contamination affects bird reproduction, and how mercury availability is related to hydrological management and restoration activities.

The net result of the wading bird monitoring program has been a detailed understanding of the relationship between bird nesting, foraging ecology, hydrology, and aquatic community ecology. During this process, hypotheses and assumptions about key ecological relationships in the trophic ecology of the Everglades have been directly tested, resulting in a much strengthened series of predictions about the effects of hydrological restoration. This information fits well with the characteristics of historical nesting, and has also allowed the development of four key indicators of ecosystem-wide restoration success.

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Chemical Treatment of Phosphorus in Lake Okeechobee Sediments as a Management Option to Reduce Bioavailability

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Chemical removal of various contaminants is a common practice in the water treatment industry. As such, this treatment may have application for inactivating or reducing biological availability of phosphorus (P) in the water column and sediments of lakes, rivers and estuaries. A laboratory study was conducted to chemically treat and reduce the bioavailability of phosphorus in Lake Okeechobee sediments. A total of 102 intact sediment/water core samples were collected from the central P-rich mud sediments. The cores were treated in the laboratory with four chemicals, calcium carbonate, calcium hydroxide, aluminum sulphate, and ferric chloride of varying doses and the change in soluble reactive phosphorus was monitored for 32 days. The results of this study showed that ferric chloride at concentrations at concentrations greater than 10 mg/l and aluminum sulphate concentrations greater than 30 mg/l significantly reduced water column SRP concentrations from 0.12 mg/l to approximately below 0.05 mg/l. The results suggested that both aluminum sulphate and ferric chloride were effective in reducing phosphorus bioavailability and the next step would be a limited pilot field application.

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Modeling Vegetation Succession Dynamics to Evaluate Landscape-level Responses to Everglades Restoration

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The Comprehensive Everglades Restoration Plan (CERP) is the largest wetland restoration project in the world whose objectives include improving the quantity, quality, and timing of water deliveries to the Everglades. Vegetation dynamics are largely influenced by current and past water management actions that have altered flow dynamics which changed the timing and quantity of water resulting in varying water depths and hydropatterns. The Everglades Landscape Vegetation Succession Model (ELVeS) predicts estimated shifts in the coastal saline, freshwater marsh, hammocks and pineland vegetation communities. Ecological drivers of succession in the model integrate hydrology (hydroperiod, water depths, frequency and duration of dry downs), nutrients, salinity, and large-scale dynamics including fire, hurricanes and climate change. The model is designed to address landscape dynamics of Everglades vegetation communities positioned along stress and competition gradients where species and community spatial dynamics are represented by a balance in niche space, transition probabilities between communities, and large-scale disturbances. Transitions between community states are defined with conditional probabilities weighted by spatial neighborhood community abundance and temporal lag periods specific to each respective plant community. The ELVeS's modular, object-oriented construction facilitates model expansion, improvement and flexibility to promote open source computing. Preliminary simulation results for Everglades freshwater marsh communities demonstrate anticipated vegetation community responses to future conditions following implementation of the CERP.

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Controls on Mangrove Carbon Cycling in Western Florida Everglades

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Mangrove forests inhabit harsh coastal environments where temporal and spatial nutrient and salinity gradients prevail. Due to their pan-tropical distribution mangroves also experience warm (> 30 ^{o}C) conditions and excessive evaporative demand. Despite their ecological importance, only limited information exists to ascertain the role mangroves exert to sequester carbon. Since 2004 we have investigated the net carbon ecosystem exchanges (NEE) between a mangrove forest and the atmosphere in the western Florida Everglades. With the aid of an eddy covariance system, deployed above the canopy, we have investigated edaphic and physiological conditions controlling the rates of carbon assimilation by mangroves. The magnitude of daytime NEE is highly variable throughout the year. Maximum daytime NEE occur during the springtime (March to May) and range from -20 to -25 µmol (CO_2) m^{-2} s^{-1}. Respiration rates are relatively low (2.81±2.41 µmol (CO_2) m^{-2} s^{-1}) in response to reduced biomass decomposition in the soils. Tidal inundation can exert control on NEE by reducing respiration by as much 0.9 µmol (CO_2) m^{-2} s^{-1} and 0.5 µmol (CO_2) m^{-2} s^{-1} during day- and night-time conditions. Salinity is another important determinant of forest carbon assimilation. As a result, light-use efficiency can be reduced at high salinity levels (>34 parts per thousand, ppt), with reductions around 45 % compared to low (<17 ppt) salinity. Mangroves exhibit substantial variations in the seasonal patterns of net ecosystem production (NEP) and NEE. The forest can be a large carbon sink, with an annual NEP of around 1,000g C m^{-2}. Such unusually high NEP values can be attributed to year-round productivity and low ecosystem respiration. The emerging results suggest that carbon balance in mangrove ecosystems can change in response to variable salinity and inundation patterns, possibly resulting from sea level rise and atmospheric warming.

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Risk Assessment of Invasive Wildlife Species in South Florida

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The recent focus of attention on invasive wildlife species in South Florida requires effective management strategies. Since most invasive wildlife species originate from the pet trade, screening imported wildlife to identify potential invasive species may provide an effective means to prevent future invasions. We developed quantitative models to assess risks from reptiles imported into South Florida based on logical correlates to predict establishment success using establishment records of exotic reptiles. Of the 17 biotic, abiotic, and human factors we examined, taxonomic order, similarity of maximum temperature between a reptile's native range and Florida, animal sale price, and manageability were effective predictors of establishment success. Applying the models to predict establishment success of 33 reptiles that were most frequently imported through Miami and St. Petersburg ports from 2000-2005, and two additional reptiles of concern in Florida, we identified eight lizards and four snakes as potentially successful invaders. We further assessed adverse impacts associated with potential invaders, should they become established, by identifying species that are (1) dangerous to humans, (2) dangerous to the ecosystem (e.g. upper trophic-level predators), and (3) rapidly spreading. We propose to extend this screening procedure to other wildlife species in the pet and aquaria trade in South Florida.
Although South Florida is generally considered to be highly susceptible to invasions by alien species, invasion potential may vary by site characteristics such as land cover type and human disturbance. A geographic based risk assessment of invasive wildlife to further understand relative site susceptibility would be informative to identify specific areas of concern. Moreover, there is a growing concern about the relationship between invasions of alien species and global climate change. Studies to predict climate change impacts on exotic invasions and adverse impacts on native ecosystems would increase our understanding of future risks posed by non-natives. Controlling invasive wildlife can be expensive and labor intensive once they are established. Development of novel methods to identify potential invaders, areas of invasion risks, and potential impacts of climate change will be a valuable input to the development of proactive management strategies.

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How to Incorporate Variability in Community Sensitivity in Detecting Ecological Response to Management-Driven Shifts in Hydrology and Water Quality

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Communities vary in their magnitude of response to changes in the environment, depending partly on previous exposure to environmental stressors or environmental stochasticity. Such variability in sensitivity can diminish the ability to detect ecosystem response to changes in underlying environmental drivers. However, sensitivity can be measured and used to determine community types that are best suited for detecting shifts due to environmental perturbations.

Community data that are highly resolved in space and time can be used to measure sensitivity to spatial and temporal environmental change. Such data series exist for the Comprehensive Everglades Restoration Program Monitoring and Assessment Plan, where data on aquatic community composition have been collected semi-annually since 2004. We analyzed periphyton community composition across approximately 125 sites in the Greater Everglades ecosystem, and determined the relationship of species relative abundances to variability in hydrologic and water quality variables. Periphyton-based predictions of hydrologic and water quality variables were compared to baseline expectations generated from years of intensive site-based research in each landscape sampling unit (wetland compartments). The deviation of these predictions from expectation could then be mapped for each sequential sampling event, and these maps used to easily denote locations where changes departed from expectation.

We determined that the same magnitude of environmental change did not elicit the same magnitude of community response within all landscape sampling units. We performed an NMDS ordination and tracked the changes in communities over time. We then used a trajectory analysis method to determine whether the communities were changing in correlation with parameters of interest, such as TP, periphyton biovolume, water depth, and days since last dry down. We found that some regions had trajectories significantly correlated with decreasing water depth and others with increasing TP. While these patterns could be explained by water management practices, some regions may also be exhibiting responses to climatological factors such as drought or Hurricane Wilma in October 2005.

This research will determine locations within the Greater Everglades ecosystem where we are most likely to detect change in response to water management. However, our ability to determine the cause of change in sensitive communities will depend on collecting data series of long-enough duration to encapsulate inherent natural interannual variability in the ecosystem.

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Effects of Seasonal Hydrology and the 2010 Cold Snap on the Distribution & Abundance of Snook, (*Centropomus undecimalis*) in the Upper Shark River, Everglades National Park

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Abiotic and biotic factors shape distributional patterns, influence the strength and outcome of species interactions and have consequences across multiple ecological scales. At small spatial and temporal scales, abiotic conditions influence patterns of species movement and habitat use. At larger scales, abiotic factors affect patterns of species abundance and distribution. Within estuarine systems, spatial and temporal variation in seasonal hydrology and tidal cycle can have large effects on estuary function and contributes substantially to the complexity of these ecosystems. One important question in our understanding of estuarine systems is: What are the key drivers of differential habitat use?

In the seasonally-pulsed Everglades ecosystem, rainfall (60% wet season, vs. 25% dry season) alters salinity and freshwater regimes, producing spatial and temporal gradients. This study examined the effects of this spatial and temporal variability on the abundance and distributional patterns of snook, *Centropomus undecimalis*, one of Florida's most sought after gamefishes. Ten creeks within Everglades National Park (EVER) were sampled along an estuarine gradient, from Tarpon Bay (downstream) to Rookery Branch drainage (upstream). Sampling was conducted via electrofishing, during the wet, early-dry, and mid-dry seasons of 2004-2010, and was conducted monthly from February 2010 through June 2010 following an anomalous cold event that resulted in substantially fish mortality in all areas of EVER. Snook abundance (calculated from electrofishing CPUE) differed between habitats and across seasons and years. Overall, abundances were higher in the upstream reaches of Rookery Branch creeks, particularly during the drier sampling periods. This pattern reflected directed movement of these transient estuarine species into headwater creeks as marsh water levels upstream receded and salinity increased. Our results indicate that as upstream marshes dry, pulses of freshwater taxa into tidal creeks may increase seasonal foraging opportunities for transient oligohaline and mesohaline species. However, expansion of suitable upstream habitats seem to be limited by dissolved oxygen conditions.

Following the January 2010 cold event, reports of fish kills were numerous throughout the Greater Everglades Ecosystem (GEE), and the severity of these cold events likely had strong impacts on snook populations. Our analysis of 6 years of pre-cold event data indicate snook numbers have declined drastically after January 2010, however recovery estimates remain challenging as we recorded snook mortality, but do not know what proportion of the population was able to emigrate from these ephemeral cold water periods. Ongoing work will elucidate patterns of recolonization and recovery, information vital to adaptive management of one of the most frequently noted target species within Everglades National Park.

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Changing How Projects are Managed while Maintaining Traditional Protocols: An Integrated Approach to Managing and Tracking Project Information

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Long standing administrative protocols have been in place for the management of projects at Everglades National Park. Utilizing new methods supported by specialized commercial software applications, these traditional, and often disjunct, protocols are now being integrated into a comprehensive system which will serve as a single point of access for the administration of projects thus, enhancing our ability to manage project related information. I provide an example of this application to the management of the Critical Ecosystem Studies Initiative, an $80M program that has generated roughly 300 separate research projects. Presented here is an overview of the approach and tools being used at the South Florida Natural Resources Center to create a more holistic utility with broader application to the everglades restoration effort.

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How do Canals Function as Habitat for Native & Nonnative Fishes in the Everglades Ecosystem?

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Canals are an integral component of the present-day, altered Everglades. Canals disrupt water flow, hydroperiod, and hydrological connectivity of natural habitats. They are also known to act as a source of nutrients, pollutants and invasive species by linking urban and agricultural waters with more pristine habitats in the marsh interior. Yet, we have a poor understanding how canals function as habitat for both native and non-native fishes and their ecological interplay with adjacent marsh habitats. 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 fishes. This study is a component of a three-part project designed to assess the impact and potential for containment of non-native fishes across Everglades habitats.

In this study, we are examining the spatiotemporal dynamics of fish communities, both native and nonnative, in canals bordering Everglades National Park (ENP; C-111, L-31W, L-31N & L29). Sampling is being conducted via boat-mounted electrofishing. We sample repeatedly throughout the year in order to understand how hydrology influences biotic exchanges between canals and adjacent marshes. 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, both in canals and in adjacent marshes? (4) How do we control & contain nonnative fishes that have invaded canals, but are not yet present in ENP marshes?

Because restoration efforts call for the removal of only a small portion of canals, and are being used by restoration projects to deliver water to Everglades habitats, there is a strong need to understand how these "novel habitats" function as reservoirs for nonnative taxa, piscivorous predators, and their interaction as a habitat with the natural wetlands of the ecosystem. Our research should yield insights into strategies for the containment of nonnative fishes, and into how to better incorporate nonnative fishes into the delivery of water. These insights should prove valuable for more effective management as we restore this dynamic ecosystem.

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Evaluating Remote Sensing Methods to Differentiate Plant Communities in Florida's Everglades

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Remote sensing methods offer the potential to monitor vegetation dynamics at relatively high temporal and medium spatial resolutions, which would be desirable for monitoring total system change in Everglades restoration. Application of RS in wetlands, however, has lagged behind its use in other landscapes. Our objective was to differentiate freshwater marsh communities using remotely sensed imagery, to evaluate the separability of communities based on spectral reflectance characteristics derived from satellite imagery, and to estimate and compare classification performance for different classification methods at different stages of the classification process. We classified communities at the structure and species level (condensed version of Vegetation Classification of South Florida Natural Areas; Rutchey et al. 2006). The separability of classes from spectral reflectance was evaluated for (1) the training sample method (manual versus random); (2) the feature (variable) selection for single and dual date imagery; (3) the classification method; and (4) the hierarchical level of the classification scheme (species versus structure). At the variable selection stage we considered percent reflectance from radiometrically corrected imagery together with their first-order textural derivatives and tasseled cap transformations. The evaluation of classifier models included recursive partitioning (a non-parametric method) and several parametric methods, including linear discriminant analysis, a maximum likelihood classifier, and a transformed divergence measure to determine class separability. Confusion matrices were established from cross validation procedures and performance was evaluated from overall accuracy and Kappa statistics for each model; we also evaluated the significance of differences between models for specific community classes.

Our results showed that remote sensing methods were effective in differentiating wetland community classes present in the sampled area of WCA 2A. Manually selected training pixels resulted in more narrowly defined spectral feature spaces with less overlap than those derived from randomly sampled grid centroids, which was confirmed by accuracy estimates. The most accurate model predicted the species level of our vegetation classification hierarchy from spectral reflectance + texture. Open water, open marsh, floating-leaved marsh and swamp shrubs all had high levels of accuracy. 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. The best overall model, however, was to classify at the species level; even if this produced low overall accuracies at that level, it increased overall accuracy upon aggregation to the structural level. Finally, the results of the tasseled cap analysis suggest that some additional information is added using these indices for several pairs of classes. Distinguishing different pairs of classes can be quite successful using a set of variables that performed poorly overall, so we recommend finding ways to combine variable and model strengths, combining them in more effective ways.

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Contaminants in Biscayne Bay: Everything Else but Nutrients

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Over the last two decades, a number of monitoring programs have gathered a wealth of information of contaminants both within Biscayne Bay and its associated watersheds. The impacts of traditional contaminants for which quality guidelines are available are easy to assess and often considered in management decisions. Other less regulated or less prevalent contaminants such as contemporary use pesticides, vegetation control chemicals, antifoulants, ubiquitous compounds such as Atrazine or pharmaceuticals and personal care products are not used for risk assessment or hazard interpretations because of the lack of regulatory or toxicological information. As examples, low but chronic levels of Atrazine 2-30ng/L are routinely detected in canals and coastal areas of the bay. Trace metals like Copper are elevated in marinas and canals leading to the bay but likely a product of boat storage and low water circulation. The antifoulant booster Iragrol 1051 is also routinely detected around marinas. Legacy contaminants like PCBs are seldom detected and one of the few detections in Southern Biscayne Bay is at Black Point canal downstream from the landfill. Pharmaceuticals like caffeine and the personal care product DEET are also detected in the same region but concentrations are relatively low (<2.5 – 54 ng/L and <0.24-19.3 ng/L).

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Development of Background Concentration for Trace Metals in Sediments: A Management Tool for Ecological Restoration

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A Contaminant Assessment and Risk Evaluation (CARE) project is being completed at three national parks in south Florida. Concentrations of 20 metals (Be, V, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Sn, Sb, Ba, Hg, Pb, Al, and Fe) were measured in surface sediments and soil samples collected at 30 stations in ENP (Everglades National Park), 9 stations in BCNP (Big Cypress National Preserve), and 11 stations in BNP (Biscayne National Park) from 2006 through 2007. The concentrations of six of these metals (Ag, Be, Cd, Hg, Sb, and Sn) were extremely low and below the MDL (method detection level); thus, these six metals were excluded from further analyses. Aluminum and Fe were included as reference metals to assess anthropogenic enrichment. The state of Florida's SQAG (sediment quality assessment guidelines) threshold effect levels for fresh (LEL) and marine (TEL) environments were used to develop screening effect indexes (EI) for each trace metal and a combined effect index (CI) for each site. Based on the EI and CI ranking, the screening level analysis shows that four trace metals (Cr, Cu, Pb, and Zn) could be of potential concern. For example, concentrations of Pb and Cr were elevated at several stations along the eastern boundary of ENP (E1, E3, and E5), while concentrations of Cu were elevated at two stations (BB1 and BB10) in BNP and one station east of ENP (S-178).

A key goal of the study was to establish background concentrations for trace metals in order to develop a management tool for ecological restoration. All stations were divided into five groups on the basis of sediment concentration by using cluster analysis (k means). The five groups represented five sediment concentrations: very low, low, medium, high, and very high. The lower two groups, very low and low, were arbitrarily selected to represent background sediment concentrations. Choosing other grouping combinations (three, four, six, and seven) did not affect the clustering of stations with low concentration; their classification remained nearly the same. The results of the five-group cluster analysis also were employed to construct enrichment plots (normalized against Al) and were compared to results from a similar approach (Schropp plots) previously developed for the entire state of Florida. Our results are not only in good agreement with the Schropp plots but also represent a more appropriate tool to evaluate regional concentrations.

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The Presence of Endosulfan Sulfate Residues in Water, Sediment, and Biological Samples in South Florida: Potential Environmental Implications

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A Contaminant Assessment and Risk Evaluation (CARE) project, which is a multimedia assessment of trace metals and pesticides, is being conducted at 50 sites within Everglades National Park, Biscayne National Park, and Big Cypress National Preserve, and also at sites in water delivery canals near the parks. This discussion focuses on endosulfan, a broad spectrum insecticide. Endosulfan-α, -β, and their metabolite, sulfate, have been detected in samples collected from south Florida environmental settings for more than two decades. Endosulfan and its metabolite have been documented in surface waters, sediments, organisms, and rainwater. Only recently, however, has endosulfan sulfate been used in combination with endosulfan-α and -β to estimate "total endosulfan" in surface waters and to compare its concentration to the water quality criterion for chronic exposure (0.056 µg/L). We and other authors have documented exceedances of the criterion in areas along the C-111 Basin, in particular at structure S-178, and have pointed out the potential ecological risks to freshwater organisms from exposure to endosulfan-α, -β, and their metabolite, sulfate, in surface waters. Samples collected for our CARE project contained all three compounds in all three matrices at different concentrations, frequencies, and with distinct geographical distributions. Although widespread regional contamination is not observed, sites along the eastern boundary of Everglades National Park and the lower portions of the C-111 Basin have higher concentrations and frequency of detections than sites elsewhere in the study area. Most of the surface water detections and all the criterion exceedances were at sites located at or near the S-178 structure and its upstream basin, the Loveland Slough. Both sediment and tissue detections also were higher and more frequently detected at sites in the Loveland Slough and at S-178 than anywhere else. Despite the lack of regulatory guidelines for body burdens, the presence of endosulfan sulfate in small demersal fish is a concern that needs further investigation. Because these fish support higher trophic level species such as wading birds, the observed body burdens could be of ecological significance.

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Biscayne Bay Salinity Monitoring Program

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Biscayne National Park administers the Biscayne Bay salinity monitoring program in conjunction with Miami-Dade County Department of Environmental Resources Management (DERM). This is a portion of the Comprehensive Everglades Restoration Plan (CERP) Monitoring and Assessment Plan (MAP) to provide information necessary to assess the effects of the CERP program on Biscayne Bay. This program was developed in conjunction with the United States Army Corp of Engineers (USACE), the South Florida Water Management District (SFWMD), Miami-Dade County, National Marine Fisheries Service (NMFS), and Everglades National Park. The goal of this program is to better understand Hydrodynamic patterns in Biscayne Bay and the salinity regime as it relates to organisms. It is important to understand how the bay responds to the constantly shifting natural and human induced operations. This will aid in understanding the Bay's responses to CERP.

There are 34 monitoring sites instrumented with YSI 6600 data sondes that continuously monitor temperature, depth, and conductivity. Sites were chosen by taking into consideration the contributions of navigational channels, canals, inlets, and freshwater inflow. Ten of these sites have been equipped with custom buoys that allow meters to collect surface data, while at the same site a meter is simultaneously logging data on the bottom. The northernmost site of the Biscayne National Park network is located south of Snapper Creek canal and sites are located as far south as Barnes Sound and Manatee Bay. Especially important, are the near-shore mangrove areas on the western side of the bay that have highly altered canal inflows which experience hyper-saline events alternating with extreme seasonal pulses of freshwater canal inflow. These operations result in conditions in the bay that inhibit the natural processes of Biscayne Bay and its fragile ecosystems. As the various stages of CERP projects are initiated, the salinity monitoring program will attempt to track any hydrologic changes that may be induced by these restoration efforts.

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Modeling Nutrient and Biological Sources within Hendry and Mullock Creek Basins: Identifying Areas of Concern and Recommending BMPs to Mitigate Effects

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Hendry Creek and Mullock Creek Basins are located in the Everglades West Coast Basin and have been listed as nutrient and bacteria impaired waters (Nitrogen, Phosphorus and fecal coliform). As a preliminary step in the establishment of Total Maximum Daily Loads (TMDLs) to meet applicable water quality standards, a "Desktop Model" was developed to (i) determine the relative importance (at an order of magnitude level) of nutrients and fecal coliform sources within both basins; and, (ii) provide a means of identifying important data gaps. Specifically, the goals were to inventory nutrients and biological sources in each basin, assess the relative contributions of each source, identify the primary areas of concern with respect to loading, and recommend further investigations to obtain additional data where important data gaps were found to exist in terms of local, reliable data, as well as directing "ground truthing" efforts to provide an order of magnitude calibration to the model.

The Desktop Model was developed in the form of a spreadsheet to assess the magnitude and location of the inputs (nutrient applied to the surface of a basin) and loadings (the portion of the input reaching surface and ground water bodies) of nutrients and fecal coliform within the two basins. In this Desktop Model, nutrient inputs to the basin were determined using best available data *(i.e.*, actual data from domestic wastewater, published application rates for the various land use categories), and the loadings to the basin were estimated through surface water discharge characteristics (*i.e.*, land use specific runoff coefficients and storm water event concentrations), direct discharge (*e.g.*, domestic wastewater and septic systems), and groundwater recharge.

When surface water loading alone is considered, the results suggest that the predominant nutrient loading to both basins is the storm water runoff loadings associated with residential land use, indicating best management practices for nutrient pollution abatement to the surface waters within the two basins should focus on fertilizer and storm water management in urban landscapes. When both surface and groundwater loadings are incorporated, septic tanks were identified as the predominant loading source. Importantly, several data gaps and the need for ground truthing of several model input parameters and results were both noted. Hence, further investigations consisting of field sampling activities to confirm and/or refine the modeled inputs are recommended. Of particular importance is the Lee County specific field measurement of nutrient attenuation with distance from typical onsite sewage treatment and disposal systems (OSTDS) to groundwater that subsequently contribute nutrient loading to the surface waters.

Animal waste, particularly from dogs and septic tanks were estimated as the primary fecal coliform input sources, but these loadings were not determined as presently little is known about their specific biological loading mechanisms. While incorporated in to the model, an important data gap is the loading from wildlife, particularly from rookeries. Further spatial trends and ground-truthing tracking studies using indicator fecal bacteria, including alternative fecal indicators and polymerase chain reaction (PCR)-based source identification are needed to confirm the magnitude and source of the loading mechanism of fecal coliform in the basin used in this study.

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A Synthesis of Recent Studies Showing How Prey Availability Affects Wading Bird Habitat Selection, Physiology, and Productivity

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The trophic hypothesis rests on the premise that food limits wading bird nesting in the Everglades and that hydrology controls the production and availability of aquatic prey animals. This synthesis paper tests part of that idea with a set of studies on wading birds and their prey conducted in 2005-2009. Data from a study of prey concentrations from the CERP Monitoring Aand Assessment Plan were linked to studies of wading bird habitat selection, physiology, and productivity. The responses of the Great Egret (*Ardea alba*) and White Ibis (*Eudocimus albus*), two species with contrasting foraging strategies, were compared in a year with high and low prey availability. Habitat selection was also determined from a comparison of random and used sites, and in enclosures where water depth, food, and habitat were manipulated.

White Ibises were more selective of foraging sites, particularly after hydrological reversals, lowered their clutch size, and fledged chicks in poorer physiological condition relative to Great Egrets in poor habitat condition years, suggesting that they are more constrained in their use of Everglades habitat. Poor foraging conditions should produce earlier and larger negative responses in White Ibis than Great Egrets, and may explain the difference in population trends between the two species.

When experimentally controlling for fish density, wading birds select sites where vegetation is present rather than open areas where prey are vulnerable. Prey concentrations are highest in areas with dense vegetation so it is likely that birds are selecting sites based on expected prey density rather than actual prey density or prey vulnerability. Receding water is more important to both species in years with poor habitat conditions than in years with good habitat conditions; however, egrets are more dependent on recession rate than are ibises. Fish-eating birds are reportedly more dependent on receding water than birds like the White Ibis, which eat primarily crayfish. Our study confirms that crayfish density does not increase as much as fish density during a drydown. The shape of the response to recession shows that recession rates below 5 mm per day or above 7 mm per day will increase nest failures. When prey availability is low, water level recession is more important to both species than when prey availability is high, supporting the idea that receding water is more important in a degraded landscape.

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Everglades CISMA Rapid Response to *Python sebae* in Miami Dade County

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The establishment and expansion of a population of Burmese pythons (*Python molurus*) has been well documented in South Florida for over a decade. Between 2002 and 2009, evidence of the establishment of second python species, Northern African pythons (*Python sebae*) increased after several large adults and neonate juveniles were collected in an area known as the Bird Drive Basin Recharge Area in Miami-Dade County. In January, 2010 the Exotic Animal Strike Team of the Everglades Cooperative Invasive Species Management Area (ECISMA) organized and conducted three days of systematic surveys in the Bird Drive Basin to locate and capture Northern African Pythons, Over 75 volunteers from the Miccosukee Tribe, county, federal and state government, NGOs and private citizens participated in the surveys to assist the Florida Fish and Wildlife Conservation Commission assess the status of African pythons by addressing the following questions: 1) To what extent are African pythons present in the Bird Drive Basin and can a large volunteer corps expect to find evidence of a population of African pythons by carrying out systematic surveys? 2) Have African pythons expanded beyond the boundaries of the Bird Drive Basin, north of US 41 or west of Krome Ave? 3) Are Burmese pythons also present in the Bird Drive Basin? The Everglades Cooperative Invasive Species Management Area was created to formalize cooperation among land management agencies to improve the effectiveness of exotic species control by sharing information, innovation and technology across borders through a memorandum of understanding with the ultimate goal of helping to ensure the success of the Comprehensive Everglades Restoration Plan

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Growth and Survival of *Pomacea paludosa* Say (Florida apple snail) Associated with Water Chemistry Gradients in the A.R.M. Loxahatchee National Wildlife Refuge

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Florida apple snails (*Pomacea paludosa* Say), the primary food source for the critically endangered Everglade Snail Kite, depend upon periphyton as a major part of their diet. Because periphyton assemblages are influenced by water quality conditions, the influence of varying water quality-driven periphyton assemblages on the growth and survival of the Florida apple snail was investigated. Eggs were randomly collected from the interior of the A.R.M. Loxahatchee National Wildlife Refuge (Refuge) and hatched into aerated aquaria at the Refuge headquarters. Hatchlings were maintained at the Refuge until they reached 4 – 7 mm (~4 - 6 weeks old) and then randomly distributed to cages set up along a water quality gradient extending from the perimeter (poor water quality) to the interior (better water quality) of the Refuge marsh. Snails were measured in two weeks intervals for a total of eight weeks. Growth, growth rates, and survival were compared among sites. Differences in growth and survival were detected among some sites. Weak, but significant, trends and correlations were detected between snail growth and periphyton AFDM, carbon content, and diatom and filamentous green algae abundances. Some dietary parameters of periphyton were also weakly linked to periphyton growth such as fat content and, inversely, protein content. A slight positive trend between snail aperture length and snail survival was also detected.

No one single factor responsible for differences in snail growth and survival was identified in this study. The results of this study indicate that while snail growth and survival are variable across gradients of water chemistry, even the oligotrophic conditions in the pristine, interior of the Refuge support snail growth and survival. This may have implications for future management promoting native apple snail and Everglades snail kite populations in the Refuge interior.

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Seagrasses and Subaqueous Soils of Lake Surprise, Florida

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Recent construction of U.S. Highway 1 across Lake Surprise, Florida arose concerns of detrimental effects to the local ecosystem. Potential eutrophication and burial events were thought to threaten a seagrass community dominated by *Thalassia testudinum* and *Halodule wrightii*. After construction completion in November 2008, a three-year monitoring project was initiated to track ecosystem health. Ninety-eight fixed sites arranged in a grid within the ~1.8 km^2 system were established to address the status of the seagrass and macroalgal communities and collect subaqueous soils. Vegetation surveys assessing seagrass community composition, shoot density and coverage, epiphyte and macroalgae coverage, and subaqueous soil sampling were conducted semi-annually. Additionally, a transplant study was carried out to determine the suitability of fill material used during bridge construction as a subaqueous soil for supporting *H. wrightii* survival and growth.

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Submerged Aquatic Vegetation (SAV) Monitoring in the Southern Indian River Lagoon, St. Lucie Estuary, Lake Worth Lagoon, and Caloosahatchee River and Estuary

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Submerged aquatic vegetation (SAV) provides important habitat for numerous organisms including fish, invertebrates, marine mammals, and turtles. Accordingly, SAV and the associated faunal communities are important indicators of estuarine condition. Our SAV monitoring project will provide the scientific basis for quantifying improvements made to this key indicator of restoration success brought about by the Comprehensive Everglades Restoration Program (CERP) and other restoration activities.

The Southern Indian River Lagoon, St. Lucie Estuary, and Lake Worth Lagoon are located on the south-central east coast of Florida. The Caloosahatchee River and Estuary are located on the southwest coast of Florida. Historically, natural freshwater discharges into these water bodies sustained an ecologically appropriate range of salinity conditions to facilitate the presence of healthy floral and faunal communities, including SAV.

SAV monitoring requires the in situ collection of biological data and water quality parameters accompanied by a statistical analysis of relationships, and an interpretation of the results with regard to CERP priorities. Monitoring is conducted bimonthly at a spatial one square meter scale for up to a five-year period.

A Monitoring and Assessment Plan (MAP) has been developed as the primary tool to assess the system-wide performance as part of the Restoration Coordination and Verification (RECOVER) program. The system-wide performance measures mentioned above address the responses of the South Florida ecosystem that the program is explicitly designed to improve, correct, or otherwise directly affect.

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Using a Spatially Explicit Crocodile Population Model to Predict Potential Impacts of Sea Level Rise and Everglades Restoration Alternatives

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The Restoration Coordination and Verification (RECOVER) component of CERP has determined that American crocodile (*Crocodylus acutus*) juvenile growth and survival must be achieved if CERP is to be considered successful in restoring the Everglades as a unique ecosystem. Juvenile crocodiles rely upon coastal wetlands characterized by low salinity and adequate volume, timing, and distribution of freshwater inflow.

As part of the U.S. Geological Survey's Priority Ecosystems Science (PES) initiative to provide the ecological science required during Everglades restoration, we created a spatially explicit stage-based crocodile population model that can be used to predict potential impacts associated with CERP restoration alternatives and sea level rise. The CERCM (Comprehensive Everglades Restoration Crocodile Model) integrates the TIME (Tides and Inflow in the Mangroves of the Everglades) hydrology model with American crocodile research and monitoring data. The stage-structured models are integrated with a spatial landscape grid to display crocodile movement behavior in response to changing environmental conditions.

The model predicts that full CERP implementation will result in a minimal increase in crocodile survival, density, and distribution in areas east of Taylor Slough in northeastern Florida Bay and a minimal decrease in areas around Buttonwood Canal, Coot Bay, Whitewater Bay, and Cape Sable. The next phase of model output is focused on CERP restoration alternatives that account for various levels of sea level rise. Initial model output predicts that sea level rise will have a substantial impact on the distribution of the crocodile population in southern Florida as salinity increases within coastal wetlands and historic nesting habitat becomes submerged. Future distributions of crocodiles are predicted to center around those areas that continue to provide available nesting habitat and receive adequate volumes of freshwater inflow well into the dry season.

Restoration efforts and sea level rise will alter salinity levels and water depths throughout the habitat of the American crocodile. Managers can use output from this model to develop management strategies that are able to adapt to these changing conditions.

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Salinity Tolerance of Wild-Caught Hatchling Burmese Pythons (*Python molurus bivittatus*)

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Non-native Burmese pythons (*Python molurus bivittatus*) have recently become established and are now breeding in south Florida's Everglades National Park. Pythons have been found in both fresh- and brackish-water habitats, yet it is unclear what limits salinity poses to their distribution and dispersal. Thus, we designed a laboratory study to test the salinity tolerance of Burmese python hatchlings over the course of ~7 months. In July 2009, we collected 24 pythons from the wild (mean total length [TL] 60.1 cm $\pm$ 4.4 SE; range 45.3-66.6 cm) and assigned them to one of three salinity treatments: 0 ppt (control), 10 ppt (brackish) and 35 ppt (marine). Snakes were allowed to acclimate for about one month to the laboratory setting with access to fresh-water. Once the experiment began (September 2009), we fed snakes a diet of hopper mice once every four weeks. Throughout the 7-month experiment, we maintained constant air temperatures in the laboratory setting at 25-28 ^{o}C and photoperiod at12 light hours: 12 dark hours. We checked all snakes once per day, five days per week and changed their water weekly.

We used the Kaplan-Meier product-limit estimator to determine estimated survival times at the three salinites and then used the log-rank test to compare survivorship of snakes across salinity treatments. Neither mass nor length of snakes varied by treatment at the beginning of the experiment (mass mean = 115.7 g $\pm$ 3.1 SE, range 49.0 – 126.0 g; TL mean = 60.1 cm $\pm$ 0.9 SE, range 45.3 – 67.4 cm). Salinity strongly impacted survival of hatchlings in the laboratory; both the 10 ppt and the 35 pt treatments were significantly different from the freshwater control ($P <$ 0.01). Hatchlings that were assigned to the 35 ppt treatment began dying after 16 days, with the last remaining hatchling in 35 ppt expiring on the 50th day of the experiment (mean estimated survival time = 32 days; 95% confidence interval [CI] 24-40 days). Hatchlings that were assigned to the 10 ppt treatment survived significantly longer than those in the 35 ppt treatment ($P < 0.01$). No controls (0 ppt) died during the experiment. Body size (mass and length) were not related to time until death for hatchlings exposed to the marine (35 ppt) salinity (linear regression; $P > 0.05$ for all comparisons).

Hatchling pythons exposed to full-marine salinity (e.g., 35 ppt treatment) did not die immediately. In fact, they lived about one month with no access to freshwater. Furthermore, the hatchlings exposed to estuarine (10 ppt) salinity lived significantly longer than those at the marine salinity. Thus, hatchlings emerging in marine and brackish-water environments such as coastal mangroves could survive and possibly disperse into new locations. Further tests of salinity tolerance of pythons in different age and size classes will help to clarify the significance of the apparent ability of hatchling Burmese pythons to survive in saline conditions.

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Florida Panther Recovery: Evidence, Models and Implications for Public Policy

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Over the past several decades, significant investment of public funds has been made to provide information about the behavioral habits, genetics, and ecology of the Florida panther relevant to species recovery, related land-use policy, and Everglades restoration planning. Evaluation of these data, including their use in models, has generated hypotheses regarding home range and movement/dispersal behaviors, habitat use and suitability, the need for and success of the genetic restoration program, and long-term panther population viability projections.

We first present an overview of the Florida panther recovery program and related monitoring data collected over the past 3 decades, including VHF radiotelemetry location data and more recently collected 24-hour GPS satellite data, biomedical data, observations of field sign, and yearly field counts of panthers by geographic subareas, with particular attention to conflicts about the implications of this evidence for panther science and recovery planning. We next review the published literature and identify key hypotheses and assertions regarding panther behavior and population dynamics and related public policy. We evaluate the data and models on which these hypotheses are based and identify those hypotheses with significant policy implications that are consistent with available data and those that have been determined to be incorrect or unsupported.

We then discuss the use of models in panther science, including PVA models, individual-based models and spatially-explicit index models, how these models interface with the full set of available evidence, and what advantages arise from different models to evaluate hypotheses about panther biology. We discuss the use of models as a support tool for public policy decisions and the effective application of models in conjunction with open discourse with various stakeholders to ensure the utilization of the best available science. We discuss implications for the collection and release of new data supported by public funds, including comments on monitoring schemes to address key scientific issues in panther science and to ensure that data sufficient for modeling, determining recovery requirements, and informing agency decision-making are collected and properly utilized.

Our long-term involvement with Florida panther science includes participation through the ATLSS project in modeling of the panther and its prey. We also participated on the Panther Subteam of MERIT, convened by USFWS to develop a landscape conservation strategy for panther recovery. This experience has afforded insights from multiple perspectives into the flow of information from monitoring to published literature and modeling to agency decision-making, encompassing both scientific and regulatory processes related to the panther.

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Soil Phosphorus Distribution in Ghost Tree Islands and Surrounding Marsh along a Hydrological Gradient in Water Conservation Area 2A

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Tree islands in the Florida Everglades are not only biodiversity hotspots, but are also hotspots for nutrients, especially phosphorus (P). Unfortunately, nearly all of the tree islands in the Water Conservation Area 2 (WCA-2) have disappeared due to anthropogenic influence over the past century. These tree islands, which are still visible from the air, but have lost elevation and woody vegetation, are called ghost tree islands. Very little information is available on the physical, chemical and biological changes that these tree islands have experienced. An effort is underway to understand the current physical (ground surface microtopography, soil depth and bulk density), chemical (nutrient and metal concentrations) and biological (vegetation species composition, biomass and coverage) status of these "footprints". The information may provide guidance for the restoration of these severely impacted tree islands. In order to test the hypothesis that the ghost tree islands are no longer biogeochemical hotspots and much of the P has leaked into the surrounding marsh, total P (TP) concentrations were determined 150 soil cores (30 cm long) collected from one living but impacted tree island, one severely degraded tree island and eight ghost tree islands along three transects (head, near-tail and tail) and a hydrological gradient in WCA-2A. Preliminary results revealed the dispersing trend of P into the surrounding marsh as evidenced by similar TP concentrations in the top soil layer (2.5 cm) between ghost tree islands and the surrounding marsh. The overall TP concentrations within the ghost tree islands were still higher than the marsh. This is in part due to the extremely high TP concentrations (mostly between 1000 and 90000 mg/kg) at one or two sampling sites (hotspot sites) at the head region of the ghost tree islands. For several islands, the average TP concentrations in the non-hotspot sites are not different from those in the surrounding marsh. Nutrient analysis from soil cores revealed a trend of decreasing TP concentrations with time in some hotspot sites, suggesting decreases in woody vegetation and wild animal presence when the tree islands experienced temporal changes in vegetation types from woody species to sawgrass.

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Foraging Ecology of Nesting Bald Eagles (*Haliaeetus leucocephalus*) in Florida Bay, Everglades National Park

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It is well documented that starting in the late 1980's, Florida Bay began to undergo a series of dramatic hydrologic and ecological changes due to altered freshwater inflows which affected salinities, causing seagrass die-offs, algal blooms, increased turbidity, and changes in prey-fish assemblages. It has never been documented before how these changes may have affected the Bald Eagle (*Haliaeetus leucocephalus*) population. We believe that changes in hydrological conditions may have lead to changes in prey communities, thus altering Bald Eagle foraging and nesting activity. The Bald Eagle is an opportunistic predator, scavenger, and prey thief. While there is a wide range of studies on Bald Eagle foraging, there is limited data available for their southern most range. It has been reported that eagles in southern Florida feed predominantly on fish and also wading birds, waterfowl, small mammals, and turtles, but there is no comprehensive study of diet for eagles residing in mangrove estuaries.

The purpose of this study is to document foraging ecology and test the hypothesis that food is the limiting factor to the success of Bald Eagle nesting in Florida Bay. We used digital video-monitoring equipment to monitor prey deliveries to the nest and provisioning rates of four eagle nests during the 2009-2010 breeding season. From these recordings we examined the foraging ecology of nesting Bald Eagles and determined prey consumption, percent composition of prey items, changes in provisioning rates, and changes in prey selection in relation to nest location, time throughout the breeding season, and productivity. We also collected prey remains from nests at the end of the breeding season and compared these to historical data from 1970's to examine for a potential change in prey composition, also in relation to nest location and productivity.

The significance of this study to the restoration of Florida Bay and the southern estuaries is that:

- An initial analysis of prey types and provisioning rates influence on current nesting success and productivity for nesting Bald Eagles in Florida Bay will be determined.

- Establishment of a data set of Bald Eagle prey items selected during the breeding season from nests located throughout Florida Bay based on current conditions and historical data.

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Historic Surface Water Discharge to Biscayne Bay via the Transverse Glades (TGs)

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Eighteen transverse glades (TG) are located in Miami-Dade County, fourteen cross the Coastal Ridge draining the Everglades and providing fresh water to Biscayne Bay, and two (Taylor and Shark Slough) which drain southward into Florida Bay supporting estuarine conditions. The Everglades water stage has been reduced between 2 and 4 ft since 1900 therefore historically the Everglades discharged considerably more fresh water through these TG than at present. In order to better understand the historic freshwater flow to the coastline along Biscayne Bay, we have calculated the historic volume of fresh water discharge for the southern seven TGs. The conservatively estimated minimal discharge is approximately 3.1 x 10^6 acft/y.

LiDAR data was used to create detailed topographic surface maps of the transverse glades crossing the ridge and GIS software used to produce both transverse and longitudinal elevation profiles of the southern seven TG's. The distribution of marl soils in the TG's was plotted and the highest elevation of the marl distribution in each TG was determined. Both the highest surface elevation of the marl soils and bank full cross-section areas were utilized to calculate flow. Top of the marl soil elevation was used because of the known hydroperiod (between 3 and 9 months) required for marl formation and we used 180d/y. Available historical data suggested very few no-flow days and extended periods of bank full flow but we assumed no-flow conditions of 170 d/y and 15 d/y of bank full flow. In addition, as stage increases so should water current velocity and discharge which we did not consider so our estimates are extremely conservative.

The slopes of the TG's were measured and determined to be, minimally, 15.8 times greater than the Everglades and the elevations of nick points (or sills) were also identified. Longitudinal profiles from two glades demonstrate that both went subsurface at their eastern ends. Water flow rates are estimated but are based upon observations made in the low slope Shark Slough and from the ability to transport quartz sand grains of known diameter downstream in the glades. When water stage was below the TG sill a flow rate of 0cm/sec was assumed and during periods of low flow a rate of 1cm/sec (extremely conservative) was used. During high stages a flow rate of 25cm/sec was used (the minimal flow required to transport quartz sand grains of 250 microns) observed in most TG's. Based upon the cross-section areas, hydroperiods and estimated flow velocities for the seven TG's analyzed discharge was calculated and totaled. Note that this figure does not include the northern peat TGs which had longer hydroperiods, greater slopes and much greater discharge than their southern counterparts nor does it address increased ground water flow through the presently abandoned water table cave system.

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Potential Anthropogenic Changes in Dove Lake (Tidal Lake) In the Upper Florida Keys over the Last 100 Years

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The sediment record in Dove Lake is used to document ecological shifts in response to anthropogenic modifications occurring over the last 100 years. A sub-aqueous sediment cores was collected from Dove Lake, a marine tidal lake, located in Tavernier, Florida. Dates and accumulation rates for the sediment cores were established through ^{210}Pb dating. Lead-210 is an ideal tracer for determining dates and accumulation rates on a 100 year time scale, which is the most relevant time scale for examining consequences of recent change. It is during this time that major anthropogenic modifications have taken place within the Upper Florida Keys and surrounding areas. Tidal lake deposits are a good archive for correlating historical changes in productivity associated with these anthropogenic modifications.

Total nitrogen, organic carbon, δ^{15}N, δ^{13}C and sedimentary photosynthetic pigments (chlorophylls and carotenoids) are proxies used to better interpret past ecological conditions within this system. Historical information associated with anthropogenic changes within the geographical location coupled with an examination of ecological proxies within the sediment record can be used to determine the influence of those anthropogenic changes on water quality.

The ^{210}Pb dating model indicates mass sedimentation rates were less than 7 mg cm^{-2} yr^{-1} from approximately1875 through the early 1950s with a noticeable increase beginning after the early 1950s. The mass sediment accumulation rate increased to greater than 20 mg cm^{-2} yr^{-1} by approximately1980. The sediment accumulation rates continued to increase until the 1990s when values reach a plateau of approximately 30 mg cm^{-2} yr^{-1}.

Percentage of organic matter increases along with sediment accumulation suggesting the acceleration in sediment accumulation is the result of enhanced productivity possible due to increased nutrient loading. Anthropogenic influences on the Dove Lake system have increased both the mass accumulation rate as well as the fraction of organic matter..

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Evaluating the Impacts of *Cichlasoma urophthalmus* (Mayan cichlids) in the Southern Everglades

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The Mayan cichlid (*Cichlasoma urophthalmus*), which is endemic to Central America, was first recorded within the Everglades National Park in 1983. The impact of this species on native biota has not been well quantified, but recent observational data has suggested that Mayan cichlids negatively impact native fish species. We examined the effect of Mayan cichlids on native fish populations from 1991 to 2006 in the mangrove zone of southeastern Everglades National Park. Fish community data from drop traps were collected and analyzed from six sites within the Everglades (Rookery Branch, Craighead Pond, Taylor River, Joe Bay, Highway Creek and Barnes Sound respectively).These sites range in salinity from 0 – 49 ppt and were sampled eight months per year from 1991 to 2006. Analysis of similarity (ANOSIM), nonmetric multi-dimensional scaling (NMDS) plots, and similarity (SIMPER) analyses showed that the sites differed significantly in community composition consistent with the presence or absence of Mayan cichlids ($p<0.01$). It was hypothesized that Mayan cichlids contributed to the community differences by impacting the densities of native fish. By analyzing temporal patterns at the two sites with periodically high density of Mayan cichlids, we found that their density was negatively affected by low water temperatures in four winters of the 16 year study. Analysis of the axes from NMDS showed that several native fish species were negatively correlated with Mayan cichlid relative abundance and GLM (general linear model) analysis indicated strong negative relationships between the densities of Mayan cichlids and native fish, including sailfin mollies, rainwater killifish and clown gobies. These results indicate a negative effect, probably through predation and competition, of Mayan cichlid presence at sites where they reach high densities on some native fish that are known to be important foods for wading birds, including Roseate Spoonbills. It is not known if Mayan cichlids are equally beneficial prey items for wading birds as the native species they are replacing.

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A Field Trial of Trap Effectiveness for Invasive Burmese Pythons (*Python molurus bivittatus*) in South Florida

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Invasive species can have negative economic and environmental impacts, thus effective control tools are desirable. Data are lacking to validate efficacy of control tools for many reptiles, and virtually no proven tools are available for control of large-bodied invasive snakes. Invasive Burmese pythons (*Python molurus bivittatus*) are established in south Florida and may have negative impacts on native fauna. We conducted a trap trial in the greater Everglades ecosystem to evaluate capture efficiency of attractant (i.e., rat)-baited traps. Two different trap designs were tested in conjunction with standardized and opportunistic visual encounter surveys (VES). A total of 6,053 trap nights (early August through early November 2009) yielded three python captures (these individuals were marked and released) along with 69 non-target captures. Trap success was not dependent upon trap design. No pythons were observed during standard VES; two pythons were observed during opportunistic VES. After the trial, the 80.93 ha study plot was mechanically disked to assess python population size within the study site; 11 pythons were observed, resulting in a minimum population density of 0.136 snakes/ha. Capture rates may have been reduced by extremely high prey abundance as well as lower python density during initial study stages due to less vegetation in the early phase of the study. Our results corroborate previous research indicating that snakes are difficult to trap and that trapping alone will not be sufficient for management of pythons in South Florida. However, trapping may be effective at removing a snake or snakes from a small area or particular location. The low capture rate observed in this study highlights the need for both validation of control methods in reptile trapping studies and development of techniques that are based on the life history traits of target species.

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Inter-Nesting Habitat for Dry Tortugas Loggerhead Sea Turtles

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The threatened loggerhead sea turtle *Caretta caretta* is the focus of much attention in the southeastern U.S. due to declining nest numbers and increasing bycatches from commercial longline fishing. Understanding the spatial and temporal habitat-use patterns of these turtles, especially reproductive females in the neritic zone, is critical for guiding management decisions. In an effort to protect resources of presumed importance, the U.S. National Park Service recently created a restricted-use zone, the Research Natural Area (RNA), within Dry Tortugas National Park (DRTO), Florida. To assess marine turtle-habitat use within DRTO, and in the RNA in particular, we used satellite telemetry and identified inter-nesting habitats for seven loggerhead females intercepted and tagged on one of two main nesting beaches in 2008 and 2009. This effort represents the first satellite tracking of DRTO loggerheads, a genetically distinct subpopulation that is one of seven recently proposed for upgrading from threatened to endangered under the U.S. Endangered Species Act. We also used a rapid, high-resolution, digital imaging system to map benthic habitats we determined to be core-use areas (i.e., 50% kernel density zones). Loggerhead females were seasonal residents of DRTO for 19 to 51 days. Individual inter-nesting habitats were located offshore within 1.9 km (2008) and 2.3 km (2009) of the nesting beach and tagging site. The core area common to all turtles was 4.2 km^2 in area, spanned a depth range of 7.6 to 11.5 m, and was located completely outside the RNA. Mapping results revealed the diversity and distributions of benthic cover available in the core-use area, as well as a heavily used corridor to and from the nesting beach. This combined tagging-mapping approach shows great potential for planning and improving the effectiveness of marine protected areas and for developing spatially explicit conservation plans.

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Mercury Bioaccumulation in Everglades Pythons

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The USGS and NPS are collaborating on an examination of mercury bioaccumulation in pythons captured in Everglades National Park. Interest in understanding the levels of mercury in pythons from the Everglades is two-fold: (1) an examination of the literature revealed no published papers with any information regarding mercury body burdens in pythons; and, (2) one possible population-control strategy for the pythons is allowing hunting, thus concerns exist for safe levels of mercury exposure to those who may consume python tissue. In the summer of 2009, the USGS Mercury Research Laboratory analyzed 24 python tail-tissue samples for their total mercury and methylmercury content. Samples included 13 females and 11 males, with a mean total length (TL) of 265.3 cm (range 168.5-471.0 cm, SD 64.6). The mean observed levels of mercury was 5.5 ppm (micrograms per gram, dry weight; range 0.2-17.4 ppm, SD 4.7). The results for methylmercury, which is the more toxic and bioaccumulative form of mercury, showed that on average 79% of the total mercury body burden in the pythons was in the methylated form. In addition, an initial examination of this data set revealed no apparent spatial trends, or any associations with sex, size, or location, perhaps because of the as yet small sample size. Currently the NPS and USGS are collaborating on a follow up effort to examine the mercury and methylmercury content of an additional 100 specimens. With this added information, we hope to better understand the high mercury bioaccumulation levels of pythons, so resource managers can better inform the public about potentially unsafe exposure levels from consuming python tissue.

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Use of South Florida's Protected Areas by Threatened and Endangered Marine Turtles

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Establishment of marine protected areas (MPAs) is one tool for protecting both natural and cultural resources from significant pressure by human activity. In the Dry Tortugas National Park (DRTO) located 112 km west of Key West in the Florida Keys, a Research Natural Area (RNA) was designated in January 2007 to set aside ~74 km^2 of the Park as a no-take preserve to restore ecological integrity by minimizing human influences. The DRTO harbors several key benthic habitats that are important for federally protected marine turtles, including threatened loggerheads (*Caretta caretta*), endangered hawksbills (*Eretmochelys imbricata*), and endangered green turtles (*Chelonia mydas*). In addition, the sandy beaches of DRTO provide suitable nesting habitat for all three species.

To address whether and to what extent the no-take area of the RNA is used by marine turtles, I initiated a study in 2008 to 1) characterize the size classes of each species present in the Park, and 2) quantify the amount of time tagged individuals of all three species spend within various zones of DRTO. Methods of turtle capture include intercepting reproductive females on one of two major nesting beaches and capturing additional turtles of various sizes and both genders using in-water capture techniques (i.e., rodeo, dip nets). Tracking methods include satellite tracking to determine movements of individuals over time.

To date, satellite-tracking of seven reproductive loggerhead females revealed that the inter-nesting habitat used by loggerheads in both 2008 and 2009 was outside the RNA, but still within the Park boundary. Additionally, these female loggerheads departed DRTO after approximately 2.5 to 3 months of residence and migrated to locations off the southwest coast of mainland Florida and the Bahamas. Satellite-tracking of three hawksbills (two immature, one mature) since August 2008 revealed that all three turtles were resident in the Park until May 2009, when the larger mature turtle departed and migrated to Cuba; the other two immature hawksbills are still transmitting from within DRTO, where they appear to be resident. Finally, satellite-tracking of six subadult and adult green turtles captured in the water (three female, three male) in June 2009 revealed that all six individuals are resident within the Park thus far, in an area of lush, relatively shallow-water seagrass beds that is outside the RNA. Additionally, none of the mature females appeared to nest within the Park in 2009.

These data represent the first satellite-tracking data for turtles at DRTO. Such data will contribute to determining the effectiveness of the RNA for protecting threatened and endangered marine turtles and their requisite habitats, and the development of more effective decision-support tools to adaptively manage coral ecosystems and MPAs in the Greater Everglades.

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Incorporating Vegetation Resistance into Hydraulic Models as a Tool for Managing a Free Flowing Everglades

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Removal of levees to restore more natural sheetflow patterns will fundamentally change how water is managed in the Everglades. Restoration will move us from an era focused on managing water depths in largely stagnant pools behind levees to an era where timing, volume, and speed of delivery of flow inputs will be adjusted to manage subtle interactions between flow surface water slopes, water depths, and vegetation effects on flow resistance to achieve targeted water depths. Water managers will require the most reliable tools that are available to predict the effects of their actions. Hydraulic rate laws that express the interdependence between discharge, water depth, water surface slope, and vegetation characteristics will be essential for this purpose. We recently completed a new, physically-based hydraulic analysis using three years of field data. The results emphasize that Manning's equation is not the best choice for predicting flow velocities and water depth in a laminar flow regime like the Everglades where flow resistance is dominated by vegetative drag. We used the field data to verify theoretical expressions of drag's dependence on vegetation characteristics, and to empirically parameterize drag's dependence on flow velocity, a step only rarely taken in hydraulic studies. Field data were used to verify the theoretically based and laboratory tested relationship $C_D \sim (ad)^{-0.5}$, which states that the drag coefficient, C_D , is proportional to one over the square root of the product of vegetation frontal area, *a*, and average stem diameter, *d*. We also used our data to quantify how much drag decreases with increasing flow velocity in the laminar flow regime of the Everglades. Substituting those results back into a governing equation for steady-state flow produced a new hydraulic "rate law" equation that takes an important first step toward predicting how water depths will respond to restored flows.

As a proof of concept we are now developing simple, vegetation community specific, flow equations that relate discharge and water depth to water surface slope and vegetation characteristics. In addition to serving as the basis for improved management modeling, our new hydraulic equations can also be used to resolve estimates of historic flow conditions in the Everglades, a subject of considerable interest due to recent paleoecological findings. For this presentation we demonstrate the potential of our new hydraulic rate law in its simplest form (one dimensional and steady state) to address important questions, including "What average flows would have produced the average water depths known to have existed in the historic Everglades?" and "How will vegetation changes that have occurred in the past fifty years affect water depths after flows are restored?" It should be noted that these highly simplified calculations only represent a proof of concept. The full benefits of using a more theoretically grounded and field tested equation such as ours (in lieu of Manning's equation or some other calibrated rate law) will not be realized until our new rate law is incorporated into the two dimensional hydraulic models most frequently used by water managers.

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Sediment and Particulate Phosphorus Transport in a Free Flowing Everglades

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The effects of flow interactions with aquatic vegetation and sediment transport are uncertain, yet these processes could be very significant to ecological processes and contaminant transport in a restored Everglades. Here we quantified sediment transport in a relatively well preserved Everglades slough by progressively increasing flow velocity (0.3 – 5.7 cm s^{-1}) in a field flume constructed around undisturbed bed sediment and emergent macrophytes (Harvey et al., 2010). Suspended sediment < 100 µm was dominant in the lower range of laminar flow and was primarily supplied by detachment of epiphyton from submerged plant stems. Coarse flocculent sediment > 100 µm became dominant at higher velocities. Flow remained laminar at the higher tested velocities (up to 6 cm s^{-1}) although flow conditions changed from a situation with stable vortices that had formed downstream of plant stems to a condition where vortices had begun shedding from alternate sides of plant stems. The sediment flux increased substantially (by a factor of four) when velocity was raised from 3.2 to 5.3 cm s^{-1}, which coincided with surpassing the threshold shear stress for entrainment of bed floc, and which also coincided with the onset of stem vortex shedding. Modeling determined that the potentially entrainable sediment reservoir in well preserved Everglades sloughs, 46 g m^{-2}, was similar to the reservoir of epiphyton on plant stems (66 g m^{-2}) but smaller than the reservoir of flocculent bed sediment (330 g m^{-2}). All of the suspended sediment that we measured in the Everglades, whether entrained from the sediment bed or from detachment from epiphytic coatings on plants, was enriched in phosphorus (by approximately twenty times) compared with bulk flocculent sediment present on the bed or as epiphyton. Therefore, the most easily entrainable sediment in the Everglades is also the most nutrient rich (and likely the most biologically active).

Determining that sediment entrainment from submerged plant stems is a significant source of suspended sediment is a new finding in shallow vegetated aquatic ecosystems. Suspended sediment from epiphyton may contribute to transport and redistribution of organic carbon and phosphorus in ways that influence sediment accretion, topographic variability, water depth, and related ecosystem characteristics, including habitat diversity, habitat connectivity, and ability of ecosystems to adsorb and store excess nutrients and other contaminants. Our experiment established quantitatively some of the important criteria that will be useful for predicting entrainment of sediment in a restored Everglades. Results also apply to the STA (Stormwater Treatment Area) wetlands, designed to remove phosphorus from waters before they flow into the Everglades, and potentially can be used to improve how treatment wetlands are operated hydraulically to increase phosphorus removal efficiency.

Reference:

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Loxahatchee's Living Laboratory

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The A.R.M. Loxahatchee National Wildlife Refuge (Refuge) holds an annual Science Workshop designed to bring together scientists across agencies and disciplines having current (and/or future interest in) scientific studies conducted at the Refuge. Previous Refuge Science Workshops have been held as part of GEER and have improved the science program at the Refuge. This year's workshop will follow a similar format. As the 2010 Science Workshop, this special session is intended to present: (1) the status of the current science at the Refuge; (2) the applicability of that science for Refuge management purposes; and (3) examples of applying science from the Refuge to other parts of the Everglades system. This special session consists of oral and poster presentations on science conducted by Refuge staff and our partners that will allow us to seek and facilitate comments and suggestions from attendees.

This year's annual Science Workshop and GEER special session focuses on science being conducted within the living laboratory of the Refuge – with specific attention to its direct management implications. This presentation focuses on current and future scientific activities at the Refuge. A multi-disciplinary scientific approach (e.g., integrating efforts on hydrology, water quality, biology, exotics, etc.) to shaping the future vision for the Refuge is being pursued through the Refuge's Habitat and Management Plan and the Inventory, Monitoring, and Research Plan. These two plans are our major steering documents that shape management-relevant science for the Refuge. Please consider attending the entire special session and learn about the spectrum of science being conducted at the Refuge – and its potential applicability to other parts of the Greater Everglades.

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The IMMAGE Project - Internet-based Modeling, Mapping, and Analysis for the Greater Everglades

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Recent analyses using current projections of sea level rise and LiDAR data for the eastern portions of Miami-Dade County suggest that coastal areas in South Florida will be subjected to the degradation of coastal habitats, contamination of municipal water supplies by the intrusion of salt water into coastal aquifers, alteration of ground water flow patterns, and increased risk of surge-related flooding and wind damage from coastal storms. It is critical that water resource planners, park managers and municipal authorities have the best tools to assess the societal risks and economic impacts that these adverse environmental changes could have on coastal communities, protected lands, and the region as a whole. In evaluating and preparing for possible outcomes, alternative climate and land use scenarios are needed to evaluate the impacts of sea level rise and severe storms on existing and future land portfolios and social infrastructure. It is critical that these scenarios be based upon the best-available monitoring data and numerical flow models, rather than relying solely on static representations of sea level rise based on elevation data.

An impressive body of work has been generated in the last several years with numerical models to forecast the impact of sea level rise on salt water intrusion, inland flooding, surge from coastal storms, and the resulting impact on the suitability of habitat for key species in the Greater Everglades. However, the usefulness of many models is constrained by the need to run them offline on dedicated workstations, lengthy run times, and the need for post-run processing and integration of results with other data.

The IMMAGE project is intended to enhance the usability of and broaden the user community of four key models by creating a GIS-based web interface for each model capable of serving model output to, and consuming output from other web-based applications. By running computationally-intensive models in advance and storing output in a server-side database, users are able to select from broad range of input parameters and obtain results online without excessive wait times.

IMMAGE will develop interfaces for the following four models: 1) The BIscayne SouthEastern Coastal Transport (BISECT) model, a coupled ground and surface water model developed by Eric Swain and others at the U.S. Geological Survey's Florida Water Science Center, 2) Selected habitat distribution models, which utilize output from BISECT, developed by Leonard Pearlstine and others at the Everglades National Park, 3) The National Land Change Community Model, being developed by modelers within and outside the USGS, with contributions from Peter Claggett and David Donato of the USGS Eastern Geographic Science Center, and 4) the Sea, Lake and Overland Surges from Hurricanes (SLOSH) model developed by the National Oceanic and Atmospheric Administration' National Hurricane Center.

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More than an Inventory – Prioritizing Invasive Treatment Sites with Limited Resources

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Cost-effective invasive plant suppression within a restoration context requires a full understanding of the site-specific spatial, ecological, and sociological variables that impact successional trajectory, invasion biology, intervention methodology and funding sustainability. The Fairfax County Park Authority, responsible for over 24,000 acres in the highly urbanized setting of Northern Virginia, has developed a defensible assessment and resource allocation protocol in response to the ecological threats posed by invasive species.

In the majority of jurisdictions across the country, invasive suppression resources are frequently expended on a sporadic, per unit land area basis that equates total number of infested acres treated with success. This approach often results in inadequate levels of native vegetation colonizing a site and the eventual re-infestation of the location with aggressive exotics. If the ultimate goal of an invasive suppression program is to restore a regionally representative, native plant community, then an intervention model that prioritizes treatment based upon ecological risk and natural capital value is required.

Given spatial heterogeneity within an ecosystem and the corresponding variation in vulnerability to biological invasion, it is important that a treatment prioritization model reflect site-specific circumstances. It is also critical that the intervention strategy proposed recognizes differences in invasive plant biology and susceptibility to control. Prioritization of treatment should reflect a range of both ecological and sociological variables including; patch size, patch location, plant biology, plant frequency in landscape, feasibility of control, vectoring corridors, disturbance regimes, existing natural capital value, site utilization and sustainability of treatment funding. Adoption of a defensible intervention model has enhanced opportunities for successful invasive plant suppression within Fairfax County, Va.

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Ecohydrologic Feedbacks and Topographic Pattern in Everglades Peatlands: A Model of the Self-Organizing Canal Hypothesis

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Regular, self-organized patterning has been observed in a wide range of ecosystems and is attributed to the interaction of positive local and negative distal feedbacks. One such system is the Florida Everglades, which were historically dominated by a mosaic of high elevation ridges supporting productive emergent communities and lower elevation sloughs inhabited by floating and submerged plants. Interactions among hydroperiod, plant community composition (and therefore productivity), and respiration have long been hypothesized to produce and maintain the local elevation differences via their effects on peat accretion; however, mechanisms capable of producing the elongated, flow-oriented patterning of the ridge-slough mosaic habitats are less clear. In this study we evaluate a simple model in which peat accretion is coupled to hydrologic conditions, and in which hydrologic conditions in one patch are coupled to adjacent patches via their reciprocal effects on discharge through flow-perpendicular cross-sections.

Analytical solutions of our model demonstrate that under a reasonably wide range of conditions, the necessity of maintaining some minimum discharge competence can produce distal negative feedbacks between patches. In effect, differential peat accretion between two patches displaces flow onto (and thus increases water depth in) the more slowly-accreting patch, creating conditions less favorable to rapid peat accretion due to threshold responses of productivity to inundation depth and duration. Importantly, these feedbacks act anisotropically, with greater effects between adjacent than downstream patches. This 'self-organizing canal' model thus represents a plausible mechanism of pattern formation even in the absence of sediment transport feedbacks recently suggested to produce ridge-slough patterning. Over a more limited, but highly probable, set of conditions, the self-organizing canal model produces global bi-stability between patterned and unpatterned configurations, suggesting the potential for catastrophic transitions in landscape structure. Also notable is that the model predicts divergence of ridge and slough elevations with increasing water levels, consistent with recent observations of the responses of microtopographic patterns to anthropogenic modification of Everglades hydrology.

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Counteracting the Effects of Sea Level Rise on Southeast Florida's Water Resources

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Sea level rise and changes in precipitation patterns due to climate change increasingly imperil Southeast Florida's water resources and the Everglades. Water managers will be faced with daunting challenges to preserve the region's water supply and ecological systems. These will include: 1) maintaining adequate water supplies during periods of extended drought in the face of exacerbated saltwater intrusion, 2) preventing devastating urban flooding during torrential rain events of increasing intensity in the face of compromised stormwater drainage, and 3) moderating the impacts on Everglades ecological systems. New approaches will be required to improve the resilience and prolong the sustainability of the region's water resources. A number of logical, potentially controversial proposals are presented to stimulate thinking about new solutions.

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Effects of Sea Level Rise on Southeast Florida's Water Resources

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Sea level rise, as well as changes in precipitation patterns, increased ambient temperatures and more intense hurricanes, individually and in combination, will likely have detrimental effects on Southeast Florida's water resources. Hydraulic back pressure due to sea level rise will increase saltwater intrusion, reduce groundwater seepage, and compromise stormwater drainage systems. Within the next few decades, sea level rise of as little as 3 to 9 inches can affect the integrity of Southeast Florida's urban water supply and increase the risk of urban flooding during heavy rainstorms unless adaptive measures are taken.

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Projected Reorganization of Florida Bay Seagrass Communities in Response to Increased Freshwater Inflow with Everglades Restoration

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Assessing the potential for ecosystem restoration efforts to meet management goals requires reliable, flexible forecasting tools. Simulation models allow for such forecasting, but can be expensive and difficult to build and validate. Here, we present an alternative approach that uses computationally simple box models and statistical relationships derived from long-term monitoring data to forecast the response of a coastal ecosystem to alternative future water management scenarios. Historic changes in water-use management in the Florida Everglades have reduced the quantity, timing, and distribution of freshwater inflow to Florida Bay by approximately 60%. Two consequences have been (1) an increase in salinity, a decrease in salinity variability, and occurrences of hypersalinity, and (2) a change in benthic habitat structure. Restoration goals have been proposed to return the salinity climates of Florida Bay to more estuarine conditions through changes in upstream water management, thereby returning seagrass species cover to a more historic state. We used long-term monitoring data and two modeling approaches. First, we applied the hydrological mass-balance model FATHOM to predict changes in salinity climates in sub-basins of the bay in response to a broad range of freshwater inflow scenarios. Second, because seagrass species exhibit different sensitivities to salinity climates, we used the modeled salinity climates as input to a discriminant function model that associates eight seagrass community types with water quality variables including salinity, salinity variability, total organic carbon, total phosphorus, nitrate, and ammonium, as well as sediment depth and light reaching the benthos. Increases in freshwater inflow decreased salinity and increased salinity variability, especially in the north and northeast regions of the bay, while the largest (5-fold) increase in freshwater inflow had negligible effects on the western regions of the bay bordering the Gulf of Mexico. We forecasted increases in *H. wrightii* communities and decreases in *T. testudinum* communities in areas returned to more estuarine conditions. Our results suggest that the desired restoration of seagrass community distributions could be achieved with a three-fold increase of water inflow rate from the Everglades to Florida Bay.

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The Role of a Robust Science Program in Large-Scale Ecosystem Restoration – A Comparison of the Comprehensive Everglades Restoration Plan and the Missouri River Recovery Program

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Over the past decade, large-scale ecosystem restoration/recovery has become an important mission of the U.S. Army Corps of Engineers (USACE). Two of the country's largest programs, restoring the Everglades and South Florida ecosystem (Comprehensive Everglades Restoration Plan [CERP]) and the recovery of both the ecosystem and threatened and endangered species in the Missouri River Basin (Missouri River Recovery Program [MRRP]), are coordinated by the USACE and present immense challenges given their size and complexity. One of the most important components of both CERP and the MRRP is their robust science programs. Though very different from one another, both REstoration COordination and VERification (scientific arm of CERP) and the MRRP Integrated Science Program (ISP) supply critical scientific information via system-wide/regional monitoring and assessment. Key data is collected, synthesized, assessed and then reported in various formats. Equally as important, is the communication of these scientific findings to managers and decision-makers so they can be integrated into the adaptive management (AM) process and program implementation. This presentation will compare and contrast these science programs, the applied science aspects of each, and identify lessons learned.

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Monitoring Fish Communities and Populations on the Eastern Boundary of Everglades National Park

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Water storage impoundments were constructed on the eastern boundary of Everglades National Park (ENP) in 2002-2003 in an effort to control water levels to the west by limiting groundwater seepage to the east. We monitored fish communities to evaluate environmental changes associated with the operation of the impoundments. We present data collected at marl-prairie sites in the Rocky Glades region of ENP adjacent to the S332 water control structures, control (un-impacted) sites from the same region and Shark River Slough. We used drift fence traps constructed of ground-cloth to corral moving fish into wire-mesh minnow traps. Past work has demonstrated that drift fences provide estimates of encounter rate or 'activity density' that is determined both by local fish density and movement rate, hereafter reported as catch-per-unit-effort (CPUE). These traps were deployed biweekly when surface water depth exceeded 20 cm between December 2003 and October 2009. We sampled 2,416 trap-nights and captured 33,515 fish. These CPUE data have allowed us to estimate community structure, seasonal changes in activity density, patterns of size distribution, the occurrence of non-native fish and patterns of sex ratio for selected species. We can use this to track community and population variability between long and short hydroperiod regions and between wet and dry years.

Overall, CPUE was greatest in the sites adjacent to the S332 water control structures, followed by those in the eastern Everglades control sites. The sites adjacent to the S332 structures and the Eastern control sites also had the greatest abundance of non-native fish (notably, the jewelfish, *Hemichromis letourneuxi*). Abundance of non-native fish peaked in 2005, but was greatly reduced after the very dry wet-season of 2006. CPUE in Shark River Slough remained relatively stable throughout the year. In the Eastern Everglades sites and by the S332 structures, CPUE was greater early in the wet season and declined as the season progressed. Species richness was greater in Shark River Slough and the S332 sites than in the eastern Everglades control sites. Over the course of this study, sites within Shark River Slough were less variable (most similar to each other, lowest Bray-Curtis dissimilarities) across years than sites adjacent to the S332 structures, which in turn were less variable than the sites from the eastern Everglades. The five most common fish (eastern mosquitofish, flagfish, bluefin killifish, sailfin mollies, least killifish) all had female skewed sex ratios. However mosquitofish had a greater proportion of male fish in Shark River Slough and followed a general pattern of greater proportion male in sites with longer hydroperiod. Bluefin killifish were strongly female biased in Shark River Slough, but close to equal proportions in the eastern Everglades (both by the S332 structures and in the control sites). The results generated from this dataset show important differences in community structure, fish assemblages and population ecology between long and short hydroperiod sites, across years and in regions possibly affected by management activities. This data strongly links properties of fish communities to water availability and highlights the importance of careful management of the water levels in the eastern Everglades and near the S332 water control structures.

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Regional Ecological Effects of Local Scale Land Use Change

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Miami-Dade County in South Florida is characterized by a diverse and growing human population directly adjacent to the Everglades wetland ecosystem. As the County continues to grow, it may experience widespread urbanization of agricultural lands. This has significant regional implications for the ecological functions of the remaining vacant lands in the County, the ecological health of Everglades and Biscayne National Parks, and the well-being of Miami-Dade County residents.

Land use decision making is often done at the local level, and it can be difficult to demonstrate that while each single land use change may result in a negligible impact, the accumulation of these individual changes over time and within a region may constitute a major impact. Many resource managers and land use planners recognize that evaluating land use conversions on a parcel-by-parcel basis leads to a limited view of the regional effects, but need tools to help them better visualize the regional cumulative effects of smaller local level projects.

The Ecosystem Portfolio Model (EPM) is a web-enabled regional land use planning tool designed to integrate user judgments with model results to help stakeholders visualize ecological assessments and alternative land use scenarios. One component of the EPM is ecological value (EV), which is evaluated using modeled ecological criteria related to ecosystem services. The calculation of EV uses metrics for 1) biodiversity potential, 2) threatened and endangered species, 3) rare and unique habitats, 4) landscape pattern and fragmentation, 5) water quality potential, and 6) ecological restoration potential.

We also use Circuitscape modeling to estimate the effects of land use on wildlife habitat connectivity and the potential for species dispersion. This model is an application of electronic circuit theory that predicts paths of animal movements in heterogeneous landscapes, and can be used to identify critical areas for connectivity conservation (habitat corridor pinch points) and allow visualization of larger areas for connectivity redundancy.

This presentation uses case studies to illustrate the effects of local level land use changes on regional EV and species habitat connectivity. The goal of this work is to enable resource managers and stakeholders to better visualize and communicate the ecologic value of land and the regional ecological effects of spatially explicit land use decisions.

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The Florida Landscape Conservation Cooperative – a Strategic, Partnership-driven Conservation Program for Florida's Future Generations

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The U.S. Fish and Wildlife Service, together with the Florida Fish and Wildlife Conservation Commission and The Nature Conservancy, are working together to facilitate conservation activities among state and federal agencies, tribes, private landowners, and stakeholder organizations. This new collaborative conservation approach is in response to the complicated issues that cannot be solved by any single agency, organization or individual. We have invited stakeholders to participate in the early planning stages to help shape the Peninsular Florida Landscape Conservation Cooperative (http://www.fws.gov/southeast/LCC/PeninsularFlorida/). The Landscape Conservation Cooperative (LCC) concept has grown from strategic habitat conservation approaches developed by the Service that encourage landscape-scale conservation integrated among diverse public and private partners. LCCs are being developed in 13 regions in the continental United States (http://www.fws.gov/southeast/LCC/). These LCCs will provide a platform to identify and prioritize key species and habitats, expand public-private conservation efforts, identify information and management needs, and combine skills, resources, and funding and to monitor the results. This approach will eliminate duplication of effort, increase conservation effectiveness, and save time and money.

Rather than create a new conservation infrastructure from the ground up, LCCs build upon explicit biological management priorities and objectives, and science available from existing partnerships, such as fish habitat partnerships, migratory bird joint ventures and flyway councils, as well as species- and geographic-based partnerships. LCCs support adaptive resource management by evaluating conservation strategies, maintaining and sharing information and data, and improving products as new information becomes available. Shared data platforms serve multiple purposes, including collaborative development of population/habitat models under alternative climate scenarios to inform landscape- and finer-scale resource management decisions. Decision-support systems and products developed by LCCs not only help determine the most effective conservation actions to support shared priorities, but also provide tools to compare and contrast the implications of management alternatives.

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The History of Lake Okeechobee Restoration Efforts and Where We Are Today

Lewis Hornung
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Excess nutrient loading to Lake Okeechobee has been recognized as a problem for more than 30 years. In response, the state of Florida has undertaken a number of major capital improvement, operational, and regulatory initiatives that have changed the face of water management in south Florida. Some of the initiatives that have been implemented partially or wholly for the purpose of improving Lake Okeechobee water quality are the Interim Action Plan, Everglades Construction Project, Kissimmee River Restoration, Dairy Buyout Program, Works of the District Regulatory Program, Comprehensive Everglades Restoration Plan, Lake Okeechobee Protection Act, and the Northern Everglades and Estuaries Protection Program. Collectively, these initiatives have substantially changed (improved) water management infrastructure and operations for the benefit of the ecosystem health. However, the latest 5-year (2005 – 2009) moving average annual phosphorus load to the lake was 572 metric tons – more than 400 metric tons over the total maximum daily load target. In addition, over the last 30 years, several complicating factors have developed and grown: accumulation of nutrient rich sediment in the lake that is highly susceptible to resuspension, accumulation of "legacy phosphorus" in the watershed soils, loss of assimilative capacity of upstream Lakes Kissimmee and Istokpoga, and interpretation of policies that effectively prevent federal cost sharing of water quality features. The ongoing Northern Everglades and Estuaries Protection Program consists of a large and comprehensive suite of projects and programs that will lead to restoration of the Lake Okeechobee Watershed and downstream estuaries. However, there are many challenges to overcome and continued long-term focus will be required.

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Effects of the Picayune Strand Restoration Project on Vegetation Assemblages of the Mangrove/Marsh Transition Zone at Ten Thousand Islands National Wildlife Refuge

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The Ten Thousand Islands region of southwest Florida is characterized by a complex of mangrove forests and salt, brackish, and fresh marsh habitats. Hydrologic modifications to the region have occurred since the 1940's, resulting in decreased freshwater inflow to many wetland areas; this decreased inflow has led to changes in vegetation community structure. On Ten Thousand Island National Wildlife Refuge (TTI NWR), mangrove coverage has increased approximately 35% over 78 years, with mangroves currently occupying about 86% of the refuge. Highways and other infrastructure prevent migration of marshes landward, and concern exists that TTI NWR may be displaced toward primarily forested habitat. The Picayune Strand Restoration Project (PSRP) will increase overland flow of freshwater to TTI NWR. To investigate the effects of the PSRP on the vegetation and hydrologic characteristics of the transition zone between mangrove and marsh habitats, a network of north-to-south running stations to monitor water level and salinity was established on TTINWR in 2006. At nine of these stations, three located in each of three marsh types (brackish, salt, and transition to mangrove), vegetation monitoring sites consisting of permanent 50-m long transects were established. Additional transects were established as controls at five sites outside the PSRP impact area. Plant species cover was estimated to the nearest 5% at 0.5-m^2 quadrats located along each transect, as was number and height for mangrove species within a 125-m^2 belt.

Analysis using multi-response permutation procedures (MRPP) indicated separation between the three marsh types at TTI NWR; three separate control groups were also identified. Indicator species analysis identified species associated with each of the six vegetation groups. Analyses of water level data suggested that enhanced mangrove expansion on the eastern portion of the refuge compared to the central and western portions may be influenced by increased tidal fluctuation associated with the Faka Union Canal, a major canal that was constructed in 1970. Salinity, however, did not differ significantly in the eastern relative to the other two transects; this result likely was due to increased freshwater input to the upper section of the canal. Long-term monitoring will identify future shifts in plant community composition, providing information on the link between specific hydrologic characteristics and vegetation response, thereby quantifying the effect of the PSRP on vegetation assemblages of TTI NWR.

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Hybridization of Typha Species Contributes to Cattail Invasion and Landscape Vegetation Change in Wetlands

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Three species of cattails, *Typha latifolia* (broadleaf cattail), *T. angustifolia* (narrowleaf cattail), and *T. domingensis* (southern cattail) are recognized in North America. Both *T. latifolia* and *T. domingensis* are native species, although *T. latifolia* also occurs in Europe and *T. domingensis* occurs in Central and South America. *T. angustifolia* is considered by many to be an exotic introduced from Europe in the 1800s (although recent studies indicate its presence in northern New England prior to European settlement). Scientists have used both genetic and ecological field methods to evaluate the dynamics of cattail invasions in North America. We investigated hybridization dynamics between *Typha latifolia* and *Typha angustifolia* in cattail populations located in Great Lakes national parks using microsatellite molecular genetic analysis. Hybrids, referred to as *Typha x glauca*, occur throughout the U.S, and exhibit the most pronounced invasive properties, having invaded many wetlands during the past 100 years. Hybridization between the native *T. domingensis* and other *Typha* species needs to be clarified using available molecular techniques. Invasion of wetlands by hybrid cattails homogenizes wetland vegetation and reduces biodiversity. Thus, it will be important for managers to recognize the extent of hybrid cattails in their parks and respective regions. They can then apply existing management methods to control hybrid cattail expansion in order to protect biodiversity.

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Lessons Learned: Invasive Species Management at 8.5 Square Mile Area

Angie Huebner, *Joana Savinon, Jeremy Crossland, Jon Lane* and *Jon Morton*
US Army Corps of Engineers

The Invasive Species Management Branch of the US Army Corps of Engineers executed a contract in May of 2009 to remove invasive plants from 8.5 Square Mile Area. The area is a portion of the Modified Waters Deliveries authorized to rehydrate and improve flow to portions of Everglades National Park. The contract was completed in September 2009 with a total of more than 36000 man-hours, 1479 acres treated and 19 FLEPPC Category I and II species treated.

The poster will describe the process of planning the vegetation management contract, oversight of the contract, coordination between divisions of the USACE, and lessons learned from working in the area. Initially, the project did not identify an invasive species as component of the restoration; it was believed that restored hydrology would eliminate the invasive plants. The Operations Division and Planning Division were able to work together to identify the need for this component in the project and plan the vegetation removal component. Herbicide treatments were conducted from the beginning of the wet season through September. The disparity in project condition from initial surveys in October and November of 2008 until the contract was initiated created many challenges. These challenges included access to the area and effective control of some of the vegetation. Additionally, the delays in funding of the contract created separate challenges with coordination with the other agencies involved in the project, including Everglades National Park and South Florida Water Management. Through many natural and manmade challenges the project was successfully completed in September 2009.

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Picayune Strand Restoration: Preparing the Exotic and Nuisance Vegetation Management Plan

Angie Huebner
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The implementation of the Picayune Strand Restoration Project (PSRP) will result in creating disturbed, vulnerable areas in the road and logging tram removal footprints, which may be dominated by undesirable nuisance and exotic vegetation. These areas are particularly vulnerable to invasion by undesirable plant species because of the elimination of all vegetation and severe substrate alteration during restoration activities. The overall goal of the Exotic and Nuisance Vegetation Management Plan is to deal with exotic and nuisance species when they first invade a restoration site after construction rather than after they have become established, when it would take a much larger control effort.

The Vegetation Management Plan will involve monitoring and control of a variety of invasive plant species, particularly sabal palm and exotic Brazilian pepper on the restored canal, road and logging tram footprints, as well as other sites where activities associated with the restoration will occur. Although sabal palm is a native species, reducing the dominance, density, and recruitment of sabal palm is necessary because one of the primary differences observed on the 1940 and 1995 Natural Resource Conservation Service (NRCS) vegetation maps is its dramatic spread through the project area. The spread and increased density of sabal palm has greatly increased the magnitude of the effects of forest fires in the project area. In addition, other exotic and nuisance species, including invasive grasses such as cogon and torpedo grass, would be controlled as they are encountered on these disturbed sites before they can become established long-term problems.

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Evaluation of Annual Herbicide Application for Control of *Lygodium microphyllum* on Tree Islands in A.R.M. Loxahatchee National Wildlife Refuge

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We evaluated the effects of annual aerial and ground herbicide treatments with glyphosate and metsulfuron for control of Old World climbing fern (*Lygodium microphyllum*; OWCF) and impacts to native plants on tree islands in A.R.M. Loxahatchee National Wildlife Refuge during 2005-2008. Initial aerial herbicide treatments reduced OWCF cover by > 98% on metsulfuron treated islands and > 88% on glyphosate treated islands, but there was a concomitant decrease in native ground cover with both herbicides. Follow-up ground treatments, during year two and three of the study, were effective at maintaining low levels of OWCF. OWCF cover at the end of the study was 1-2% of pretreatment cover on metsulfuron treated islands and 8-10% on glyphosate treated islands. OWCF cover on untreated islands increased by 41% of pretreatment cover from 2005 to 2008.

Native fern cover, which accounted for 40% ground cover prior to treatment, was ≤ 14% for all treatments at the end of the study. The dominant native ground cover, *Blechnum serrulatum*, was reduced by 55-64% and 76-78% with metsulfuron and glyphosate, respectively, after one aerial and two ground treatments. *Vitis rotundifolia* became the dominant ground cover at the end of the study, accounting for 13-29% and 46-59% ground cover on metsulfuron and glyphosate, respectively, treated islands. At the end of the study, species richness was dominated by early successional native species.

The survival rate of tree and shrubs was 65-93% on islands treated with metsulfuron and 6-20% on islands treated with glyphosate. *Ilex cassine* was tolerant of both herbicides with survival rates of > 70%. *Persea palustris* and *Myrica cerifera* were tolerant of metsulfuron but highly susceptible to glyphosate. Minimum impacts were recorded on tree islands for canopy cover on tree islands treated with metsulfuron compared to glyphosate. Mean canopy cover was 7-17% for glyphosate and 30-40% for metsulfuron treated islands, and 58% for untreated islands at the end of the study.

We recommended that the aerial application of metsulfuron be used for control of OWCF on tree islands. Additional aerial treatments should not be conducted for > three years following the initial treatment to prevent further non-target damage and structural changes to tree islands. Follow-up ground treatments will be required for OWCF re-growth and new sporelings and should be conducted within one year following the aerial application.

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The Ability of Large Constrictors to Invade Areas of the United States Beyond Extreme South Florida: Sorting Out the Facts

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The Burmese python (*Python molurus bivittatus*) has become a problematic invasive species in southern Florida. Although accurate estimates are not available, some investigators believe that tens of thousands are established and represent an expanding reproductive population. The Northern African rock python (*Python sebae*) and boa constrictor (*Boa constrictor*), although highly restricted in their present distribution, are also breeding in certain small areas of southern Florida. However, the boa constrictor has failed to spread beyond their current location since first being seen in the 1970s. Given the size that these species can attain, it is feared that they will further damage an ecosystem that has already been altered by the establishment of exotic plants and other animals, and by surrounding agriculture and residential and commercial developments. Fear has factored heavily in pushing forward legislation and proposed policy to restrict the importation and sale of these large snakes. There is fear that these large snakes are a direct threat to the welfare of people inhabiting nearby areas. Yet, given the large numbers of these snakes already established in south Florida, very few human interactions have occurred. The greater concern is that the Burmese python will expand its current range in the US. In a recent report from the U.S. Geologic Service, climatic matching indicated that large portions of the United States had a climate suitable for its survival. In a second independent report, authors employed ecological niche models to identify that only extreme southern Florida and southern Texas could support populations of Burmese pythons. To decide which of these disparate reports provide the most accurate assessment of the establishment of Burmese pythons and other large non-native snakes within the U.S., we can turn to evidence from the field and laboratory. From the field, the only established population of Burmese pythons is in extreme southern Florida, even though this species and other large constrictors have for decades been released into the wild or have escaped from captivity throughout the country. Second, the death of many free-ranging Burmese pythons were documented this winter in southern Florida and attributed to a cold front where temperatures $\leq 0^{o}C$ were recorded for 3 hrs and were $\leq 4.4^{o}C$ for 7 days in Homestead, Florida, east of Everglades National Park. Laboratory studies reveal that Burmese pythons are unable to digest meals at body temperatures of $20^{o}C$ or below. Although such data is lacking for pythons, the critical thermal minimum of other snakes is approximately $5^{o}C$. Therefore minimum winter temperatures will undoubtedly dictate the geographic limits of a reproducing population of Burmese pythons within the U.S. This will preclude the northern expansion of the Florida population and largely eliminate any additional populations from becoming established elsewhere in the U.S. Clearly this issue needs more robust research, empirical validation, and serious discussion before effective assessments, actions plans, or restrictive federal regulations are developed.

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Characterizing the Dynamics of Dissolved Organic Matter (DOM) in the Greater Everglades Ecosystem: Assessment of Spatial and Temporal Variability and Reactivity

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Dissolved organic matter (DOM) dynamics in wetlands and estuaries are complex and often difficult to assess using traditional geochemical approaches. It has become clear that quantitative measurements (DOC) alone do not properly allow assessing the multitude of sources (e.g. emergent and submerged vegetation, soils/sediments, groundwater, and rainwater) and the various diagenetic processes (e.g. photodegradation, biodegradation) that can alter the DOM characteristics in aquatic ecosystems. In this study, we incorporate bulk DOC measurement with the determination of optical properties including Emission Excitation Matrices fluorescence (EEM) coupled with Parallel Factor Analysis (PARAFAC) in an attempt to better understand the dynamics of DOM in the greater Everglades landscape. DOM in surface waters, dominant vegetation leachates (including senescent leaves of sawgrass, spikerush, mangrove, seagrass, and periphyton) and soil leachates were characterized using EEM-PARAFAC and potential degradation processes were assessed through bio-and photo-degradation studies. In addition, DOM characteristics on both spatial and temporal scales for the freshwater Everglades and Florida Bay will be presented.

Optical properties measurements including EEM-PARAFAC revealed both spatial and seasonal DOM compositional differences in DOM composition (quality) as controlled by hydrological and biological drivers (water discharge and primary productivity) and geomorphological features of the landscape. Compositional differences between surface and ground water DOM were also observed. Photo- and bio-degradation of plant leachates readily showed that the combination of both processes was most effective in promoting DOM compositions similar to those in natural surface water of the Florida Coastal Everglades. The degradation kinetics suggests a model where the DOM pool can be divided into a labile, semi-labile and refractory pool. In general terms, chromophoric DOM (CDOM) was more sensitive to photo- compared to bio-degradation, with the latter showing an enriched refractory fraction.

The data presented here represents a review of recent activities in our laboratory aimed for a better understanding of Florida coastal Everglades DOM characterization, its environmental dynamics, biogeochemical carbon cycling processes, and potential relationships to CERP.

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Analysis and Simulation of the C-111 Detention Area System: Effects on Rocky Glades and Taylor Slough Hydrology and Proposal for Marsh Driven Operational Criteria

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Water depths and hydroperiods in the Rocky Glades / Taylor Slough wetland complex within Everglades National Park (ENP) have been significantly reduced from historical levels. Lowered groundwater levels maintained throughout the developed areas to the east have contributed to significant seepage losses from the Park and reduced marsh water depths and hydroperiods. The C-111 Project was designed to mitigate the effects of this over-drainage. The C-111 project consists of three 575 cfs pump stations discharging into a 3400 acre detention area. Pumping into the detention area creates a ridge of high water between the ENP wetlands and the developed areas to the east. The hydraulic ridge contributes to increased stages in ENP by increasing groundwater fluxes to the west and reducing seepage towards the east while maintaining other project purposes, *i.e.* flood damage reduction for developed areas. The three pump stations, S-332B, S-332C and S-332D were completed in 2003, and complete build-out of a series of connected detention areas south from S-332B to the southern extent of the Frog Pond was finished in early 2009. The current pumping operation plan to maintain the hydraulic ridge is based solely on canal stage. However, hydrologic restoration of these wetlands requires development of an operational plan focused on optimizing natural resource benefits by using hydrologic conditions in the wetlands to trigger pump operations, *i.e.* marsh driven operational criteria.

Time series, water budget, and hydropattern analyses using empirical data and hydrologic simulation model output were used to evaluate the performance of the detention areas and response of the natural system to project operations. Operational schemes based on marsh hydrology in addition to canal stages were examined using the Rocky Glades Model (RGM). The RGM was developed with the objective of testing and optimizing the C-111 detention area operational plans based on marsh conditions. Preliminary analyses indicate operation of the C-111 Project pumps reduce and return seepage to ENP producing localized increases in water depths. Increases in water depth quickly diminish with distance from the detention areas and commensurate increases in flows at Taylor Slough Bridge have yet to be realized. In order to restore hydrology across a larger temporal and spatial extent, increased operational depths within the detention areas than originally envisioned may be required. To maximize opportunities for ENP hydropattern restoration, inflows to the detention areas may be required when minimum levels at selected marsh gauges are met. Increases in detention area stage must also be closely monitored and adaptively managed to prevent impacts to ENP flora and fauna, including endangered species, associated with the increased detention area stages and potential influxes of undesirable water quality to ENP.

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Temporal Dynamics in Phosphorus Export from the Okeechobee Basin: Explanations, Predictions, and Implications

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This work examines the spatio-temporal dynamics of the total phosphorus (TP) load exported from the Okeechobee basin, coupling process-based models with the multi-decadal observational record. An empirical power function model is commonly used to describe the relationship between catchment exported solute concentration (C) and discharge (Q). Here we show how this dependency emerges based on the relationship between flow-generating zones and solute-generating zones, and we examine how this can explain the observed variability in solute concentration. Further, we show how the C-Q relationship explains the observed connection between annual exported loads and discharge. We supplement our results with complementary data for chloride and nitrate. On an intra-annual basis, the vast majority of the TP load enters the lake in only a few days. The solute sources contributing to TP loads similarly represent only a small fraction of the total basin area. Collectively, these synthesized results suggest that both intra- and inter-annual variations in nutrient loads can be robustly predicted based on hydro-climatic forcing.

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Potential for Use of Native Phytopathogens as Biocontrol Agents for Invasive Plant Species

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Invasive exotic plant species are a serious threat to the natural ecosystems of South Florida. The old world climbing fern (*Lygodium microphyllum*) and Brazilian pepper (*Schinus terebinthifolius* Raddi) are among the priority exotic invasive plant species that are spreading at an alarming rate, therefore development of additional tools to mitigate its spread and growth is critical for the overall management strategy. Exotic invasive plant species are susceptible to native microbial phytopathogens. Localized epidemics or plants with severe symptoms are good source of potential biocontrol agents. Periodic field survey for occurrence of disease were made, putative pathogens were isolated and tested for pathogenicity using detached leaf assay and seedling inoculation. Among the native pathogens tested *Neofusicoccum* sp. a fungal pathogen isolated from Brazilian pepper seed was found to cause seedling death. The seed borne pathogen *Neofusicoccum* sp. was also able to induce die back symptoms on inoculated tree branches in field and cause wilting and death of saplings following stem inoculation in the screen house. Survey conducted at *Lygodium* infested natural area sites in Jonathan Dickinson Park, DuPuis Preserve, and J.W. Corbett wildlife management area showed occurrence of severe disease symptoms on *Lygodium* caused native pathogens. We tested 78 fungal isolates that were isolated from the plant disease samples. Initially screening for pathogenicity was done using detached leaflet assay. Twelve fungal isolates were found to be highly pathogenic based on the detached leaflet assay. Majority of the fungal isolates were unidentified and the known isolates belonged to *Alternaria* sp. *Curvularia* sp., *Colletotrichum* sp. and *Cylindrocladium* sp. Inoculation experiment using selected 11 fungal isolates were conducted under greenhouse conditions. Three of the fungal isolates caused more than 50% disease incidence on *Lygodium* plants and disease severity that was based on a 0 to 4 scale ranged from 2 to 3.3. In a host range study on six native fern species, three of the fungal isolates that were found to be highly pathogenic to *Lygodium* did not produce any symptoms on native ferns. Further research into development of native pathogens could have a significant impact on availability of potential tools to manage the spread of *L. microphyllum* in South Florida.

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Alligators (*Alligator mississippiensis*) as an Indicator of Ecological Change in Greater Everglades Ecosystems

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A system-wide monitoring and assessment plan (MAP) has been developed to describe the monitoring necessary to track ecological responses to Greater Everglades restoration. The plan includes descriptions of selected indicators, how those indicators are linked to key aspects of restoration and performance measures. Alligators were one of those species selected as an indicator and a system-wide monitoring and assessment plan was designed to specifically monitor relative abundance based on encounter rates, body condition using Fulton's condition factor (Fulton's K), and occupancy rates of alligator holes. Relative abundance and body condition data were collected at ten areas in marsh and canal habitats in Arthur R. Marshall Loxahatchee National Wildlife Refuge (LOX), Water Conservation Area (WCA) 2A, WCA3A (north, central, and south), WCA3B, Everglades National Park (ENP-Shark Slough, Northeast Shark Slough, and Estuary), and Big Cypress National Preserve. Alligator hole occupancy data were collected in inaccessible areas of Everglades National Park. Targets for alligator performance measures are based on patterns that are consider natural for Everglades ecosystems, rather than a maximum or optimal value for the species. Quartiles were developed based on relative densities and body condition of alligators in the Greater Everglades using data from 1999-2006. The exception was occupancy rate of alligator holes, in which case the upper limit of the parameter was based on historical information. Assessments were then performed for each individual management unit. These increasing or decreasing trends of alligator populations relative to hydrologic changes permit assessment of positive or negative trends in restoration.

From 2006, relative abundance in LOX reached its restoration goals, WCA3A-Central did not meet its restoration goal and merits attention, and the remaining areas deviated substantially from restoration targets and merits action. Five year running mean for relative abundance indicated LOX meet its restoration goals, WCA3A-Central and South did not meet its restoration goal and merits attention and the remaining deviated substantially from restoration targets and merits action. We were able to detect trends in relative abundance; LOX had an increasing trend and ENP-Estuary and WCA3A-North had decreasing trends. Body condition in all areas did not meet its restoration goal and merits attention, except for LOX which deviated substantially from restoration targets and merits action. Three year running mean for body condition indicated that all areas did not meet its restoration goal and merits attention. We were able to detect trends in body condition; ENP-Estuary had an increasing trend and WCA3A-South, ENP Northeast Shark Slough, and LOX had decreasing trends. Alligator hole occupancy did not meet its restoration goal and merits attention.

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Canal-Related Influences on Biscayne Bay Seagrass and Mangrove Fishes and Invertebrates

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As part of the Comprehensive Everglades Restoration Plan, a Monitoring and Assessment Plan (MAP) has been developed to assess the system-wide performance of the South Florida ecosystem. South Biscayne Bay's western shoreline will be the first ecosystem to change when the Biscayne Bay Coastal Wetland Project is implemented. As part of MAP, two projects are monitoring the western Biscayne Bay shoreline, characterizing the faunal communities to provide baseline information for evaluating the ecological effects of water management changes. The first is a mangrove fish community visual census study that recognizes that impacts are likely to be the strongest and most easily discerned along the mangrove-lined shorelines. The second project samples the smaller epifaunal seagrass community using a throw-trap with stations selected offshore of those of the mangrove stations. Both projects sample twice annually (dry and wet season). Sampling has been conducted for the mangrove component for eleven years and the seagrass component for five years. Our working hypothesis was that large discharges of fresh water from canals interrupt salinity patterns along the shoreline, creating disruptions in habitat that affect species composition and abundance at nearby sites.

Canals along the Biscayne Bay western shoreline were characterized as high-flow (>4 m^3/sec) and low-flow (<2 m^3/sec) based on discharges. In the mangrove study, there were more taxa occurring at stations closest to low-flow canals than high-flow canals in the wet season. Type of canal was less important in the dry season. A significant positive relationship was found between wet season taxonomic richness and distance from a canal for samples near high-flow canals, but no relationship with low-flow canals. During the wet season, impacts were apparent to 5000-6000 m from the mouth of a high-flow canal, based on highest richness values. Four common wet season taxa were found to have their lowest densities within 500 m of high-flow canal- *Lutjanus griseus, Haemulon parra, Abudefduf saxatilis, Archosargus rhomboidalis*, and small silvery fish group (silversides, herrings, anchovies). In the seagrass study, the relative abundance of several species were observed to seasonal shift in relationship with distance from the canal- being closer to the canal mouth in the dry season and further away in the wet season. Seagrass fish taxonomic richness was higher closer to the canal during the dry season, but no strong relationship was found in the wet season. Two taxa (caridean shrimp and *Opsanus beta*) were found to be absent within 1050 m of any canal during both seasons, while *Farfantepenaeus duorarum* (1000m) and *Gobiosoma robustum* (500m) were absent in the wet season.

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Augmenting Everglades Fire History Data through Satellite Remote Sensing

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USGS research is exploring the influence that interactions among fire, soil and water have on the persistence of native and exotic plants adjacent to mangrove forest. The Everglades National Park (ENP)/Big Cypress National Preserve (BCNP) fire database (ENP/BCNP-FD) is being expanded to the year 2010 in Geographic Information System (GIS) format. Because this fire information is based on field survey and sketch maps drawn from airplanes, it is possible that these data can be improved through the synoptic, repeat coverage afforded by satellite image data. Therefore, the research is also testing the efficacy of satellite remote sensing for Everglades fire ecology research. As a first step in the remote sensing component of the study, imagery from the Landsat archive is being compared with ENP/BCNP-FD data on fires in the ENP. Images dating from just prior to burns, soon after burns and at uniform phenologic periods following burns are visually interpreted and numerically analyzed. Important improvements can be made to the spatial characteristics of the ENP/BCNP-FD GIS data as non-burn areas within database fire scars can be identified and the fire boundaries themselves can be improved through satellite data interpretation. Post-fire vegetation regrowth patterns across the Greater Everglades are also being tracked and characterized. Finally, the work is also being expanded to test the use of remote-sensing based fire severity indices.

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Mercury in Mosquitofish (*Gambusia affinis*) of the Greater Everglades: Changes in Biogeochemistry and Trophic Complexity over Time and Space -- R-EMAP 1995-2005

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Though notable declines of mercury were detected in mosquitofish and periphyton over the Everglades landscape in the last R-EMAP survey (Phase III, 2005), a number of mercury "hot spots" remained. The highest correlation of mercury in mosquitofish, the most ubiquitous forage fish in the ecosystem, was with methyl mercury in epiphytic periphyton, the most ubiquitous form of calcareous periphyton, the keystone, signature plant community of the oligotrophic system. Phosphorus in surface water was also strongly correlated over its entire range of concentration, but negatively. Other factors were related to methylation and bio-accumulation in a nonlinear fashion, namely sulfate, dissolved organic carbon, and pH in surface water; and total phosphorus and bulk density in soil. Where these five factors were all in optimal ranges, mercury concentration in mosquitofish was almost twice that of other locations in the Everglades. While these abiotic factors were good predictors of elevated levels of mercury in mosquitofish, food web dynamics, notably herbivory on epiphytic periphyton, as well as the omnivorous nature of mosquitofish, are a likely explanation for the very high concentrations observed in the parts of the ecosystem that had the most diverse trophic structure in addition to optimal biogeochemistry. Explaining the changes in mosquitofish mercury over time, as shown by the R-EMAP surveys from 1995 to 2005, is less straightforward, particularly for the wet season. Results of a predictive model, comprised of mercury and phosphorus in soil and organic carbon and sigmoidally transformed sulfate in surface water, suggest that biotic factors were at work as well.

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Vegetation Site Characterization at A.R.M. Loxahatchee National Wildlife Refuge

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At 58,275 hectares, the A.R.M. Loxahatchee National Wildlife Refuge is a unique portion of the remnant Everglades ecosystem. The predominant vegetation communities found within the soft-water Refuge include wet prairie, sloughs, sawgrass ridges and tree islands. Areas of pristine marsh throughout the Everglades, including the Refuge, have been impacted to various degrees by intrusion of water with high nutrients and other constituents. Water in the canals that surround the Refuge is higher in specific conductivity and nutrients than the marsh interior because of urban and agricultural runoff. Canal water intrusion from the perimeter canals introduces nutrient-rich water into the marsh interior, which can change macrophyte communities leading to effects at higher trophic levels. In 2004, the Refuge established an enhanced water quality monitoring network designed to improve the scientific understanding of water quality issues in the Refuge and provide information that can be incorporated into water management decisions to better protect Refuge resources. In addition to understanding surface water quality, this program documented differences in vegetation communities along surface water chemical gradients across the Refuge to provide critical baseline data. The objectives of this study are to characterize major plant communities and any changes in vegetation patterns at 39 water quality sites across a series of transects throughout the Refuge.

Macrophyte communities were sampled during the dry and wet season in 2009 at 39 sites across the Refuge to document changes associated with intrusion of nutrient/mineral rich canal drainage. Data were collected across the Refuge for a baseline study in February-March 2009, and August 2009. All vegetation characterization sites were established within approximately 50 m of the water quality sampling site. Transects at each site are 50 meters in length and have eleven vegetation sampling plots starting at 0 m with samples collected every 5 m. Vegetation samples at each point along the transect include a qualitative description of the submerged vegetation (e.g., sparse, moderate, dense), percent bare area, and percent cover of each plant species. Percent cover was recorded in increments of 5% using a Daubenmire frame consisting of $1m^2$ PVC frames.

Surveys identified a diversity of 30 plant species among the 39 sites. The quantitative and qualitative characterization of the vegetation present at each site will provide additional information on potential factors influencing site-specific water quality. Established monitoring plots will be surveyed at 2 year intervals and provide data regarding long-term effects of water quality on vegetation communities across the Refuge.

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Juvenile Sportfish Populations in Florida Bay: Influence of Salinity

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Juvenile sportfish are monitored in Florida Bay utilizing an otter trawl as part of RECOVER. This sampling methodology has been discontinuously employed in Florida Bay since 1984, providing a robust dataset to develop quantifiable, testable hypotheses regarding the influence of CERP on these populations. Spotted seatrout, *Cynoscion nebulosus*, are an established indicator of estuarine health (Bortone 2003) and an important recreational sportfish in Florida Bay that spend their entire life history within the Bay (Rutherford et al. 1989). In 1984-1985, juvenile seatrout distributions were limited to the western sub-region of the Bay and absent from the north-central sub-region, where hypersaline conditions prevailed. During 1994-1996, when hypersaline conditions in the north-central were rare or absent, the spotted seatrout juveniles expanded into this part of the Bay (Thayer et al. 1999). Hypersaline conditions are characteristic of the present salinity regime in north-central Florida Bay (Kelble et al. 2007); however, one of CERP's interim goals is to alleviate hypersalinity in Florida Bay. This could be accomplished by diverting freshwater runoff from northeast to north-central Florida Bay (Lee et al. 2008).

There is a significant inverse linear correlation between juvenile spotted seatrout and salinity throughout the north-central sub-region. This correlation was corroborated with the development of a temperature-salinity habitat suitability index via logistic regression that indicated juvenile spotted seatrout prefer lower salinities. A general linear model also found a significant bay-wide response between juvenile spotted seatrout density and salinity. Densities decreased at salinities greater than the adjacent coastal ocean (36.4) and were independent of salinity for values below the adjacent coastal ocean. These findings suggest if CERP is successful at decreasing hypersalinity it will increase the juvenile spotted seatrout population in Florida Bay. Larval spotted seatrout were observed in this north-central sub-region during hypersalinity events (Powell 2003), indicating hypersalinity causes either a failure to recruit or an increase in larval and juvenile mortality, but not a change in larval supply to this sub-region. Results will be presented to discuss this and other potential impacts of CERP on the juvenile sportfish community in Florida Bay.

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Lake Okeechobee Sediment Management

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The environmental resources of Lake Okeechobee have been significantly impaired by nutrient enrichment (primarily phosphorus), altered hydroperiod, and expansion of exotic species. There are two major sources of nutrient enrichment, external loading that occurs in the form of discharge of nutrient-rich stormwater runoff from the watershed and internal loading, which results from the flux of phosphorus from the nutrient-rich, soft organic fluid mud that has accumulated at the bottom of the lake. This fluid mud covers an area of over 200,000 acres of the lake bottom. It consists of material transported into the lake or formed within the lake primarily during the past century. Approximately 57,000 tons of phosphorus are conservatively estimated to be present in this mud. Due to the lake's shallow depth the upper layers of the mud are mixed into the water column every time strong winds blow across the lake surface. This keeps water column phosphorus concentration high, and when the turbid water is transported to the near-shore region, it prevents submerged plant beds from getting the amount of light they need to grow.

It is generally believed that if internal phosphorus loading from these fluid mud sediments is not addressed in a timely manner, the lake may not respond to reductions in external phosphorus inputs or the response may be significantly delayed. There is general consensus that some combination of mud sediment removal and external load reduction is needed to achieve holistic recovery of Lake Okeechobee in a relatively short (decades) time frame. This paper will discuss the many options have been evaluated over the past decade for removal and disposal of the mud sediments from the lake bottom. It will highlight the challenges that have to be overcome for achieving holistic restoration of Lake Okeechobee through effective sediment management.

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Island Apple Snails, *Pomacea insularum*, in Everglades National Park: 5 Years Later

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Drainage of marsh habitats and delivery of nutrient enriched waters are considered among the main threats canals pose in the Everglades. Non-native species are known to refuge in canal habitats and may colonize Everglades marshes from canals. An increase in the number of non-native species certainly makes the Everglades a living laboratory of change. The non-native island apple snail, *Pomacea insularum*, is yet another relatively new addition to Everglades habitats.

The island apple snail was first found in Everglades National Park (ENP) within the Old Tamiami Canal at the Shark Valley entrance in 2005. At the same time, island apple snails were found upstream in the L-29 canal at the S-12B structure that flows into Everglades National Park. Monitoring that began in 2005 has documented the spread of the island apple snail from a small section of the Old Tamiami Canal at the entrance of Shark Valley to filling a 4 mile stretch of the canal east of Shark Valley. Island apple snails have also been found in the marshes of ENP south of the S-12A and B inflow structures and culverts in the Old Tamiami Canal, but do not yet appear to have expanded to detectable levels more than a mile south of the structures. A reproductive population of island apple snails has been found over a 15 mile stretch of the L-29 canal upstream of Everglades National Park. In addition, the reproductive effort within the L-29 canal is usually higher than in the Old Tamiami Canal within Everglades National Park. Preliminary results suggest the reproductive effort within the Old Tamiami Canal may be related to inflows from the S-12 structures and the high reproductive effort of the population of island apple snails upstream in the L-29 canal. Given the large and expanding area that the island apple snail exists in the L-29 canal and the direct inflows to Everglades National Park from this canal, it is expected that the island apple snail will continue to expand its range within Everglades National Park. However, little is known how well this species will do in the more natural marsh habitats. A shift to include studies to understand the ability to survive in and the impacts of the island apple snail on Everglades marshes will be key to assessing the living laboratory of change of the highly invaded Everglades landscape.

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Seasonally Changing Surface Water Discharge Drives Ecosystem Metabolism Rates in Estuarine Taylor River

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Everglades restoration calls for an increase in water delivery to the major watersheds of Everglades National Park. The responses of the estuarine end-members of these watersheds to hydrologic restoration are not entirely understood. In this project, we investigate how ecosystem metabolism in estuarine Taylor River, an important linkage between Taylor Slough and Florida Bay, is related to existing seasonal changes in hydrologic and environmental drivers. While seasons in South Florida are marked by tropical wet/dry patterns of rainfall, salinity concentrations appear to be the best indicator of seasonal change in Taylor River as salinity is a better indicator of freshwater delivery to the estuary. We derived rates of aquatic metabolism from high-frequency (10-minute), free-water, diel changes in water column dissolved oxygen. Ecosystem gross primary production (GPP) and respiration (R) rates were greater in magnitude during the “euhaline” season than the “oligohaline” season. However, net ecosystem production (NEP) did not always show seasonal differences, reinforcing the tight coupling of autochthonous organic matter (OM) production and ecosystem respiration. Furthermore, we investigate the relationships between aquatic metabolism and other driving environmental variables. Seasonal metabolism differences appear to be driven by seasonal changes in total phosphorus (TP) concentrations, which are in turn dictated by seasonally changing water source and water quality patterns in the coastal, southern Everglades.

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A Recent History of Taylor Slough Hydrology

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The only remaining uncontrolled breach in the Atlantic Coastal Ridge, Taylor Slough provides a drainage path for the interior Everglades to reach tide water. Cutoff from its headwaters by agricultural and urban development it now lacks the refreshing effect it once had on Florida Bay. Efforts to restore ecological function to this drier, but still valuable natural resource, date back to the late 1970's and have included three additional modifications to the infrastructure aimed at enhancing the volume of discharge in the Slough and in turn conditions in Florida Bay.

The first plan was to deliver water via a new canal excavated along the Park boundary in 1978. However, the L31W, as it is called, had more of a tendency to drain away the headwaters than to provide the much needed water supply. Clearly a pump was required. The S332 was constructed on the L31W as it intersected the center of Taylor Slough. It compensated for the excess drainage effect of the L31W, but provided little more water than was available prior to the canal excavation. Following a severe sea grass die off in Florida Bay that occurred in the late 1980's, additional capacity was added at the S332 location. This additional capacity achieved higher discharge rates into the slough, however it did so by partially draining the marsh upstream. More recently, the C-111 Restoration Project has provided a new approach to water delivery focused on reducing seepage by raising groundwater levels along a broad expanse of the eastern border of the Slough.

A thorough analysis of the various water delivery paradigms has been undertaken by staff of the National Park Service to evaluate the hydrologic response of each scheme. The results of this analysis are intended to provide the physical stage on which to interpret the Slough's ecological condition. The interaction between hydrology and ecologic conditions has received substantial attention in recent years in response to the build out of the C-111 Restoration Project that has been ongoing for the last 10 years. As a result, many researchers in various disciplines have worked to deepen our understanding of this resource. Of particular interest is the effect of the new water delivery features on the water quality in the Slough. And one of the most significant remaining questions is whether impacts to soil phosphorus levels and effects such as the expansion of *Typha* sp. is a result of legacy effects from previous management regimes, or is being aggravated by the current scheme.

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The Influence of Canal Water Releases on the Distribution of Mercury, Methylmercury, Sulfate and Dissolved Organic Carbon in Everglades National Park: Implications for Ecosystem Restoration

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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 in biota centers 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. 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 about 70 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 elevated sulfate. The top of the Shark River and the C111 regions are associated with canal derived sulfate, whereas sulfate at the two coastal zones appears to be marine in origin.

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Bacterial Mercury Methylation: The Role of Dissolved Organic Carbon

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Sulfate-reducing bacteria (SRB) are the primary known environmental producers of the potent neurotoxin methylmercury (MeHg). Sulfate reduction readily occurs in sediments of aquatic ecosystems where an ample supply of sulfate and there exists organic rich sediments that support anaerobic conditions necessary for SRB metabolism. Being a freshwater wetland, the Everglades have always contained extensive organic peat deposits, and thus potentially can support MeHg production. However, two relatively recent perturbations to this ecosystem, elevated atmospheric mercury (Hg) deposition and sulfate loading from canals draining agricultural fields, have resulted in an increased level of MeHg generally observed in the Everglades. One possible exacerbating factor that is unresolved in the scientific literature, however, is whether there is a "self-feeding" mechanism of Hg methylation in some ecosystems whereby dissolved organic carbon (DOC) increases the bioavailability of inorganic mercury (Hg(II)). To answer this question we conducted laboratory-based, pure-culture experiments using a known strain of SRB (Desulfobulbus propionicus), tracer Hg (e.g., ^{202}Hg) and different DOC isolates from several locations, including two from the Everglades. Given field and lab observations that DOC correlates with both dissolved Hg and MeHg abundance, we hypothesized that presence of a hydrophobic DOC should enhance Hg(II) methylation rates.

The experimental results showed clearly that those cultures exposed to tracer Hg with DOC had distinctly greater MeHg production rates that those without (tracer Hg only controls). Among the DOC isolates used, the two from the Everglades exhibited the greatest amounts of produced dissolved methylmercury. An interesting response was also observed for experiments that included pre-reaction (5 and 30 days) of the tracer Hg and the DOC. Those tests showed that 5-day reacted Hg-DOC showed maximal production of methylated tracer. One unplanned observation from these experiments was the revelation that the experimentally applied DOCs contained "natural Hg", so we were able to examine the relative bioavailability of that Hg versus the tracer Hg. The experimental results revealed that generally greater amounts of non-tracer Hg associated with the DOC fraction was methylated, revealing that naturally-partitioned mercury was at least as bioavailable as the tracer. Methylation of natural DOM-hosted Hg suggests a commonality with respect to the form of Hg(II) that can be methylated by SRB.

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Inferring Effects of Historic Extreme Storms in the Everglades from Hindcast Models

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Several different types of hindcast models have been examined to estimate potential effects of extreme storms in the Florida Everglades. This analysis is part of a larger Future Impacts of Sea-level Rise on Coastal Habitats and Species (FISCHS) interdisciplinary modeling effort, designed to provide information to resource managers about sea-level rise effects.

The initial effort to model historic hurricanes is focused around 1928 to correspond to aerial photography coverage. Hindcast projections from the BISECT (Biscayne and Southern Everglades Coastal Transport) model were compared with historical hurricane data from 1926 to 1932. The BISECT model applies the FTLOADDS (Flow and Transport in a Linked Overland/Aquifer Density-Dependent System) hydrodynamic simulator to the Everglades area. The initial model output showed no signature for the Great Miami Hurricane of 1926. Analysis revealed that all the input gauges for the event had been destroyed by the storm. Using narrative descriptions and storm statistics, rainfall parameters were estimated for the missing time interval.

Based on examination of the 1926, 1928, and 1929 hurricanes, a pattern of rapid growth of inundated areas was noted in the BISECT output. Analysis revealed similar patterns not tied to historic hurricanes. An interval in June 1930 was given the informal name, the “Florida Disturbance”. Such an event would not show up in the historic hurricane catalog, indicating that other non-hurricane events may also need to be revaluated.

The extent of the wind field is a key parameter in identifying areas of hurricane impacts. A series of mudflats near Cape Sable, Florida, has been attributed to the 1935 Labor Day Storm. Meteorological hindcasts from the 20th Century Reanalysis Model indicate that the extent of the hurricane-force winds of the Labor Day Storm may not have directly impacted the Cape Sable area. In 1929, the “Andros Island” hurricane tracked directly over Cape Sable. This sequence indicates that the cumulative effect of multiple storms in vegetated areas may have as significant an impact as a larger solitary event.

These early examples indicate that using hindcast models to reanalyze historic storm data may not only help refine the model for better predicative analysis, but also may illuminate new types of interactions between storm events and the Everglades landscape.

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An Update on USACE Sea Level Change Guidance and Preliminary Applications for Everglades Restoration Projects

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The U.S. Army Corps of Engineers (USACE) issued guidance in July 2009 requiring all Civil Works projects in the Planning, Engineering Design, Construction, or Operations and Maintenance phases to consider potential impacts from future sea level change. This guidance, Engineering Circular (EC) 1165-2-211, provides detailed information on how to calculate forecast low (historic), intermediate and high rates of sea level change, but provided very limited guidance on subsequent planning and decision making steps required to implement this EC. This presentation will provide current information on additional guidance now being developed for these steps and examples of preliminary applications for Everglades Restoration Projects.

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The Everglades Cooperative Invasive Species Management Area

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Successful implementation of everglades restoration is dependent on successful management of invasive species throughout the greater everglades area. Successful invasive species management is contingent on successful coordination of invasive species management efforts between the land owners and stakeholders in the everglades. This presentation will discuss the purpose, formation, objectives and successes of the Everglades Cooperative Invasive Species Management Area (ECISMA). ECISMA is a partnership of Federal, State and local governments, Tribes, NGO’s and other stakeholders in the greater everglades area dedicated to managing invasive species in a cooperative manner. Although the organization was officially recognized less than a year and a half ago, it has many successes including an interagency treatment database, coordinated interagency mapping efforts, successful early detection and rapid response efforts, as well as development of annual operating plan.

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USACE Policy to Address Invasive Species Issues

Angie Huebner, Joana Savinon, Jeremy Crossland and ***Jon Lane***
US Army Corps of Engineers

The US Army Corps of Engineers developed and issued a new policy regarding invasive species in June 2009. The policy addresses invasive species and management of invasive species across all USACE missions. The policy is being implemented to bring the USACE into compliance with EO 13112 and the National Invasive Species Council's (NISC) national management plan.

The poster will describe what is required of USACE missions to comply with the policy and the NISC's directives to improve invasive species management throughout the country. The poster focuses on how the USACE will address invasive species issues and what is required of each mission. Specific to ecosystem restoration and the Comprehensive Everglades Restoration Project (CERP) the poster will focus on requirements improve activities related to planning and construction to prevent the introduction and spread of invasive species.

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Special Session: Predicting Past and Future Impacts of Sea Level Rise on Coastal Habitats and Species in the Greater Everglades — Integrating Hydrological and Ecological Models

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This special session highlights new modeling efforts that integrate hydrological and ecological models to assess the consequences of Sea Level Rise (SLR) in the Greater Everglades. The morning session focuses on the USGS FISCHS Project (Future Impacts of Sea Level Rise on Coastal Habitats and Species). This integrated modeling project, established in March 2009, merges biological and hydrological models into new models to hindcast and predict SLR effects for resource management. It builds on prior USGS models and research in support of the Comprehensive Everglades Restoration Plan (CERP). To develop a realistic suite of predictive models, we are (1) Enhancing the FTLOADDS hydrologic model to reliably hindcast multi-decadal observed SLR phenomena based on historical tidal sea level, meteorological data, and documented changes in coastal vegetation types derived from historic charts and aerial photography; (2) Incorporating episodic disturbance from hurricanes, which impact both hydrology and ecology; (3) Developing mechanistic models of coastal vegetation change to understand and predict tipping points for regime change; (4) Integrating the models to simulate variables for both spatially-explicit population models and models of habitat suitability indices; and (5) Developing predictive capability for the new models, incorporating comparative assessments of effects on species under various projected restoration, management, and SLR scenarios.

The afternoon session focuses on additional FTLOADDS applications and conjunctive use with other models to analyze specific SLR issues in the Greater Everglades including: (1) Simulations to examine SLR effects on flooding and saltwater intrusion with ongoing ecosystem restoration efforts; (2) Applications to Everglades National Park to examine SLR effects on the relationship between the upstream freshwater marsh and the coastal mangrove estuaries; (3) Use of model output in the development of an Alligator Population model; and (4) Application of a smaller-scale three-dimensional model to determine factors affecting haloclines and thermal inversions in manatee warm-water winter refugia.

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Modeling to Predict Causes of Degradation and Likely Outcomes of Restoration of the Everglades Ridge and Slough Ecosystem

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Flow-mediated sediment redistribution between adjacent vegetation communities has been proposed as a dominant feedback mechanism responsible for the formation and evolution of the patterned Everglades ridge and slough landscape structure. Although flow and sediment redistribution are known to be important controls on landscape structure in tidal marsh systems, their potential role in creating anisotropic, regular patterning or in promoting nonlinear behavior with large ecological repercussions, such as catastrophic shifts between alternately stable landscape states, have been poorly understood.

Numerical models that simulate key physical and biological processes controlling the dynamics of a landscape are essential tools for understanding landscape evolution under different combinations of initial and ambient environmental conditions and for understanding how the landscape will respond to perturbation or changes in management. Here we explore the sensitivity of ridge and slough landscape behavior to changing hydrologic conditions, sediment properties, and vegetation communities using the Ridge and Slough Cellular Automata Landscape (RASCAL) model, described in Larsen and Harvey (2010a and b). The model, based on field and experimentally derived relationships for flow and floc transport, simulates landscape evolution resulting from vegetation colonization, differential peat accretion, spatiotemporal variations in flow depths and flow velocities, and sediment transport.

In 137 simulations that fully spanned the range of environmental conditions bracketing many low-gradient, shallow wetlands, stable and longitudinally oriented ridges and sloughs developed only over a narrow set of conditions, in which flows were slightly above the sediment entrainment threshold. A bifurcation analysis revealed that landscapes governed by this sediment redistribution feedback exhibit alternate stable states. With changes in flow velocity and water level, they can catastrophically shift from a regularly patterned landscape to one uniformly vegetated with emergent species. When stable ridge and slough landscapes that had evolved within RASCAL were perturbed by decreased water depths, decreased water velocities, and increased spikerush abundance within sloughs, all diverged to homogeneous ridge coverage, with altered water depth inducing the fastest rates of divergence. Reversal of these perturbations reduced sawgrass coverage only at low-elevation ridge edges, but most ridge expansion persisted permanently. Results highlight the importance of promptness in restoring more natural hydroperiods and flow velocities and of the potential need to re-initiate sloughs where topographic and vegetation heterogeneity has been lost.

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Using Fluorescence Spectroscopy to Trace Seasonal DOM Dynamics, Disturbance Effects, and Hydrologic Transport in the Ridge and Slough Landscape

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Dissolved organic matter (DOM) quality reflects numerous environmental processes, including primary production and decomposition, redox gradients, hydrologic transport, and photochemistry. Fluorescence spectroscopy can detect groups of DOM compounds sensitive to these processes. In the Everglades peatland, these processes affect rates of peat aggradation and degradation and therefore serve as a direct control on landscape structure and related ecosystem functioning. Consequently, fluorescence spectroscopy has the potential to be used as a tool for evaluating the success of restoration measures in creating environmental conditions favorable for a patterned ridge and slough landscape. However, different environmental gradients (e.g., redox, DOM provenance) that are present across ridge and slough vegetation communities can have confounding effects on DOM fluorescence spectra.

Here we show how a statistical technique using discriminant analysis and parallel factor analysis (PARAFAC) modeling, described in Larsen et al. (2010), can deconvolve fluorescence spectra, resulting in interpretable, quantitative measures of redox potential and DOM provenance gradients. We employed this technique to interpret DOM fluorescence spectra from surface water and porewater samples collected from adjacent ridge and slough vegetation communities in central Water Conservation Area 3A and from ridge and slough peat core leachates. Vertically distributed water samples were obtained at a monthly resolution for 1.5 years by pumping minipoint piezometer arrays screened at seven different depths. Peat cores were collected from ridge and slough centers at two times during the sampling period.

Source discrimination of DOM in whole-water samples and peat leachates revealed strong temporal variability associated with seasonal drydown/wet-up cycles and the passage of Hurricane Wilma in 2005. Through its long-term elimination of floating periphyton mats, the hurricane's effects on organic carbon cycling persisted for longer periods of time (>1 year) than previously recognized. Using the DOM source signal as a hydrologic tracer, we show that the system is hydrologically well-mixed when surface water is present, and that limited transport of flocculent detritus occurs in surface flows. Redox potential discrimination shows that vertical redox gradients are shallower on ridges than in sloughs, creating an environment more favorable to decomposition and diagenesis. The sensitivity, high resolution, rapidity, and precision of these statistical analyses of DOM fluorescence spectra suggest the utility of this technique as a performance indicator of restoration of the ridge and slough landscape.

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Assessment of Wood Stork Foraging Opportunity for Southwest Florida

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Prior to 1970 a majority of the US population of wood storks (*Mycteria americana*) nested in South Florida. Continued loss of habitat in their south Florida range has caused a steep decline in nesting effort and nesting success in this region. Southwest Florida's (SWFL) stork population is particularly unstable and vulnerable due to the proportion of available foraging habitat in private ownership, and subject to potential wetland impacts. Development pressure and limited conservation funding make it vital to have adequate tools to prioritize land acquisitions and guide permitting decisions to ensure the continued viability of the Greater Everglades for wood storks.

Wood storks are a keystone species and have been identified as an indicator of Everglades restoration success. Our study looked at assessing the quality and quantity of foraging opportunity available to wood storks in SWFL, with a goal of providing insight into how best to stabilize nesting efforts in SWFL and aid in species recovery. We employed aerial and ground surveys to record more than 700 foraging events over the course of the 2006-07 and 2008-09 nesting seasons. An additional 3000 positions were generated from satellite tagged birds nesting within Corkscrew. Quality digital photography, GoogleEarth and ArcGIS mapping tools contributed to our ability to confirm and analyze foraging locations. Foraging locations were assigned a FLUCCS category derived from the 2004 Land Use Land Cover map developed by the South Florida Water Management District. Our analysis looked at habitat use within an 18.6mile radius of the Corkscrew colony, known as the core foraging area, as well as the study area as a whole. Availability of each habitat type was compared to wood stork use to identify habitat preferences. Comparisons were made between a nesting year (2008-09) and a non-nesting year (2006-07), as well as temporal use of each habitat type over the course of the nesting season (mid-October through May). Habitat usage detected from satellite locations were compared to usage detected through aerial observations to measure biases against detection of use in forested habitats.

Preliminary analysis has revealed two important trends. Wood storks utilized forested wetlands over 40% of the time, which runs counter to the prior belief that forested wetlands are only marginally important. The second trend relates to the role agricultural and roadside ditches play in providing foraging opportunity for wood storks. In both the nesting and non-nesting years, ditches and canals were shown to be used more than any other wetland type. Results from this study will be used to direct acquisition, restoration, mitigation and guide permitting decisions for Southwest Florida in an effort to make the most of Everglades conservation dollars and aid in the recovery of the wood stork.

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Trajectory Analysis of Everglades Diatom Community Response to Natural and Anthropogenic Influences

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There are distinct gradients of phosphorus and hydrology that drive differences in communities across the Everglades. Natural impacts, such as hurricanes, and anthropogenic influences, such as water management, both strongly influence the spatial range and intensity of these gradients. To explore community responses to changes in these gradients, trajectory analysis was performed on diatom species composition data from 2005 and 2006. Trajectory analysis is a statistical method for examining community data that tracks each point in ordination space through time and evaluates whether communities are progressing toward or away from restoration goals. We found trajectories of communities significantly correlated with decreasing water depth, reflective of the drought experienced in South Florida during this time period. Communities were significantly correlated with increasing total phosphorus, especially in regions near canal inflows, as well as regions impacted by Hurricane Wilma. One community in Taylor Slough, a relatively unimpacted region, showed significant correlation with decreasing total phosphorus. We chose to represent these results as color-coded maps in efforts to develop an effective means of communicating ecosystem-scale patterns, especially for use by ecosystem managers. We plan to use Geographic Information System tools to further develop these maps to represent trajectories of communities from 2005 to 2008 using color gradients, and will ultimately indicate levels of vulnerability or sensitivity to change.

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Picayune Strand Restoration Project: Engineering Design; Pump Stations and Other Project Features

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The engineering and design aspects of the Picayune Strand Restoration Project are presented. Included in this presentation is the overall configuration of the project and features that ensure that potential for flooding is not increased as a result of the project. The general arrangement, size and capacity of the three pumping stations as well as construction site access design are discussed. The details and sequence of construction for the levee, canal plugging, and road and tram removal are delineated. These elements all must work in concert to produce the desired flow regime across the project. Details of the pumping stations including, instrumentation and control, provisions for exercising the pumps using a recirculation bay, and the configuration of the distribution cells including weirs are also discussed. The transfer plan for the constructed elements that provide for operational testing and monitoring prior to release of the construction contractor are presented. Finally future analysis and design work will be discussed that address alternatives being considered to ensure hydraulic discharges are properly routed through U.S. 41.

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Degradation of Methylmercury and Its Effects on Mercury Distribution and Cycling in the Florida Everglades

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Methylmercury (MeHg) is recognized as one of the major water quality concerns in the Florida Everglades. Degradation of MeHg in the water is thought to be one of the most important processes to the cycling of MeHg, but there is a lack of quantitative estimations of its effect on the distribution and cycling of MeHg in this ecosystem. Stable isotope ($Me^{201}Hg$) addition method was implemented to investigate the degradation of MeHg in the Everglades. By combining these results with the field monitoring data, effects of photodegradation on MeHg distribution and its contribution to MeHg cycling were estimated. The results indicate that degradation of MeHg in Everglades water is mediated by sunlight, and that UV-A and UV-B radiations are the principal driver. The spatial pattern of MeHg photodegradation potential (P_{PD}) generally illustrated an increasing trend from north to south in the Everglades, which was opposite to the distribution of MeHg in water column. Correlation analysis shows that MeHg concentration in the water had a significant negative relation to $P_{PD,}$ suggesting that photodegradation could play an important role in controlling the distribution of MeHg in Everglades water. Furthermore, about 31.4% of MeHg input into the water body was removed by photodegradation, indicating its importance in the biogeochemical cycling of MeHg in the Everglades. This percent reduction is much lower than that reported for other ecosystems, which could be caused by the higher concentration of DOC in the Everglades. The relatively slower degradation of MeHg could be one of the main reasons for the high ratio of MeHg to total mercury (THg) in this ecosystem.

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Status and Trends of Nearshore SAV Communities of Biscayne Bay: A Multi-scale Approach

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The **Nearshore Benthic Habitats Program** focuses on the nearshore benthic habitats (< 500 m from shore) of Southern Biscayne Bay, from Matheson Hammock to Manatee Bay, which have been largely understudied due to the difficulties associated with access to extreme shallow zones (< 1 m in depth) and are the habitats most likely to experience significant changes in water quality due to CERP components. This program was designed to evaluate spatial and temporal patterns of abundance, diversity, and distribution of SAV in relationship to distance to shore and freshwater discharge from water management canals. Synoptic surveys have been conducted seasonally since 2003. In 2008-2009 two additional components, macroalgal surveys and remote sensing analyses were incorporated into our research program. In this presentation, we will provide: (1) an overview of the status and trends in the abundance and distribution of seagrasses and macroalgae, (2) a description of the macroalgal communities of Black Point and Deering Estate and relationships to physical parameters; and (3) a description of our progress on the evaluation of the impacts of freshwater deliveries on the seascape structure of SAV patches.

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Aquatic Prey Communities in Southwest Florida Wood Stork Foraging Sites

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The marked decline in Southwest Florida's Wood Stork (*Mycteria americana*) population has been linked to the loss of short-hydroperiod wetlands within their historic foraging range. This habitat loss has led to a 1-2 month delay in nest initiation and consequential poor nesting success. Numerous studies in the Everglades have linked wading bird nesting patterns to food resources. Understanding the hydrologically-driven availability and production of prey animals in remaining short-hydroperiod wetlands is critical for assessing the relationship between delayed nesting and nesting success, as well as, the cause of the decline in the number of Wood Storks nesting in Southwest Florida.

Aquatic prey communities were sampled at 42 active foraging sites within the range of the Corkscrew colony in the 2007 and 2009 nesting years. The Corkscrew colony (Corkscrew Swamp Sanctuary, Naples, FL) is historically the largest Wood Stork colony in North America, but the population has declined precipitously since the late 1970s concurrent with increased residential and agricultural development in Southwest Florida. Between February and May of each year, foraging sites were identified from a fixed-wing aircraft and replicate fauna samples were collected using a 1-m^2 throw trap, usually within 24-h of observed foraging. We describe community structure and standing stock of aquatic prey in natural (e.g., cypress dome, alligator hole, depressional wetland) and man-made (e.g., roadside ditch, agricultural impoundment, golf course pond) prey refuges in the two nesting years. Comparisons are made between Southwest Florida dry-season prey communities and those in other parts of the Greater Everglades system. We also describe the abundance of non-indigenous armored catfishes in dry-season refuges and discuss their potential impact on higher trophic levels. Results from this study, coupled with concurrent observations of Wood Stork nesting, will be used to direct acquisition, restoration, and mitigation efforts for Wood Stork recovery.

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Mass Distribution of Mercury among Ecosystem Components in the Florida Everglades

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Large-scale (e.g., ecosystem- and management unit-wide) studies on mercury (Hg) cycling in the Florida Everglades are important for evaluating the magnitude of legacy Hg contamination in this wetland ecosystem. Construction of mass inventories of total Hg (THg) and methylmercury (MeHg), which include inputs, outputs, and storage in ecosystem components (e.g., water, soil, flocculent detrital organic matter (floc), periphyton, macrophyte, and fish), would not only provide complete information on Hg mass distribution and transport in the Everglades, but would also reveal the relative importance of each input and output pathway in Hg cycling. By utilizing a synoptic approach to analyze data from multiple datasets which include the U.S. Environmental Protection Agency (EPA) Everglades Regional Environmental Monitoring and Assessment Program (R-EMAP), the USGS Aquatic Cycling of Mercury in the Everglades (ACME) project, the Mercury Deposition Network (MDN), and the DBHYDRO database, mass inventories of THg and MeHg were constructed for the entire Everglades and for the four management units of the Everglades. Masses of THg storage in Water Conservation Areas (WCA) 1, 2, 3, and the Everglades National Park (ENP) are 914, 1138, 4931, and 7602 kg, respectively, with most Hg being stored in soil. Masses of MeHg storage are 15, 6.8, 32, and 51 kg for WCA 1, 2, 3, and ENP, respectively. In addition to soil, floc stores a significant fraction of MeHg, in particular in WCAs where the fraction of floc to soil MeHg is about 50% corresponding 4.53, 2.33, and 9.65 kg MeHg in WCA 1, 2, and 3, respectively, indicating the importance of floc in MeHg cycling. The current annual THg inputs (primarily from atmospheric deposition) account for 1-2% of the legacy THg. Transport of THg or MeHg across management units during a season amounts to 1% or less of THg or MeHg storage, except for WCA 2 where inflow inputs can contribute 4% of total MeHg storage. The disparity between Hg inputs and storage underscores the importance of understanding the cycling of legacy Hg that has been stored in the system when investigating Hg contamination in the Everglades.

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Effects of Historical Changes and CERP Restoration Projects to Endangered Everglades Avian Populations

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Our literature synopsis and ecomodeling results provide an investigation of the suitability of the estimated pre-drainage Everglades habitat and the projected effects of Comprehensive Everglades Restoration Plan (CERP) implementation on endangered Everglades avian populations. Restoration of ecosystem-forming parameters that characterized the pre-drainage Everglades landscape is predicted to provide benefits to the Everglades ecosystem including multiple endangered avian populations. Parameters including spatial contiguity of the landscape, landscape geomorphologic processes, and hydroperiods and hydropatterns are predicted to affect our endangered avian populations. Pre-drainage, existing, and future hydropatterns anticipated with implementation of the CERP were modeled with the Natural System Model (version ENPmod1) and the South Florida Water Management Model (ECB2 and CERP0) to estimate historical changes and anticipated effects of CERP restoration projects on hydropatterns affecting Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*), Everglade snail kite (*Rostrhamus sociabilis plumbeus*), and wood stork (*Mycteria americana*) populations in the Everglades.

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BISECT: A Hydrologic Model of South Florida for Evaluating Ecosystem Restoration and Sea-Level Rise

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The Everglades system and surrounding areas, including Biscayne Bay, are important natural features in the south Florida landscape that continue to be affected by both natural and man-made events. The spatially-extensive BIscayne and Southern Everglades Coastal Transport (BISECT) model was constructed to attempt to predict hydrologic responses to these events. BISECT was developed using the numerical hydrodynamic program known as the Flow and Transport in a Linked Overland/Aquifer Density-Dependent System (FTLOADDS), to evaluate the effects of (1) sea-level rise on surface-water and groundwater flow and solute transport, and (2) Comprehensive Everglades Restoration Plan (CERP) ecosystem restoration of the groundwater exchange between Everglades National Park (ENP) and Biscayne National Park (BNP) along the L-31 and C-111 canals on the movement of the saltwater-fresh water interface.

The BISECT model was developed by linking the USGS TIME (Tides and Inflows in the Marshes of the Everglades) model of the southern Everglades with a coupled surface and groundwater model of Biscayne Bay. BISECT covers the area south of the Tamiami and C-9 canals, including Florida Bay, and spans from the east coast to the west coast including all of Biscayne Bay. The model has 500 x 500 m grid cells and simulates existing conditions for the time period of 1996-2004. BISECT was used to assess how different restoration and sea-level rise scenarios will affect water flows and salinity transport in both ENP and BNP. BISECT was linked with the South Florida Water Management District's (SFWMD) Natural Systems Model (NSM) to simulate predevelopment conditions as a baseline with which to compare the potential effects of restoration. It has also been linked to the SFWMD's South Florida Water Management Model (SFWMM) to simulate CERP restoration scenarios and evaluate the impacts of restoration upon the ecosystem. BISECT also has been used to simulate sea-level rise, sea-level rise with CERP restoration plans, and sea-level rise with modifications to the Miami-Dade County canal system.

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Potential Impacts of Localized Hydrologic Features on Sea-Level Rise Induced Saltwater Intrusion in South Florida

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Localized hydrologic features within the hydrologic system of southern Florida require consideration in predictive studies of the effects of climate change on saltwater intrusion. The hydrology of the western and southern Everglades is characterized by a transmissive aquifer directly overlain by the "River of Grass", an extensive body of surface water, flowing slowly toward the coast and draining through open coastal creeks. Urban areas to the east contain a highly managed canal system with a complex system of levees and gated waterways to control drainage and saltwater intrusion. Flow gradients are typically small, allowing surface water to pond and not rapid run-off, thereby creating a continuous body of water that provides a natural barrier of fresh water to dilute saltwater flowing inland due to wind and tide. Additionally, the groundwater and surface-water systems are well connected, which can create or prevent saltwater intrusion, as a result of changes in the water level of the Biscayne aquifer. Three hydrologic features that may help prevent or enhance saltwater intrusion in surface and groundwater are: (1) the topographically high buttonwood embankment in the southern coastal area, which may restrict saltwater intrusion to areas surrounding coastal creeks and rivers such as Taylor River; (2) a topographically low area in the western coastal area of Everglades National Park where the coastal groundwater flows to the surface and then is directly routed to tides by rivers and recharged locally; and (3) the Miami-Dade canal system which restricts inland movement of the saltwater interface using control-structures near the coast.

To examine the effects of these features on saltwater intrusion, the hydrologic system was simulated using the USGS simulator Flow and Transport in a Linked Overland/Aquifer Density Dependent System (FTLOADDS). The model was calibrated to the years 1996-2004. Two groups of sea-level rise scenarios were simulated. The first group simulated current conditions and simply raised sea level by varying amounts, in respect to estimates of future sea-level rise. The second group simulated sea-level rise over a future 50 year period of time, using both current boundary conditions and predicted boundary conditions from Comprehensive Everglades Restoration Plan (CERP) restoration scenarios.

Model results indicate that fresh water accumulates in the aquifer beneath the buttonwood embankment, which slows the landward movement of saltwater in the upper portion of the aquifer. Groundwater drainage in the western coastal area of the Everglades results in landward and upward movement of saltwater in the aquifer. Finally, modifications to the canal water levels, such as increasing the daily water level by 1 foot can reduce the inland extent and rate of salt-water intrusion. The current model only represents the canals as set water level boundaries, so more dynamic flow routing plans cannot be represented at this time.

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Trait Variation across the Range of an Invasive Species: Boldness, Dispersal and Reproductive Traits in Multiple Populations of African Jewelfish

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Invasive species have the potential to severely affect the ecological integrity of natural ecosystems, and interfere with the management and restoration of protected areas. Previous studies have shown that invasive range expansion, and in particular, the spread through novel habitat is correlated to the dispersal behavior and boldness of individuals. Bold individuals tend to be better explorers, and populations at the invasion front appeared to have a higher proportion of bold individuals. Bolder individuals may also have greater reproductive success, as they may be more active, more likely to encounter potential mates, and better able at securing resources to allocate to reproduction.

The invasion of the African jewelfish, *Hemichromis letourneuxi,* provides a great opportunity to test the role of boldness and dispersal behavior in the invasion success of non-native taxa. African jewelfish are among the most recent invaders in Everglades National Park (ENP), and more importantly their spread has been rapid and traceable since first detected in 2000. This non-indigenous fish species entered ENP from the east side of the park and has rapidly spread to the west, now reaching estuarine areas of the Park.

Our study examined variation in boldness, dispersal behavior, and life history traits (i.e., fecundity) of African jewelfish across their range in ENP. We hypothesized that boldness and dispersal tendency would be higher in populations from the invasion front (western ENP) relative to the longer-established populations in the eastern region of ENP. Moreover, we hypothesized that there would be a positive relationship between boldness and life history traits. We tested boldness and dispersal behavior of jewelfish pairs in videotaped trials conducted in an outdoor experimental setup. We then examined the gono-somatic index (GSI) of the females from each population, as well as the condition factor of both females and males.

There is a continued need for research that improves our understanding of how nonnative species respond and function in the Everglades ecosystem, in particular, on how these species interact with the Everglades at the landscape level. Our results indicate strong links among boldness, dispersal behavior, and life histories, which may explain spread patterns. Insights from this study should be useful to the development of risk assessment tools that examine the likelihood that a nonnative species will become a widespread pest, given its traits, and accounting for behavioral traits. These models are key to invasive species management.

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Banding and Tracking of Roseate Spoonbills Suggests That Florida Bay May be at a Tipping Point in Reference to Everglades Restoration Efforts

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Since 2003, more than 2500 Roseate Spoonbill (*Platalea ajaja*) chicks were banded in nesting colonies located in Florida Bay and Tampa Bay. In addition, 10 adult spoonbills were outfitted with global positioning system recorders and satellite transmitters in both 2004 and 2005. Results from this study indicate that spoonbills reach sexual maturity between 3.5 and 5 years of age and live for between 20 to 30 years. Previous studies indicate that nesting success in Florida Bay is on the order of 0.5 chicks/nest (c/n) while Tampa Bay nesting success is on the order of 2.0 c/n. The banding program supports these results with 20% of the birds banded in Tampa Bay being resighted post fledging while only 3% of the chicks bandied in Florida Bay have been resighted post fledging. In 2007 and 2008 the first banded spoonbills reached sexual maturity and began to appear in and around their natal colonies. Although this is common in many avian species (most notably pelagic sea birds), it has not been well documented in wading birds (of the order Ciconiiformes). Most wading bird studies indicate that these birds are catholic in the choice of nesting sites. However, preliminary data from this study indicate that spoonbills exhibit fidelity to their natal colony. Of 23 adult birds in breeding plumage during the nesting season, 21 of the birds were sighted within or in association with their natal colony. The satellite tracking data also supports this in that these birds repeatedly returned to the same colony and did not nest anywhere else. Also these data indicate that all but 2 of the 20 birds with satellite transmitters remained within the Everglades/Florida Bay landscape year round. Between 1978 and 2008, the number of nesting spoonbills in Florida Bay declined from more than 1250 nesting pairs to just over 200 nests. If spoonbills do exhibit nesting fidelity to their natal colony and the success rate of Florida Bay's spoonbills is so low that the chicks that fledge do not survive to adulthood, this may explain why Florida Bay nesting numbers have declined so dramatically. The cause of the low nesting success in Florida Bay has been attributed to water management practices and spoonbills are recognized as an indicator species for Florida Bay. The implication of this study is that Florida Bay may be at a tipping point due to adverse water management practices and that immediate restoration of natural freshwater flows to the bay are imperative to keeping the bay healthy.

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Biscayne Bay Coastal Wetlands Project Adaptive Management Plan

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An adaptive management plan was developed to describe how the CERP adaptive management principles are applied to address uncertainty associated with the Biscayne Bay Coastal Wetlands Project. The goal of the plan is to provide information regarding key project questions (uncertainty), based on assessement of documented ecological response relative to how the project is meeting it's restoration goals. This information provides input to a matrix of management options for optimization (as necessary) of project response and function to ensure restoration goals are likely to be achieved. The initial plan was developed before, yet is consistent with National U.S. Army Corps of Engineers guidance issued on August 31, 2009 that requires development of adaptive management plans linked to monitoring and assessment for all ecosystem restoration projects. This plan describes how key questions linked to restoration project goals and objectives will be addressed by verifying hypotheses identified in conceptual ecological models with monitoring and assessment performance measures focused on key outcomes to determine restoration success. The plan identifies potential management options to be cost shared if U.S. Army Corps of Engineers and the Governing Board of the South Florida Water Management District in consultation with trust resource agencies (e.g., U.S. Fish and Wildlife, Miami-Dade Department of Environmental Resources Management, and Florida Department of Environmental Protection) determine they are necessary to optimize restoration results based on actual assessment results and funds are available to implement. The plan development also proved to be beneficial in the review and refinement of the Project Monitoring Plan, as the monitoring network had to provide needed information of the appropriate spatial and temporal scales to feed into the adaptive management process.

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Modeling Surface-Subsurface Exchange of Water and Reactivity of Solutes in the Ridge and Slough Landscape and Implications for Restoration

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The structure of patterned peatlands, such as the Everglades ridge and slough landscape, is highly sensitive to spatial variation in rates of peat accretion. In oligotrophic wetlands accretion rates are strongly controlled by both water level and local nutrient concentrations, which are affected by regional flow patterns, evapotranspiration (ET) and other surface-subsurface hydrologic exchange processes, and biological uptake and release processes. Feedback between macrophyte distribution, ET, and phosphorus (P) accumulation is known to produce regular patterning of boreal bogs, but the extent to which this nutrient accumulation mechanism controls landscape pattern in the Everglades has not been well quantified. An improved understanding of controls on nutrient cycling in ridge and slough vegetation communities is needed to better predict how restoration of flow and potentially higher nutrient concentrations will impact landscape pattern and ecological function of the ridge and slough landscape.

We performed advection-dispersion-reaction modeling to interpret high-resolution measurements of ambient surface water and porewater solute concentrations sampled from adjacent ridge and slough vegetation communities in central Water Conservation Area 3A. Minipoint piezometer samples were taken monthly from seven to eight depths between August 2005 and November 2006 and analyzed for multiple conservative and reactive solutes. Chloride concentration profiles were modeled conservatively using a Levenberg-Marquardt optimization procedure to determine porewater velocity, effective diffusion coefficients in both floc and peat, and partitioning of ET with depth. Solute reactivity was examined qualitatively by comparing measured concentrations to values predicted using the optimized conservative transport parameters and quantitatively by performing new optimizations to calibrate spatially distributed uptake and release rates.
The data and models indicated that greater total ET occurred in the slough than in the ridge; however the ridge had a higher fraction of ET take place as subsurface transpiration, resulting in higher chloride concentrations during the drydown period. Interestingly, subsurface P concentrations did not significantly differ between ridge and slough and the relatively flat water tables during dry periods suggested that lateral subsurface flux of P was negligible. Modeling indicated that both the ridge and slough subsurface served as sinks for dissolved organic phosphorus, likely from biological uptake. During the rewetting event, it appeared that organic matter that had been mineralized during the drydown was mobilized, as indicated in the data set by a significant release of dissolved reactive phosphorus (DRP) from both the ridge and slough subsurface. The ridge subsurface was a larger source of DRP and nitrate, which were both quickly utilized as indicated by a lack of sustained buildup in the surface or subsurface. The slough, and to a lesser degree the ridge, served as a source of nitrogen, primarily in the form of dissolved organic nitrogen. In summary, though ridges and sloughs exhibited key differences in nutrient cycling and biological uptake, it is unlikely that these differences would promote landscape differentiation through a nutrient accumulation mechanism under present, historic, or future conditions.

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Coupling Statistical Models with Paleoecological Information - A Synthesis of Pre-drainage Hydrology and Salinity Estimates in the Greater Everglades Ecosystem

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Paleoecological data from six sediment cores in Florida Bay, Everglades National Park have been interpreted to estimate the pre-drainage salinity regime. Statistical models were coupled with the paleoecological data to estimate the stage and flow in Shark River Slough and Taylor Slough that would be required to meet the pre-drainage conditions under the current system constraints. In addition, the resulting salinity throughout Florida Bay was estimated. A synthesis of the information from these studies is being developed to integrate the results for a more complete picture of the freshwater flow conditions needed to re-establish pre-drainage conditions.

Paleosalinity estimates were derived from the analysis of molluscan assemblages in sediment cores (see Wingard, this volume). A three phase process was used to couple paleoecologic assemblage data and regression models. The overall mean values produced by the models indicate that existing freshwater flows into the remaining Everglades are about half of what is required to meet pre-drainage conditions given the current water management system. The deficit in Taylor Slough is much greater than Shark River Slough, particularly in the dry season. Average water levels in these marshes are about 0.15 meters lower than needed to sustain the pre-drainage variability in hydroperiod and patterns. According to the model simulations, re-establishment of the pre-drainage conditions in the Everglades should return Florida Bay to oligohaline-to-polyhaline conditions compared to the existing conditions of mesohaline to euhaline. Comparisons of Natural System Model based estimates and paleo-based estimates in Florida Bay indicate that the paleo-based salinity conditions were considerably fresher than the NSM-based regime.

The multiple lines of evidence from these separate analyses are being combined using an Optimal Linear Combiner statistical technique to reduce the uncertainty in the synthesized characterization of the hydrology and salinity of the southern Everglades. The combined characterization can be used to develop a paleo restoration target for performance measure use by the Southern Coastal Systems and Greater Everglades Sub-teams of RECOVER to evaluate the effectiveness of Comprehensive Everglades Restoration Plan (CERP) improvements.
The linked paleo/regression model methodology will be used in 2010 and 2011 with the existing cores in the Shark River estuaries to develop a system-wide picture for the paleo restoration target. Integration of FATHOM and USGS FTLOADDS models with paleo hydrology and salinity conditions is anticipated during the synthesized interpretation. The knowledge gained regarding the pre-drainage Everglades ecosystem conditions will be used for climate change forecasting to understand the impact of sea level rise on the paleo-restoration target.

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GEER Progress from a Total Ecosystem Services View

John Arthur Marshall
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Five Arthur R. Marshall Summer Interns will be assigned a project to present their perspective on GEER progress from a total ecosystem services view. The project will include big picture findings on progress and major impediments to Comprehensive Everglades Restoration Plan (CERP) implementation, from the fresh eyes of young scientists from several state universities. Ecosystem services valuation leading to benefit/cost analysis, as postulated by the National Research Council (NAS, 2005) will be addressed. As preparation for the GEER project, the interns will attend the ongoing River of Grass Workshops. A major objective will be potential application to the ROG Workshop decision-support. Presentation will likely be in the form of a poster paper. ROG workshop information can be found at www.SFWMD.gov. Additional details await the Interns'arrival. The course starts May 21, 2010. Part of the intern's “mid-term exam” will be pro-active participation in the GEER conference. For the senior scientists attending the GEER Conference, please join the ArtMarshall.org in training our replacements.

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Replacing Torpedograss (*Panicum repens*) with Native Species in Shallow Herbaceous Wetlands

Chris Matson and *Debi Tharp*
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Torpedograss is an aggressive, non-native, aquatic, invasive plant that can displace native vegetation and change the aquatic environment. While one study examines and describes maidencane's ability to exclude torpedograss, most research focuses on herbicide trials and economic efficacy of chemical control without any long-term vegetation establishment goals. Application of herbicide trial methods has demonstrated that mere chemical control is not adequate for any permanent result, thus many agencies are reliant on cyclic vegetation management, rather than true control of torpedograss.

Our staff's experience performing adaptive management has taught us that with active establishment of aggressive, native competition, torpedograss control is a plausible, long-term proposition where control through chemical treatments can be phased out. We have developed methods to successfully replace chemically-treated torpedograss in shallow wetlands formerly dominated by torpedograss by following researched herbicidal control protocols and planting native competition, thus reducing and sometimes reversing the effects of torpedograss invasion on water quality and aquatic habitat quality, and eliminating or drastically reducing future needs to apply chemical treatments to areas with re-established natives. Labor costs for various projects, a bibliography and a general protocol are available as a handout.

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Unifying Concepts for Environmental Restoration Planning: Quality Assurance & Quality Control

Francine Matson and *Larry E. Fink*
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Wise environmental restoration decision-making is based on sound science and sound science is based on sound, legally defensible data. Such data are generated following a scientifically rigorous design and captured according to a rigorous quality assurance plan with quality control diagnostic tests at each step in the life cycle of each data set. This need is true for data collected for a wide variety of purposes from applied research at one extreme to reasonable assurance of no adverse environmental impacts for permit compliance at the other. Data from these efforts are unique and cannot be repeated. Therefore, they must be preserved, documented, and archived for current and future use. The success of these projects depends on the extent to which each project's goals are established and tasks are clearly delineated to project team members. Quality assurance (QA) activities for all environmental projects occur at several levels. Three distinct levels can be identified: *Organizational or Programmatic Level.* At the organizational level, QA activities ensure that the program or organization is successful by overseeing the infrastructure necessary for individual projects in the program, and making sure activities have the resources they need to be successful. *Project Level.* At the project level, QA activities support the success of an individual project by ensuring that accurate information is channeled to the right people at the right time so that decisions can be made during project implementation that are defensible and cost-effective. *Technical Level.* At the technical level, QA activities ensure that the individual technical activities that generate, process, or synthesize data (or other information) for the decision process are performing within accepted limits. These activities are also commonly known as quality control. The aim of quality control is simply to ensure that the results generated by the test are correct. However, quality assurance is concerned with much more: that the right test is carried out on the right specimen, and that the right result and right interpretation is delivered to the right person at the right time. Evaluation of the inventory allows us to assess an overall level of compliance. In this presentation I describe and define terms for each step in the life cycle of environmental data and associated metadata from capture through storage in a centralized database that is accessible to a wide variety of potential users. I then provide real-world examples of common errors in quality assurance at each step in the data life cycle, their consequences, and the actions taken to correct them based on the District's experience with permit-mandated mercury monitoring, research, water quality modeling, and ecotoxicological risk assessment over the last decade. This is followed by a summary of the results of the District monitoring program audit conducted by Battelle Northwest under District contract, including significant deficiencies and corrective actions. Finally, I provide web links to the District's Laboratory, Field, and Data Management Quality Assurance Manuals and associated Standard Operating Procedures (SOPs), as well as the Battelle audit report.

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Crocodiles (*Crocodylus acutus*) as an Indicator of Ecological Change in Everglades Ecosystems

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The system-wide monitoring and assessment plan (MAP) for the Comprehensive Everglades Restoration Plan (CERP) identifies indicators and establishes performance measures to monitor system responses and track progress toward meeting restoration goals. The American crocodile is an indicator for the Greater Everglades module in the MAP. The distribution and abundance of crocodiles in estuaries is directly dependent on timing, amount, and location of freshwater flow. Responses of crocodilians are directly related to suitability of environmental conditions, including changes in water levels and salinities. The crocodile indicator uses monitoring parameters (performance measures) that have been shown to be both effective and efficient in tracking trends: a three year running mean for juvenile growth and five year running mean for hatchling survival. Assessments of parameters defined for crocodile performance measures support this contention. Here we review results of monitoring programs for *C. acutus* that have been used as a basis for assessing ecosystem response to restoration projects.

We examined crocodilian data through the use of quartiles. Stoplights were developed by division along quartiles based on all animals captured, and defined as follows: red-substantial deviation from restoration target creating severe negative condition that merits action (first quartile); yellow-current situation does not meet restoration targets and merits attention (second-third quartile); green-situation is good and restoration goals or trends have been reached (fourth quartile). Currently, both growth and survival are yellow with no trend detected. In addition to existing CERP crocodile parameters, nesting success and body condition (i.e., a ratio of body length to body volume) or how crocodiles are "coping" with their environment are correlated with hydrologic conditions. These variables include depth, duration, timing, spatial extent and water quality. Nesting effort and success and body condition could be added to growth and survival as monitoring parameters.

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Performance Measures for Adaptive Management of Burmese Pythons

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Burmese pythons are established in South Florida. Eradication of Burmese pythons may not be possible, but management of the impacts of pythons is feasible. Objectives of python management for the National Park Service include reduction of the population and its associated impacts in the core area and preventing spread of the current population into new locations. Currently we have a few rudimentary tools for removing pythons but no integrated approach to their application. Similar to ecosystem restoration, considerable uncertainty surrounds responses of invasive species to management actions. Adaptive management is widely recognized as the best approach to reducing uncertainty inherent in natural resource management. Sources of uncertainty include incomplete knowledge of population responses to different management actions (for example removal rates or stochastic events such as freezes). Performance measures (PMs) are a key element in adaptive management for assessing population responses to management actions and learning which approaches are most effective.

In this talk we discuss two possible PM for assessing reduction of the population of Burmese pythons and its associated impacts in Florida. These measures are Encounter Rate and Presence of Marsh Rabbits and Florida Muskrats. We propose encounter rates rather than population estimates because it is notoriously difficult to come by reliable estimates for a wildlife population. Unreliable population estimates can be misleading and cannot be used to reliably detect population changes. Encounter rates, measured as a sighting or capture per unit effort (generally of time over distance) are often used as a surrogate for population estimates for snakes and other reptiles because they can be obtained in a consistent manner. We assume, but need to test, that a lower encounter rate for Burmese pythons could indicate that the python population has been reduced. Once we have an understanding of the relationship of encounter rate to python population estimates we can assess the effectiveness of different management options. The next question is: if we have a reduced python population, can we see a reduction in impacts of pythons on native fauna? The second PM, Presence of Marsh Rabbits and Florida Muskrats, addresses this question. Burmese pythons eat birds, mammals, and alligators in Everglades National Park. Presence of Burmese pythons has been linked to the absence of marsh rabbits and Florida muskrats and the absence of pythons has been linked to the presence of rabbits and muskrats. We propose a PM based on presence of marsh rabbits and Florida muskrats coincident with reduction of the python population; this measure could also be used as an early warning sign that pythons might be present in an area. To make PMs for Burmese pythons effective, we need to increase our understanding of the linkage between encounter rates and population numbers for pythons and the linkage between pythons, rabbits and muskrats. Additional research is needed to develop reliable PMs and to set realistic targets.

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The Real World – Merging Science and Engineering for Ecosystem Restoration

Katie McCallion and *Eliza Hines*
Everglades Partners Joint Venture, Jacksonville, Florida, USA

The Comprehensive Everglades Restoration Plan (CERP or Plan) is an $11 billion, 30-year plan to restore the Everglades and South Florida ecosystem. The Plan was authorized by the Water Resources Development Act (WRDA) 2000 and includes 68 separable components organized with the overarching goal of restoring quantity, quality, timing and distribution of water in South Florida. WRDA 2000 also included a provision for development of a system-wide science program (Restoration Coordination and Verification [RECOVER]) to monitor and assess the ecosystem and determine whether the goals and objectives of the Plan are being met. Successful restoration requires the integration of comprehensive project planning and design with the use of the best available science. To date, the integration of planning, engineering and science during CERP project planning and implementation has been challenging. These challenges are the result of many factors including: (1) the intricacy of planning, designing, and implementing complex ecosystem restoration projects; (2) the multi-disciplinary, multi-agency, collaborative approach being advocated as part of the CERP Adaptive Management (AM) Program, and (3) the necessary separation of engineering and science in the organizational structure of federal, state, and local agencies.

In an environment where it is not feasible to restore the ecosystem to its historic condition, successful restoration is impossible without bridging this gap between engineering and science. In the ten years since the authorization of the Central and South Florida (C&SF) Project Comprehensive Review Study (Restudy), there have been lessons learned about the integration of planning, engineering, and science. Although often implemented and tracked separated, it's become evident through work done to date that sound science underlies good project planning and design and a project is only successful if it achieves its environmental goals and objectives. The integration of these disciplines throughout the life of the project has been recognized as one of the most important factors contributing to project and program success. Ultimately, CERP projects and the science program must be viewed as one in the same if ecosystem restoration is to be achieved.

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The Southwest Florida Feasibility Study: A Comprehensive Watershed Plan

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Authorized as part of the Comprehensive Everglades Restoration Plan (CERP), the Southwest Florida Feasibility Study (SWFFS) is a multi agency effort to develop a conceptual framework for regional ecosystem restoration similar in scope to the Central and Southern Florida Project Comprehensive Review Study. At past GEER conferences, members of the SWFFS Project Implementation Team (PDT) have presented the plan formulation and evaluation aspects of this regional environmental study. As a follow-up, the PDT would now like to take the opportunity to share the draft SWFFS Comprehensive Watershed Master Plan (CWMP) with Federal, state and local agencies and stakeholders to further draw from the body of knowledge available for incorporation into the CWMP.

The SWFFS CWMP has taken a unique approach to regional ecosystem restoration. Incorporating and building upon ongoing regional efforts, the CWMP proposes over 170 projects for further study and implementation. The proposed projects have been organized into functional groups with a specific geographic location. Projects within a specific function group compliment, but are not reliant upon one another. Within each functional group, the projects have been preliminarily designated as either a potential Federal, state or local interest. This designation system is meant to serve as a guide to agencies of all levels and to encourage incremental ecosystem restoration as funding becomes available. This approach encourages a collaborative effort to achieve the regional ecosystem restoration goals and objectives of the CWMP.

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Band 1: Simulating and Analyzing the Effects of 10 Everglades Restoration Projects for the Comprehensive Everglades Restoration Plan

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Regional watershed managers and stakeholders need to know how managed and natural systems are expected to function as Comprehensive Everglades Restoration Plan (CERP) projects are built. A set of 10 initial CERP projects (termed "Band 1") were chosen to be simulated by the South Florida Water Management Model (SFWMM) and evaluated for their ecological affects using RECOVER system-wide performance measures. The simulations and evaluations are useful for anticipating areas of success as well as areas of concern. The Band 1 simulation indicates that grouping projects together provide measurable predicted restoration benefits at the system scale, which has been a challenge in evaluating single project components during plan formulation activities.

The simulations showed enhanced hydropatterns over much of the greater Everglades, a reduction in mean annual flood control releases from Lake Okeechobee to the northern estuaries and improvements in salinity in the southern coastal systems. Undesirable higher stages in Lake Okeechobee, however, did occur, as did more extreme dry conditions in most of northern WCA 3A and increased inundation duration in WCA 3B.

Lessons learned from the Band 1 simulations and ecological evaluations include:

- Grouping CERP projects together for evaluation shows measurable benefits and is in keeping with the program view of an integrated functioning system;

- A system-wide adaptive management process should begin that integrates future projects that add significant storage and delivery capacity, as well as seepage management, to the regional system and to address regional uncertainties;

- There are areas of the system (e.g., northern WCA 3A and WCA 3B) that will likely need a managed transition period so that the landscape can be shifted to plant and animal communities which tolerate longer hydroperiods in a manner that is consistent with maintaining a healthy landscape.

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The Conceptual Ecological Model for Everglades Tree Islands

Fred Sklar[1], *Lorraine Heisler*[2], **Agnes McLean**[3], *Carlos Coronado*[1], *Colin Saunders*[1], *Gregory Kiker*[4] and *Pamela Fletcher*[5]

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Conceptual ecological models (CEM) serve as a framework for integrating science and policy in ecosystem restoration programs across the United States and as the foundation for the development of quantitative performance measures to assess how well restoration plans meet their targets. Conceptual ecological models tend to depict qualitative relationships and linkages within a landscape of interest, as well as the drivers and stressors that impinge upon that landscape, and the attributes that characterize it. Eleven regional CEMs and one "total system" model have been developed in support of Everglades ecosystem restoration in South Florida.

A CEM for tree islands has lagged behind the development of the other CEMs because scientific debates regarding tree island resilience and restoration strategies have been contentious. To help direct an adaptive management solution for tree island restoration, a comprehensive Tree Island CEM that can be used for hypothesis testing was developed through a series of workshops, using a new CEM format borrowed from the CalFed and Coastal Louisiana restoration programs, and a participatory modeling approach at GEER 2008. A real-time audience polling system was used to prioritize the linkages in the conceptual model in terms of their ecological importance, current state of understanding and relative predictability. Polling was used to rank each type of criteria according to percent agreement among the expert participants.

This paper describes three new developments in the planning of Everglades environmental management and ecosystem restoration: 1) a CEM format that can be used broadly for future environmental planning and adaptive management; 2) a comprehensive Tree Island CEM that can be used for hypothesis testing; and 3) a new participatory modeling approach that can be used to build consensus and guide natural resource management decisions.

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Integrating Everglades Science for Restoration Planning

Christopher W. McVoy
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A key "fringe benefit" of the River of Grass effort has been the additional avenue presented for integrating a decade of advances in Everglades science into the Everglades restoration process. These inter-disciplinary advances include better understanding of Ridge and Slough geomorphology, including pre-drainage stability and post-drainage changes; improved mechanistic understanding of the relations of flow, sediment transport, vegetation, and landscape geomorphology; quantification of the spatial distribution of Everglades water depths through EDEN and other field measurements; improved baseline information through reconstruction of pre-drainage water depth distributions; a new regional model of Everglades pre-drainage hydrology; and field measurements of tree island elevations.

These improvements in our understanding suggested a need for integrative, intuitive ways to visualize both pre-drainage and current Everglades conditions. Animations of streamline profiles of slough ground surface, tree island elevations and temporally varying water surface have proven helpful in illustrating pre- and post-drainage differences. The animations have also helped clarify the need for storage and treatment of an upstream water source.

The substantial costs associated with re-creation of lost aspects of an upstream water source have highlighted an increased need for a predictive aspect of Everglades science: trajectory analyis. This emerging area attempts to use knowledge gleaned from the *de facto* "experiments" conducted during the past century of drainage to predict directions in which the current Everglades would evolve as a function of various restoration scenarios. While this is clearly an inexact science, Everglades scientists nevertheless have a responsibility to provide decision-makers (and society) with the best possible predictions of the likely consequences of differing levels of investment in upstream storage and treatment.

A novel approach to thinking about the relation between cost and level of Everglades restoration will be presented.

Note: this presentation represents the views and insights of the author, not the formal positions of his employer.

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Accelerated near Future Sea Level Rise (slr), a Given, based upon the Florida Stratigraphic Record, Implications for GEER

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The Florida Peninsula provides an excellent lesson in the potential effects and magnitude of future slr. Florida is a relatively stable carbonate platform which is only above present sea level because of sediment deposition that occurred during times of higher sea level stands during the last 38 x 10^6 y, more than enough to compensate for any subsidence. Between the Middle Eocene and Miocene the world was relatively free of ice caps and sea level was consistently much higher than at present with approximately twelve minor transgressive-regressive sequences with the maximum sea level stand at or near the end of the Oligocene. Sea level oscillations during this period of time are associated with global tectonic activities associated with changing ocean basin volumes and circulation patterns. Polar ice caps developed since the closing of the Mediterranean, Central America and the Artic Sea,. As polar ice caps grew, eight major transgression-regressive sequences occurred over the last 5 x 10^6 y, five of these during the past 1.8 x 10^6 y. At least 60% of the time period between the Middle Eocene and Holocene sl has been 10m or more above present sl. This estimate is based upon the interpretation of the stratigraphic record and the maximum elevations of sediment deposits of the successive sea level stands.

At the end of the Pleistocene sl was at a low stand (-50m) and sl has been rising ever since (Holocene transgression). The rate of early Holocene slr was much faster than the last 4,000y but began to accelerate several decades ago. This may represent the lag time for response between global temperature increase from industrialization and sea level rise As global atmospheric and sea temperatures continue to rise at their present unprecedented rate causing both previously unobserved rates of Artic and Antarctic ice melt and ocean thermal expansion, we can expect sea level to rise, perhaps as much as during earlier Pleistocene times. It is difficult to predict when and at what rate sl will rise but several studies suggest that the slr will not be continuous but catastrophic in nature. Equilibrium between changing increasing global temperature and slr has not been reached, in other words, slr has a lot of catching up to do to be in equilibrium with present global temperature and global temperature is still rising at an alarming rate. This is based upon comparison between oxygen isotope paleotemperature and stratigraphic onlap-offlap records. The Florida record documents that once equilibrium is reached sea level should rise to its long term average rapidly, at least +10m. Most of South Florida is less than 7m and most of the Everglades Basin less than 3m above present sl and is therefore prone to inundation by rising sea level. Predictions of global slr in the next century range from 0.5 to 7m above present sea level. The geological record of Florida suggests that we should expect a major increase in sl soon.

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Coastal Hypoxia in South Florida Associated with Projected Sea Level Rise and Holocene Organic Carbon Sediment Export

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Climate change associated with anthropogenic increases of atmospheric CO_2 is expected to result in global sea level rise (slr) ranging between +1 and +3m over the next 100 y. One major perturbation of this sea level rise is the erosion and export of organic carbon (OC) and associated nutrients stored over the last 10,000 y of the Holocene transgression. Our calculations suggest that this export may result in conditions of coastal hypoxia that will severely impact natural ecosystems. Hypoxia should occur simultaneous with conditions of increased suspended sediment loads, nutrient loading and increased salinity which will combine to adversely affect shallow inshore and bay. This paper addresses the potential magnitude of the export of OC and the related dissolved oxygen depletion (OD) using South Florida, the Everglades and Coastal Bays as an example.

At +3m sea level stand most Holocene sediments will be subject to erosion all the way northward to Lake Okeechobee as Florida Bay expands northward and Transverse Glades become tidal passes. Assuming: 1) a constant rate of slr of +3m and Holocene sediment erosion over the next century, 2) near complete loss of Holocene sediment, 3) an average coastal water DO of 7mg L^{-1}, 4) a soil volume of 3.3 x 10^9 m^3 (4.9 x 10^8 mangrove peat, 1.7 x 10^9 fresh water peat and 1.1 x 10^9 m^3 marl, only 50% is eroded of which 21% is OC and), 5) complete oxidation of OC, and 6) the calculation that 1cm^3 of OC will deplete 14.6L of water we calculate that approximately 196 volumes of Southeast Florida's Bays' water or 3.3 x 10^{13} m^3y^{-1} will be depleted in DO for the next century. Total Bay volume is 1.7 x 10^9 m^3. Soil volumes were determined from the summation of 1209 mi^2 units. A more conservative slr of +1m/100y would result in most OC in coastal mangrove peat and associated marl erosion and export causing OD of 7.64 x $10^{12}m^3$ of water or 45.1 Bay volumes y^{-1}. This is based upon mangrove peat volume of 4.95 x 10^8m^3 and marl OC content of 2.9 x 10^7m^3. If our 100y projection is extended to two centuries the calculated potential OC export and OD will be one half the above values, still very significant.

This condition of hypoxia is analogous too the development of the "Dead Zone" in the Gulf of Mexico caused by sediment and nutrient bypass of the Mississippi Delta and may offer an alternative explanation of the shallow water black shale in the geologic record. Such massive exports have been linked to decreased biodiversity and extinction in the past and certainly will change ecosystem function, biodiversity, distribution of ecosystems and productivity in the near future.

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Phosphorus Dynamics as a Result of Restoration in Subtropical Grazed Wetlands

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The phosphorus load to Lake Okeechobee consistently exceeds the mandated total maximum daily load (TMDL) of 140 Mtons annually. Excess P loading to the lake is a concern because of algal blooms and a shift in trophic status from eutrophic toward hypereutrophic. One proposed practice for reducing P loading is restoration of historically isolated wetlands that have been ditched and now drain directly to Lake Okeechobee. This study examines hydrologic restoration with a paired approach of two head-of-ditch wetlands in cow calf pastures of the Okeechobee basin. One wetland was dammed and one was left as a control. The dairy and beef industry in the Okeechobee basin, especially in Taylor creek watershed, has been identified as a significant contributor of P to Lake Okeechobee. Export of P from the study sites was determined from measured surface water discharge from the ditches draining each wetland. Surface water samples were collected approximately daily and analyzed for total P (TP) and discharge was monitored using acoustic Doppler velocimeters from August to October 2009. Net flow during the monitoring period was negative. In 2009 these wetlands had average surface water concentrations of 1.0±0.63mg/L and varied between 0.1and 3.09 mg/L. Calculated phosphorus export from the control wetland was -8.5 kg for the monitoring period. Wetland surface water concentrations were positively correlated with backflow conditions because of higher concentrations of TP in ditch water. Therefore, these isolated wetlands for this period of monitoring were not a source of P for Lake Okeechobee. Backflow into the wetlands from the ditch network should be considered when implementing restoration strategies.

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High-Density Aquatic Vegetation Baseline Surveys of Lake Istokpoga and the Kissimmee Chain of Lakes: Results and Implications for Habitat and Invasive Vegetation Management in the Upper Everglades Watershed

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Competing hypotheses have developed regarding the longer-term habitat impacts resulting from proliferation and management of invasive submerged aquatic vegetation (SAV) in the large lakes of the upper Everglades watershed. All parties seek to optimize and maximize beneficial submerged habitat though disagree as to which management strategies can best reach that goal, especially in light of all stakeholder needs. Assumptions about the status and trends of native SAV species have been a central factor in the discussion. These assumptions are difficult to test and explore because, prior to 2009, a detailed baseline SAV survey of the lakes had never been performed.

To fill this data gap, a very highly detailed submerged aquatic vegetation survey was conducted in 2009 at Lakes Istokpoga, Tohopekaliga, Cypress, Hatchineha, and Kissimmee. Emergent vegetation was also surveyed in significant detail. A total of 72 species were inventoried across the lakes. Now that the status of these species is determined, subsequent surveys can shed light on the changes and trends of native species at the lakes in response to invasive vegetation management and other environmental factors. This understanding will help make progress toward a consensus approach.

The key results of the 2009 baseline survey will be showcased in this presentation, including how to access the data. Many interesting insights have already been drawn from the baseline data. Also covered will be the implications that the data have for informing invasive vegetation management strategies and aquatic habitat optimization within the headwaters of the greater Everglades ecosystem.

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Macroinvertebrates as an Indicator of Wetland Condition: Update on a Rapid Assessment Method for Everglades Restoration

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The U.S. Fish and Wildlife Service recognized a need to develop a rapid assessment tool to evaluate existing benchmark condition and future ecological changes to wetlands associated with Everglades restoration projects. A rapid biotic assessment tool is lacking for the south Florida region. A Habitat Evaluation Team was formed representatives from government agencies, universities, and environmental for-profit and non-profit organizations to develop a process that balances the need for a scientifically based investigation of wetland biological condition with administrative timelines and cost. Three biological groups - plants, fish, and macroinvertebrates - were considered critical ecosystem components that can be used to assess biological condition through time. Indices from each of these groups will be combined into a single Ecological Condition Index.

A time-limited dip-net procedure has been developed for collecting field-identifiable macroinvertebrates that will provide a rating of wetland biological condition. Two constraints were imposed in the development of the method: 1) sampling and identification would be conducted for a period of one hour and 2) only field identifiable taxa could be used. A list of field identifiable taxa has been generated and field-tested. The method requires one trained and experienced macroinvertebrate taxonomist to collect and identify organisms while an assistant records data. Representative wetland habitats are sampled for one hour, and no constraints are put on spatial coverage or number of dip-net sweeps taken. Macroinvertebrate metrics have been tested for efficacy in discrimination between wetlands in good condition and those impacted by hydrologic alteration and/or water quality degradation. Results of the tests are presented as a refined list of metrics. Among the metrics retained are those that included crayfish and shrimp, used as performance measures for Everglades Restoration.

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Characterization of Dissolution Structures and Porosity Distributions in the Upper Part of the Biscayne Aquifer Using Ground Penetrating Radar

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The Biscayne aquifer is the primary source of drinking water for southern Palm Beach, Broward, and Miami-Dade counties, making it a critical natural resource for millions of people. Most hydrological studies have traditionally applied techniques that provide hydraulic information about a limited area of the aquifer, such as hydrostratigraphic test boreholes and single-well hydraulic tests. Such methods are invasive, time consuming, can be relatively expensive, and in most cases do not provide laterally continuous information. In contrast, near-surface electromagnetic techniques, such as ground penetrating radar (GPR), allow for accurate, rapid, and cost effective means of indirectly characterizing the subsurface with relatively minimal impact on the environment.

GPR was applied to the carbonate rocks of the Biscayne aquifer in Everglades National Park to better understand the distribution of fractures and dissolution-related karst features that can create concentrated flow of groundwater, nutrients, and contaminants. These macroporous elements contribute to the overall storage, permeability, and transmissivity of the aquifer, and for that reason, delineation of their distribution and areal extent should aid in the development of more accurate groundwater flow models. Results should ultimately contribute to a better conceptualization of Biscayne aquifer flow system, leading to improved strategies for the restoration of the Everglades ecosystem.

This study used GPR to image the uppermost 5 to 10 meters of the Miami Limestone, characterizing subsurface karst features and porosity distribution at the field scale (100-1,000 m). Newly acquired data has been compared to geologic and borehole geophysical data from previously drilled boreholes, providing a way to constrain GPR data across the survey area. Our GPR data show areas with variable electromagnetic (EM) wave velocity values interpreted as a proxy for karstic features in the upper part (3-5 m depth) of the Biscayne Aquifer.

Application of a complex refractive index model to our GPR data shows variations in calculated porosity values associated with fractures and karst features with higher permeability, increased aquifer storage and groundwater flow, when compared to adjacent areas. This information can help to better understand future hydrologic exchange between surface water and ground water in the Biscayne aquifer once sheet flow is modified as part of the restoration of the Everglades wetland.

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Contrasting Ecosystem Productivity between and Long- and Short-hydroperiod Marsh in the Florida Everglades

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Freshwater wetlands of the Florida Everglades are oligotrophic with published values for net primary productivity of sawgrass ranging from 255-606 g C m^{-2} yr^{-1} and periphyton from 17-10,371 g C m^{-2} yr^{-1}. High temporal and spatial variability in these estimates, frequently derived by harvesting and small-scale gas exchange techniques, have been attributed to the geology and hydrology of the landscape and the phenology of dominant species. However, some of this variability could be attributed to the methods being employed. We conducted a whole ecosystem non-steady-state chamber study of ecosystem productivity at two sites of contrasting hydroperiod in Everglades National Park. We performed monthly measurements of CO_2 exchange in 5 replicate plots at both sites using an LI-840 infrared gas analyzer connected to a clear, polycarbonate chamber. Estimates of maximum annual productivity at the short-hydroperiod site found it to be a source for carbon (+84 g C m^{-2} yr^{-1}) and our long-hydroperiod site was found to be a sink for carbon (-342 g C m^{-2} yr^{-1}). Our results indicate that prolonged inundation of the short-hydroperiod ecosystem causes significant decreases in net ecosystem productivity. As hydrologic restoration of the Everglades proceeds, it is imperative that we understand the consequences of these actions to carbon sequestration.

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Decline in Populations of The Non-Native Red Rimmed Melania (*Melanoides tuberculatus*) in Biscayne Bay National Park, Florida Potentially Linked to Low Water Temperatures

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The non-native freshwater snail *Melanoides tuberculatus* (Family Thiaridae: common name Red-Rimmed Melania) was identified in Biscayne National Park (BNP) in 2003 by USGS researchers. Since its discovery, we have mapped the distribution and have been monitoring the expansion of *M.tuberculatus,* but preliminary results suggest the 2010 colder than normal winter may have had a detrimental effect on the BNP population. In its native habitat of tropical Southeast Asia and parts of Africa, *M. tuberculatus* is a freshwater snail populating ponds and rivers; however, we have collected it live in salinities up to 30 parts per thousand (ppt) salts (marine waters are typically 30-35ppt). Salinity experiments have further demonstrated this organism's resilience to higher salinity waters (Murray, et al., USGS OFR in review).

Surveys within BNP over the 2004-2008 time periods show an increase of *M. tuberculatus* in the Black Point area located on the west-central edge of BNP. The estimated numbers of *M. tuberculatus* increased from $696/m^2$ in 2004 to $60{,}000/m^2$ in 2006 and down to $51{,}797/m^2$ in 2007 at site TR4, which is approximately 1400 meters from shore. These estimates are based on raw counts of both living and debris snails, using three petit ponar samples from each transect (TR) site. The population, at the seaward most point of the transect (TR6, approximately 2200 meters from shore), increased from $87/m^2$ in 2004 to $3826/m^2$ in 2006 and up to $6971/m^2$ in 2007. *M. tuberculatus* is apparently adapting to higher salinity, eliminating the possibility of a marine barrier to dispersal, and with the trends linked to global climate change is likely to increase its habitat range.

The 2010 winter in South Florida presented a unique opportunity to experiment *in situ* with the affect of cold water on the population dynamics of *M. tuberculatus* vs. native species. Average January water temperatures between 2004 and 2009 were 20.0ºC at LSNF1; winter 2010 brought unusually low air and water temperatures with lows between January 2nd and January 13th as low as 8.1ºC at the LSNF1 buoy in Long Sound just south of Biscayne Bay (noaa.gov). These unusual temperatures appear to have had a detrimental effect on the *M. tuberculatus* populations in the Black Point area. A survey was conducted at the Black Point transect sites in February, 2010 using the same Petit Ponar sampling method that was employed in previous surveys. Samples were maintained and examined regularly for five weeks to identify live mollusks. In contrast to previous surveys, no live *M. tuberculatus* were found, but live samples of native mollusks including *Cerithium muscarum, Cerithidea sp.,* and *Brachidontes exustus*, showed no adverse affects from the lower than normal water temperatures. Follow up surveys will be conducted in April/May of 2010 to determine if regions beyond Black Point (including the canals) are also showing decreased numbers of *M. tuberculatus*.

The presence of *M. tuberculatus* is significant to the visitors in BNP because it is an intermediate host for several human parasitic trematode worms and flukes that affect crustaceans, birds and smaller mammals (Murray, et al., USGS OFR in review). Resource managers and the general public need to be aware of this non-native/invasive snail and take steps to prevent/or monitor its spread and additional introductions.

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Using Floral and Faunal Assemblages and Observed Habitat Associations to Monitor Sea Level Rise in the Shark and Harney River Basins of Southwest Florida

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An observed habitat association between the clam, *Polymesoda caroliniana,* and several plant species including; *Cladium jamaicense, Acrostichum sp., Rhizophora mangle*, *Laguncularia racemosa*, and *Avicennia germinans* is being investigated in the Shark and Harney River basins along the Southwest Coast of Florida, in Everglades National Park. Site surveys conducted in the spring of 2008 and 2009 and a temperature response survey in February 2010 within the Shark and Harney River systems found groups or "nests" of *P. caroliniana* closely associated with the root structures of *R. mangle* and *L. racemosa. Acrostichum* sp. and *Cladium jamaicense* were observed within a few meters of the clusters of *P. caroliniana* and the 2010 survey found a small group (4-5 individuals in a $0.1m^2$) associated with a large *Acrostichum* sp. specimen. The shoreline mangrove forests are under-storied by *C. jamaicense*, *Acrostichum* sp. and others. The *Acrostichum* sp. specimens at some sites show degradation and are often seen with *P. caroliniana* debris. These areas appear to be the transition zone between the mesohaline/oligohaline environments and within the low tide zone. Some of the plants species in these regions have a lower tolerance to saltwater intrusions and have lower survival rates with even short duration exposures to elevated salinities. Plant assemblages respond relatively quickly to environmental changes whereas *P. caroliniana* populations can aestivate during short exposures to conditions outside their tolerance limits.

Cores taken at the mouths of the Harney River and the northern leg of the Shark River in the summer of 2005 had *P. caroliniana* shells in abundance at a depth of 114-165cm, and 10-64cm respectively, which is an indicator of freshwater to upper estuarine environment based on modern observations. The lower portions of both cores were deposited in freshwater environments, with no indicators of estuarine influence; however, with the loss of the larger freshwater fauna in the upper portions of the cores, a shift toward a more estuarine environment is evident. *P. caroliniana* debris was also found in core samples in the Lostman's River Second Bay area at a depth of 72-76cm. The ages of these core intervals and the depositional rates are currently being determined for these cores (Wingard, et.al. "Descriptions and Preliminary Report on Sediment Cores from the Southwest Coastal Area, Part II: Collected July 2005, Everglades National Park, Florida", OFR 2006-1271).

The observed associations between *P. caroliniana* and select plant species such as *C. jamaicense*, *Acrostichum* sp., *R. mangle*, *L. racemosa*, and *A. germinans* may provide a tool for monitoring short term fluctuations and for indentifying long term changes in salinity regimes at the critical fresh/salt water transition zone. By examining these faunal-floral associations in cores, it may be possible locate past positions of this transition zone – which is a function of both freshwater outflow and sea level changes. Future migration of this assemblage could serve as an indicator of the progress of restoration of freshwater flow or the encroachment of rising sea level.

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The Florida Invasive Species Partnership: Think Locally-Act Neighborly

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Invasive species know no boundaries and continue to degrade Florida's declining habitats, such as the everglades ecosystem. If landowners and land managers wish to achieve long term success, it is critical for them to reach out and collaborate with all stakeholders, including private landowners. The mission of the Florida Invasive Species Partnership is to improve the efficiency and effectiveness of preventing and controlling invasive non-native species through partnering to increase communication, coordination and use of shared resources in order to protect wildlife habitat, working agricultural and forest lands, natural communities and biodiversity in Florida.

During 2006 and 2007, FISP developed the dynamic "Incentive Program Matrix" of existing federal, state and local funding sources, incentive programs and technical assistance for private landowners in Florida. The interactive matrix database, now available on the FloridaInvasives.org website, allows both private and public land managers to determine what current technical and financial assistance is available to best suit their specific needs and coordinate control efforts across boundaries. In 2007, FISP began promoting the concept of Cooperative Invasive Species Management Areas (CISMA) in Florida. The goal of this effort is to encourage development of local partnerships between federal, state, and local government agencies, tribes, individuals and various interested groups to manage noxious weeds or invasive plants in a defined area. To date, there are 15 CISMAs across Florida from the panhandle's Northwest Florida CISMA and Apalachicola Invasive Working Group to the Florida Key's Invasive Task Force. The Incentive Program Matrix and locally led CISMAs allow us to expand invasive species management efforts across the landscape and build community awareness. These coordinated efforts serve to protect our valuable conservation areas, public lands and private lands from the continuing colonization of invasive species across the landscape.

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Integrated Surface-Ground Water Modeling in Wetlands with Improved Methods to Simulate Vegetative Resistance to Flow

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In topographically flat wetlands, where shallow water table and conductive soil may develop as a result of wet and dry seasons, the connection between surface water and groundwater is not only present, but perhaps the key factor dominating the magnitude and direction of water flux. Due to their complex characteristics, modeling these areas using more realistic formulations (integrated surface-ground water and vegetative resistance) is of fundamental relevance.

This paper presents the development of an integrated surface – subsurface hydrologic numerical model. The model couples the USGS MODFLOW-2005 Groundwater Flow Process (GWF) package (USGS, 2005) with the 2D surface water routing model: FLO-2D (O'Brien et al., 1993). The coupling included the necessary procedures to integrate both models as a single computational software system that has been named WHIMFLO-2D (Wetlands Hydrology Integrated Model). An improved physical formulation of flow resistance though vegetation in shallow waters based on the concept of drag force was included for the simulations of floodplains, while the use of the classical methods (e.g., Manning, Chezy, Darcy-Weisbach) to calculate flow resistance will be maintained for the canals and deeper waters.

The model was applied in an existing field site, the Loxahatchee Impoundment Landscape Assessment (LILA), an 80 acre area, located at the Arthur R. Marshall Loxahatchee National Wild Life Refuge in Boynton Beach, Florida. Comparison between measured and simulated stages, show average error of 0.31% with a maximum error of 2.8%. Comparison of measured and simulated groundwater head levels show an average error of 0.18% with a maximum of 2.9%.

Results from tests show that the coupled model is capable of simulating the complex hydrology of wetlands

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Fish Health of the St. Lucie River Estuarine System in Relation to Canal Discharges and Water Quality

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Indicators of environmental quality are essential for assessing change in the support value of an estuary for fish and wildlife and for evaluating the effectiveness of hydrologic and water quality restoration efforts. We propose St. Lucie fish health, as reflected in the prevalence of fish with gross abnormalities, as an index of environmental quality for monitoring the progress of both local and regional restoration efforts. In an analysis of a 12+-yr dataset, we examined the prevalence of fish with any externally visible abnormality (ANY) in relation to potential causal factors--canal discharge (including Lake Okeechobee regulatory releases) and water quality. The discharge and water quality data were obtained from the South Florida Water Management District (downloaded from DBHydro) and summarized for analysis. The discharge data of three canals, C23, C24, and C44, were combined or used separately to calculate two variables for alternative use: the weighted mean cubic feet per second and proportion of days when flows were greater than the 75th percentile. These were lagged for various periods (7-day, 30-day, or 90-day) in the analysis. The water quality variables we included in our analysis were secchi disk visibility, color, chlorophyll-a, total suspended solids, volatile suspended solids, and salinity of the previous month or the previous three months, as measured in the St. Lucie near the discharge points of the three canals. In our multi-species database, species is a major factor determining abnormality prevalence; therefore, we used mixed-effects models and entered species into our models as a random effect to account for species variation. Since the water quality variables were cross-correlated to varying extents, we examined these variables in separate equations to prevent problems associated with multicollinearity. We created separate models for the middle estuary (SLES) and the Inlet (SLIN). When we treated the canal flows as separate variables, only C44 flow was statistically significant. Our results suggested that hydrologic variables affected ANY in SLES with a 90-day lag and ANY in SLIN with a 7- or 30-day lag. Those species that had the highest prevalence of ANY were the same species that were most sensitive to change in freshwater inflow. Where they occurred in both areas, the sensitive species were the same species in both SLES and SLIN. All water quality variables were significantly related to ANY in either SLES, SLIN, or both areas. In general, color, visibility, chlorophyll-a, and salinity were negatively related to ANY (the higher the variable, the lower ANY), and total and volatile suspended solids were positively related to ANY (the higher the variable, the higher ANY). In general, previous-3-month variables had stronger effects. The beneficial effect of color on fish health that is suggested by its negative relationship with ANY may be due to the sequestering of heavy metals such as copper. Our results suggest that both discharge volumes and water quality affect fish health in the St. Lucie system. The prevalence of fish with abnormalities can be a powerful indicator of the cumulative effects of local and regional restoration efforts.

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The Disappearing Islands of Whitewater Bay, Everglades National Park

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Between 1928 and 2004, 80 islands have disappeared from Whitewater Bay with numerous others diminishing in size. Using historic maps and aerial photographs (1928, 1940, 1952, 1964, 1987, & 2004), GIS, and visual confirmation, the mangrove islands identified on these maps and aerials were present in previous years and non-existent by 2004. Increased hurricane intensity and frequency and sea-level rise are believed to initiate the island-loss scenario, with mangrove mortality and destabilized sediments completing the cycle. The vanished islands were scattered throughout Whitewater Bay, with some located along the perimeter and others in open water, and varied in size from less than 200m^2 to nearly 7000m^2. Significant alteration to the shoreline of large islands (50,000m^2 -200 ha) was also evident. In several cases small passes opened on narrow peninsular features creating one or more islands, which are also disappearing. No new islands were identified as emerging from the bay bottom, but only forming by division from a larger island. The rate of sediment erosion seems to vary throughout time. Between 1928 and 1964, the rate of sediment erosion of a noted peninsula and three islands was moderate, yet increased in the period of 1987 to 2004. Sea-level rise and hurricanes may have encouraged this erosional variation. Another potential contributor to the erosion of these islands is currently being investigated. The alteration of land use and land cover to the east over time (i.e. development of Miami and conversion of eastern Everglades) may have created a stronger atmospheric pressure gradient over Whitewater Bay, increasing average wind velocity and duration, and thus generating larger waves. Similar to the referenced historic maps and aerial photographs mentioned above, historical wind-force data is currently being analyzed to test this hypothesis. Understanding the cause of island loss in Whitewater Bay may assist in management and conservation efforts of the more than 60,000 ha of mangrove forest from Cape Romano to Cape Sable.

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Hydrologic Factors Related to the Presence of *Lygodium microphyllum* (Old World Climbing Fern) in Water Conservation Area 3 of the Everglades, South Florida

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One of the invasive exotic plant species of concern in the Everglades tree islands is *Lygodium microphyllum*, the Old World Climbing Fern. The South Florida Water Management District has been funding surveys of existing tree islands to identify and attempt to eradicate Lygodium from the tree islands on which it is found. Because the plant cannot be located remotely until it has reached the canopy, extensive field surveys are conducted to locate the plants under the forest canopy. These surveys include an initial rapid assessment followed by regularly-spaced transect surveys across each tree island. In 2008 and 2009, 104 tree islands in Water Conservation Area 3 (WCA-3) were surveyed. Of these, Lygodium was located on 26 (25%) of these islands, most of which were in WCA-3B. It is hypothesized that local hydrologic conditions in the previous two years are related to the presence of Lygodium on tree islands in WCA-3.

Hydrologic conditions of the tree islands for the two years prior to the surveys were analyzed using mean monthly water depths. Water depth data for the tree islands locations surveyed in 2008 and 2009 were extracted from the EDEN network. Monthly mean water depths were calculated for each tree island and grouped by calendar year and by hydrologic wet and dry season months. The data were then summarized by tree island and analyzed based upon presence or absence of Lygodium relative to the surveyed year (one and two years prior).
WCA-3 tree islands with and without Lygodium differ significantly in their hydrologic regimes for the previous one and two years. Tree islands with Lygodium experienced locally lower water levels in both dry and wet seasons and lower ranges of depths one and two years before the surveys were conducted. These results suggest that lower water depths are associated with higher risk of Lygodium occurring on tree islands in WCA-3.

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The Influence of Watershed Inputs on Salinity and Water Quality in Biscayne Bay

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Mass balance calculations provide a framework for investigating the influence of watershed inputs of freshwater and nutrients on salinity values and nutrient concentrations in Biscayne Bay. This report summarizes the results of two separate studies. Both studies rely on dynamic mass balance calculations implemented with monthly averaged inputs and in which average exchange fluxes are calibrated by matching calculated and observed salinity values. The first study focused on the relation between freshwater inflows and salinity in the complex of coastal lagoons extending from the Oleta River to Barnes Sound. The second study focused on the relation between estimated nutrient loads and measured nutrient concentrations in the central and south regions of Biscayne Bay. The results of these studies reveal regional differences within Biscayne Bay that should be taken into account when assessing the effects of water management and setting nutrient criteria in the watershed.

Regions of Biscayne Bay differ greatly in the degree of freshwater inflow from the watershed and in the rate of exchange with the coastal ocean. These differences are reflected in the values of four summary indices: (a) the ratio of canal inflows to total flow; (b) the ratio of net rainfall to total flow; (c) freshwater displacement rate, and (d) residence time. The north region of the bay consists of small basins well flushed by large canal discharges and strong exchange with the ocean. In the central region, the shallow inshore region is relatively isolated from direct exchange with the ocean and inshore salinity values are generally lower than in the adjacent mid-Bay areas. The net freshwater supply in the south region can be negative in dry years and exchange with the ocean is restricted, leading to high salinity values.

The general agreement between calculated and observed nutrient concentrations validates the estimated nutrient loads from sources on the watershed. Loads were estimated based on water quality data from two long-term water quality monitoring programs – the DERM and SERC/FIU monthly grab sample networks - as well as a number of other sources. Data for total phosphorous, nitrate + nitrite (NOx) and ammonia were assembled and time series of loads were developed for canals, precipitation, groundwater, and overland flow contributions. The agreement between calculated and observed concentrations is best for total phosphorous. In contrast, calculated concentrations of NOx and dissolved inorganic nitrogen (DIN) in the bay are sensitive to uncertainties in the estimated loadings both under current conditions and related to how loads will change in response to changes in land use.

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Integrating Human Dimensions into Ecosystem Management of the Florida Keys and Dry Tortugas: Preliminary Findings from the MARES Project

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Humans are an integral part of all ecosystems, including especially the Florida Keys and its surrounding marine ecosystems. The overall goal of the MARES project is to reach a science-based consensus about the defining characteristics of a South Florida coastal marine ecosystem that is both sustainable and capable of providing the diverse ecological services upon which our society depends. Whereas the over-riding focus in the Everglades has been upon ecosystem restoration, management of coastal marine ecosystems must, by legal mandate, integrate and give equal priority to interactions between environmental and human dimensions components ecosystems. Incorporating human dimensions aspects of these ecosystems into conceptual ecological models and ecosystem indicators represents a major challenge in the MARES project.

The MARES project has adopted a Driver-Pressure-State-Ecosystem Services-Response (DPSER) framework for developing integrated conceptual ecosystem models. This framework extends the Driver-Stressor-Effects-Attributes (DSEA) framework, originally used by EPA for ecological risk assessment, by incorporating elements of the more recent Driver-Pressure-State-Impact-Response (DPSIR) framework. The DPSIR framework explicitly represents the interdependence between human dimensions and environmental attributes through feedback loops in the model structure. Human dimensions aspects of the ecosystem are also represented in the Ecosystem Services component of the DPSER model. Linking conditions in the ecosystem to "services", rather than the more general "impacts," allows human use values, activities, and impacts to be modeled explicitly.

Quantitative Ecosystem Indicators (QEI) provide metrics for monitoring and reporting the progress of ecosystem management based upon the integrated conceptual ecosystem model. The QEIs developed by the MARES project represent both environmental and human dimensions aspects of the regional ecosystem. These provide better integration of all ecosystem processes into regional management plans. With a resident population of 81,000 and the arrival of 3 million visitors per year, humans have long been a significant component of the Florida Keys and Dry Tortugas marine ecosystems.

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Persisting Effects of Hurricane Wilma Storm Surge in Pine Rockland Habitat on Big Pine Key, FL

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The loss of pine rockland habitat in the Lower Florida Keys is being driven by a combination of sea-level rise, episodic storm surge events, and reduced fire frequency. Since 2006, lower elevations of the pine rockland community on Big Pine Key have seen massive mortality of pines and a change in herbaceous flora. We hypothesize that the recent mortality and species change is being driven primarily by the lingering effects of inundation from storm surge from Hurricane Wilma which passed over the Florida Keys on October 24th, 2005 and created a surge of water from the Gulf of Mexico of up to 8 feet.

In an effort to determine how the storm surge affected community change in pine rockland habitat on Big Pine Key, this study investigated how herbaceous layer diversity has changed in areas of contrasting fire history and storm surge impact along an elevation gradient. Storm surge impact was determined by calculating the normalized differenced vegetation ratio (NDVI) from Landsat TM imagery acquired before and after Hurricane Wilma. Percent cover and density of herbaceous plants and shrub species less than 1 meter in height were sampled in permanent plots before and after Hurricane Wilma. The first sampling events occurred in 1999-2001 as part of a fire effects study, with one sampling event before and two after a prescribed fire in burn treatment plots and control plots. In the post-storm surge sampling (summer 2008), ten groups of four 1-m^2 circular subplots were randomly selected for resampling in four of the previously sampled permanent plots. A soil sample was taken at each sample location and analyzed for electrical conductivity using the soil: water extract method.

Compositional data was analyzed using Non-Metric Multidimensional Scaling (NMDS) and ANOSIM was used to compare communities among years and plots. The temporal change in herbaceous plant composition was analyzed using Trajectory Analysis and relationships between ordination axes and soil electrical conductivity were examined. Substantial decreases in pre- to post-Wilma NDVI were assumed to represent areas where extensive flooding from storm surge impacted the canopy layer vegetation. Species richness of the herbaceous layer decreased significantly from 2001 to 2008, with a significantly greater decrease observed in the highly-impacted area (large percent change in NDVI post-hurricane Wilma) control plot compared to burned treatment plot ($p < .01$). The results of this study shed light on how a pulse disturbance (hurricane storm surge) interacts with fire history to drive community change on this low-lying island. Patterns observed in the Florida Keys may be a harbinger of what to expect in similar mesic forest fragments on the south Florida mainland as sea level rise proceeds, and should be integrated into the planning process for Everglades restoration.

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Spatial Occurrence of Ridge Senescence in Water Conservation Area 3A, 3B, and Everglades National Park in 2004

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A phenomenon described as sawgrass (*Cladium jamaicense*) die-off, senescence, or decadence has been widely observed in the Water Conservation Areas and Shark River Slough of the Florida Everglades at various times in the last 30 years. Even though our previous survey and scientific observations from other agencies have been reported, only limited quantitative data exist. One implication of ridge senescence is a reduction in organic matter input to ridge soils which may cause a critical change in the soil accretion rates on ridges relative to slough habitat and maintenance of the ridge and slough mosaic in the Everglades. Therefore, spatial and temporal information about ridge senescence is important to predict the change of these two habitats in the central Everglades. The main objectives of this study was 1) to quantify incidence of ridge senescence using 2004 ortho-rectified images and 2) to develop photointerpretation keys which allow us to evaluate ridge senescence using aerial imagery or other remote spectral platforms. We selected 12 Probabilistic Sampling Units (PSUs); PSU 2, 4, 71, and 58 in Water Conservation Area 3A, PSU 20 in Water Conservation Area 3B, and PSU 24, 0, 50, and 62 in the Everglades National Park. We digitally overlaid 200 random points within each PSU and water depth raster file using ArcGIS 9.3. We then classified each point into four major categories (ridge, slough, tree island, and disturbed) and seven subcategories (healthy, type I senescence, type II senescence, type III senescence, periphyton, open water, and floating-leaved plant). To evaluate the relationship between hydrology and occurrence of ridge senescence, we compared water depth of each PSU from the Everglades Depth Estimation Network with frequency of occurrence based on 2004 aerial images. Findings show a significant relationship between water depth and the occurrence of senescence with R^2 values ranging from 0.60 to 0.69 depending on type and intensity of ridge senescence. In addition, there was an interactive effect among water depth, percent periphyton occurrence in sloughs, and frequency of ridge senescence. At this point of the investigation, it is unclear what the specific causal mechanisms result in ridge senescence, but these findings suggest that water depth and possibly some water chemistry factors may be influencing the occurrence of this phenomenon.

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Impacts of Sulfate-Enriched Water Discharged into Northwestern Water Conservation Area 2A

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Sulfate has emerged as a key water quality issue for Everglades restoration. Sulfate, originating in Lake Okeechobee and the Everglades Agricultural Area (EAA), enters the Everglades in discharges from canals or stormwater treatment areas (STAs). Sulfate concentrations in Everglades marshes near discharges may average 60-70 mg L^{-1} compared to background levels of <1 mg L^{-1} in the ecosystem. The STAs, designed to remove phosphorus discharges to the Everglades, have little effect in reducing sulfate loading to the ecosystem. The high sulfate loading stimulates microbial sulfate reduction and buildup of sulfide in Everglades anoxic soils. The enrichment of sulfate in the ecosystem has been demonstrated to be a major control on the production and bioaccumulation of toxic methylmercury (MeHg). Other impacts of sulfate loading include sulfide toxicity to flora and fauna, lowering of soil redox conditions, and enhanced nutrient remobilization from soils by internal eutrophication.

One area of the Everglades where sulfate levels have changed dramatically over the last decade is northwestern Water Conservation Area 2A (NW WCA-2A). Prior to the opening of STA-2 in July 2001, this area was rainfall dominated and sulfate concentrations in surface water ranged from 5-17 mg L^{-1}. Sulfate levels of 50-60 mg L^{-1} in surface water at sites closest to STA-2 discharges were observed in August 2009 and February 2010. Sulfide levels in porewater ranged up to 3,000 µg L^{-1}. These sulfide levels are insufficiently high at present to be toxic to *Cladium*, but may increase over time if current levels of sulfate enrichment are sustained. In surface water, measurable sulfide was present at all sites in both August 2009 and February 2010, with levels of total sulfide up to 300 µg L^{-1} and 40 µg L^{-1}, respectively. At pH values of about 7 in NW WCA-2A free H_2S levels exceeded EPA standards of 2 µg L^{-1} free H_2S in surface water at all sites. Other reduced sulfur species such as sulfite and thiosulfate were also present at high concentrations in surface water and porewater in NW WCA-2A. Nutrient (phosphate and ammonium) levels in porewater are elevated in the most sulfate enriched sites, suggesting the possibility of sulfate-induced nutrient remobilization via internal eutrophication. MeHg distributions in NW WCA-2A reflect a balance between stimulation of mercury methylation by sulfate and inhibition by sulfide. Overall, except for much lower levels of total phosphorus, NW WCA-2A is similar geochemically to site F1 in eastern WCA-2A, which received very high sulfate loading during the 1990s. NW WCA 2A represents an important natural laboratory for examining the impacts of high sulfate loading on the Everglades.

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Sulfate Contamination in the Everglades – What Concentration Minimizes Impacts?

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There is extensive sulfate enrichment of the Everglades as a result of: (1) current use of sulfur in the Everglades Agricultural Area (EAA), (2) oxidation of soils in the EAA releasing agricultural legacy and natural sulfur, and (3) from sulfate stored in Lake Okeechobee. The sulfate enters the Everglades in discharges from EAA canals and stormwater treatment areas (STAs). As a result of these discharges, about 60% of the Everglades have sulfate levels in surface water that exceed background (< 1 mg L^{-1}), and marsh areas near canal or STA discharges have average sulfate levels of 60-70 mg L^{-1}.

Sulfate enrichment has a number of impacts on the Everglades, including: (1) effects on production and bioaccumulation of methylmercury (MeHg), (2) stimulation of microbial sulfate reduction and production of toxic sulfide, (3) enhancement of nutrient recycling via internal eutrophication, and (4) changing redox conditions in wetland soils. These impacts may affect both flora and fauna in the Everglades, and the MeHg issue poses concerns for human health through fish consumption.

These different impacts occur at various levels of sulfate enrichment. If restoration efforts to reduce sulfate loading to the ecosystem are implemented, what level of sulfate would minimize impacts? While sulfide toxicity and internal eutrophication have not been extensively investigated, these impacts appear to occur only in areas with levels of sulfate consistently exceeding 50 mg L^{-1} and 40 mg L^{-1}, respectively. MeHg production occurs at much lower levels of sulfate, and is complicated by the fact that sulfate stimulates and sulfide inhibits MeHg production. Maximum MeHg production appears to occur at around 10-20 mg L^{-1}, but significant MeHg production is observed at sulfate concentrations as low as 2-3 mg L^{-1}. With high mercury deposition, and the right environmental conditions, the Everglades is primed to produce MeHg even at relatively low levels of sulfate enrichment. However, studies in central Water Conservation Area 3 indicate that the ecosystem responds quickly to a reduction of sulfate loading with dramatic declines in MeHg production. Any reductions in sulfate loading are likely to reduce overall MeHg production in the ecosystem. Thus, rather than focusing on a specific numerical criterion for sulfate, efforts could be aimed at reducing sulfate levels as much as possible, within the context of feasible and affordable source reduction and remediation strategies.

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Vegetation Community Responses to Prescribed Fire Regimes in the A .R. M. Loxahatchee National Wildlife Refuge

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Historically, wildfire was common in the Everglades landscape during dry conditions with lightning being a common ignition source. Because the Everglades ecosystem developed with frequent wildfire events, it is thought to be an integral part of Everglades restoration. Balancing the valuable regenerative benefits of fire on the ecosystem with fuels and smoke management requires prescribed burning under low water, but not overly dry conditions within the ARM Loxahatchee NWR. This allows for maintenance of landscapes and vegetation communities without risk of muck fires which could consume organic soils and create undesirable smoke conditions. Recent introduction of exotic species of vegetation such as *Melaleuca*, *Lygodium*, and the invasive species such as *Typha* further constrain prescribed fire as some of these species respond positively to fire events.

The objective of this research was to investigate the potential of invasive or exotic species to spread to areas treated with prescribed fire under the current protocol of burning with sufficient water on the landscape to prevent muck fires. Four large fire events (2007-2009) provide the opportunity to monitor vegetation community responses to prescribed fire and the potential for colonization or spread of exotic and invasive species. All burn areas were monitored for two to three years via vegetation quadrats (n=62) established prior to prescribed fire events. Vegetation types including native species such as *Cladium* and *Typha*, and exotics such as *Melaleuca* and *Lygodium* were evaluated for regeneration and new colonization.

There was no significant difference observed in exotic species (*Melaleuca* and *Lygodium)* colonization within burn plots versus non-burn controls. Several small areas of *Lygodium* infestation within the canopy of *Cladium* were completely eradicated by fire. Typha was not observed to spread via seed or rhizome to areas dominated by Cladium prior to burning. We conclude that surface water presence at the time of prescribed fire events is likely a significant factor in preventing the spread of undesirable vegetation types into burned areas. Further, under the current prescribed fire protocols, there seems to be little to no risk of inadvertent spreading of undesirable vegetation in burn areas.

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The Effect of Hydrology, Fire Regime and Exotic Invasion on the Postburn Successional Trajectory of Plant Communities in the Big Cypress National Preserve

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Relatively little is known about how exotic invasion interacts with hydrology and fire regimes to influence community composition and successional trajectories. In April 2009, severe fires burned through more than 12,000 hectares of pine flatwoods and hardwood hammocks in the northwestern portion of the Big Cypress National Preserve (BICY), presenting a unique opportunity to collect baseline data and study how the interactions among long-term hydrology, fire history, and invasion by exotic plant species affect the regeneration of canopy species in forested communities of the Big Cypress.

The study area encompassed approximately 25,000 hectares of BICY to the north of I-75 between the Okaloacooche Slough and the L-28 Interceptor Canal. Forested communities within the study area included deep cypress strands, cypress prairies, cypress domes embedded in wet prairies and marshes, hydric pine flatwoods, hydric oak hammocks (dominated by *Quercus laurifolia*), and mesic oak hammocks (dominated by *Quercus virginiana*). With the exception of the deep cypress strands and swamp forests, large portions of the study area experienced a wildfire or prescribed burn at least once since 2000 and many areas had burned at least twice since 1980. GIS maps of vegetation cover, burn history since 1980, and exotic invasion history were used to select sampling locations that captured the spatial variation of these attributes within the study area. During the wet season in 2009, vegetation cover and seedling density was sampled at a total of 53 100m x 100m plots across the hydrologic gradient at 19 locations. Water depths measured at sample plots on a given day were related to water surface elevation data generated by the Everglades Depth Estimation Network (EDEN) for the same day to determine the offset between the EDEN water surface and the ground level at the plot. The offsets were then used in combination with the EDEN time series data to generate the hydrograph of water depth for each plot, and measures of hydrological conditions were derived from the resulting hydrographs for the period from January 2000 through September 2009.

NMS ordination of plot data produced three significant axes. One of the significant axes was strongly correlated with average annual hydroperiod, inundation depth, and soil thickness. A second significant axis was significantly correlated with percent cover of the invasive exotic *Schinus terebinthifolius* in the shrub and canopy layer. This axis was not correlated with the density of *Schinus* seedlings, but was significantly correlated with the presence of *Q. laurifolia* and *Q. virginiana* in both the canopy and seedling layer, suggesting that exotic invasion may not have a significant effect on the post-burn regeneration of canopy species in intact hammocks. Direct gradient analyses showed that the highest density of *Quercus* seedlings was found in relatively short-hydroperiod plots that had recently burned. High densities of *Quercus* seedlings were also observed early in the wet season at locations with a known history of exotic disturbance where prescribed burns had taken place during the previous dry season, highlighting the importance of integrating fire management and invasive control.

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Hurricane Effects on Mangrove NDVI and EVI values estimated from SPOT and MODIS Imagery

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The effects of two hurricanes (Katrina and Wilma) on protected mangroves in southwest Florida and two hurricanes (Emily and Dean) on protected mangroves in the Yucatan Peninsula were assessed using sets of 20 m multispectral SPOT and 500m MODIS images. NDVI and EVI values were calculated to measure mangrove canopy reflectance using three methods of analysis— 1) mangrove NDVI sample point extraction, 2) assessment of 500m MODIS NDVI and EVI time series, and 3) transects of NDVI differences before and after storm events. Results show each method effectively captures changes in mangrove canopies consistent with storm effects. However, the extent of damage to mangroves in South Florida and Sian Ka'an was highly variable. Wilma and Katrina produced a large drop in NDVI although Emily apparently increased mangrove photosynthetic activity. Comparison of SPOT NDVI and MODIS NDVI values revealed that the changes pre- and post-storms were consistent at the different scales of observation. Further analysis regarding seasonality and hurricane features is suggested.

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Environmental Filters of Wet-Season Aquatic Communities into Dry-Season Pools

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The annual drying of Everglades wetlands creates a challenge for fish and macroinvertebrates that must find refuges for the dry season. We hypothesize that species-specific patterns of refuge finding and patterns of landscape features determine the composition of drying pools that attract wading birds for dry-season foraging. We used data collected for the CERP Monitoring and Assessment Plan (MAP) to evaluate models seeking to predict aquatic animal communities in dry-season pools. We asked if fish communities in drying pools could be predicted by local wet-season community data and measures of the local habitat matrix. We compared wet-season community composition to composition in dry-season pools where wading birds were foraging and in randomly selected dry-season sites. Wet-season samples were selected by Generalized Recursive Tesselation Sampling (GRTS) with post-stratification by landscape subunit. Dry season samples were collected at random points and also at locations where wading birds were observed actively feeding. We- season sampling occurred in Loxahatchee National Wildlife Refuge, WCA 2A, 3A, and 3B, and Everglades National Park. These comparisons were repeated for data from the 2005 wet season and 2006 dry season, through the 2008 wet season and 2009 dry season. Fish communities from corresponding wet and dry seasons were compared within regions using Bray-Curtis dissimilarity coefficients and we examined how dissimilarity changed as a function of distance separating sampling sites. Preliminary results show that even over short distances, fish communities may change markedly over the wet to dry-season transition. GIS analysis is ongoing to evaluate landscape factors tied seasonal change.

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Influence of Canals on Dispersal Patterns of Native and Non-native Fish in the Everglades

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The addition of canals to south Florida has not only altered the hydrology and connectivity of different portions of the Everglades landscape, but also created artificial habitat for large, predatory fish species. The artificial conditions of canal habitat also provide an environment where non-native species can thrive. Canals that border the Everglades creates the potential for predation impacts into marshes by both native and non-native species. Direct tracking of excursions by predatory fishes into marshes from canals provides an assessment of canal impacts. Radio-telemetry techniques were used to track the movements of largemouth bass *Micropterus salmoides*, a native predator, and Mayan cichlids *Cichlasoma uropthalmus*, a non-native species, at two canal-marsh interfaces. Data on Florida gar *Lepisosteus platyrhinchus* movement within marshes was used as an additional interspecific comparison. Fish were tracked during seasonal transitions in patterns of precipitation in order to measure the influence of hydrology on dispersal within and between canals and marshes. For both native and non-native species, movement rates were higher and more variable during the spring and summer than during the winter. Native predators exhibited greater movement rates during the winter than Mayan cichlids. Following the transition from the dry to wet season, Mayan cichlids made earlier excursions from the L31W canal into marsh habitat than largemouth bass. During the wet season, Mayan cichlids dispersed from 0.25-14 km within the Everglades and 0.02-4 km within the L31W canal. Preliminarily, largemouth bass appear to disperse greater distances within canals and lesser distances between canals and marshes than Mayan cichlids. During the winter, Mayan cichlids and largemouth bass generally dispersed less than 1 km within the C-111 and L31W canals. All three predator species exhibited a great deal of individual variation in movement patterns. Though preliminary, these patterns of movement already have provided evidence that a non-native predator will make long-distance excursions from canals into the marshes of the Everglades. Further effort is underway to measure the movement of predatory fish between these habitats in order to quantify the spatial scale of the connectance between the communities of canals and marshes in the Florida Everglades.

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A Conceptual Ecological Model for the Everglades Agricultural Area

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The Everglades Agricultural Area (EAA) is a 700,000 acre agricultural area on former marsh habitat in southern Florida located south and east of Lake Okeechobee, north of Everglades remnant natural habitat and west of the large metropolitan area of Palm Beach County. Sugarcane is the primary crop and is rotated with rice. Vegetables and sod are also grown in the area. Wildlife is diverse and abundant in the agricultural fields, edges and associated habitat. The EAA has been identified as an important component of Everglades restoration with the proposed purchase of 73,000 acres for water treatment, water storage and habitat restoration.

Conceptual ecological models are used as planning tools in Everglades restoration to explicitly delineate stressors, anthropogenic effects, linkages and valuable ecological components in an ecosystem. They are valuable in restoration and conservation programs and provide tools for communication and assessment between scientists and policy-makers. While the EAA is a converted agricultural landscape and contains very little of the original natural habitat, a conceptual ecological model may help to understand the system, its place within the larger south Florida landscape and potential for restoration. This landscape is heavily managed for economic benefit and provides income for local communities and residents. It is also a large acreage agroecosystem with unique attributes and wildlife communities.

Economic development and ecosystem restoration are important, but not mutually exclusive drivers of the ecological future of the EAA. Stressors include present and future land use changes, water use (drainage and irrigation), and use of pesticides and fertilizers. Ecological attributes include soil accretion, carbon sequestration, water treatment and storage, wildlife habitat, and recreational uses. Socioeconomic and political transitions may change land use and habitat within the EAA and impact habitat quality in the Everglades. The goal of this presentation is to present a preliminary conceptual ecological model for the EAA and to seek input from and interaction with stakeholders and potential partners.

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A CircuitScape Dispersal Model and Index for Connectivity in South Florida Landscapes

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CircuitScape is a unique approach to dispersal modeling that predicts paths and patterns of animal movements in heterogeneous landscapes using algorithms from electronic circuit theory. The approach links circuit and random walk theories based on the idea that corridors connecting habitats can be represented as current flows between electrical nodes. Multiple or wider corridors between habitats will have greater conductance than narrower paths. Because circuit theory can measure all possible pathways across a landscape simultaneously, it is being adapted as a particularly effective approach for evaluating impacts of development and landscape changes on mammal dispersal and habitat connectivity. To develop a useful landscape index, the impacts of landscape scale, extent and configuration on CircuitScape results in South Florida were tested. Sensitivity analyses tested CircuitScape results against changes in spatial resolution, the number of habitat types used, and changes in the resistance of habitat types to animal movement. Results are presented in environments ranging from open habitat with increasing rock mine development to complex urban environments with intertwined natural corridors and habitat core areas. Methods for aggregating CircuitScape results into an index of connectivity are presented.

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A Collaborative Computing Framework for Rapid Ecomodel Development

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A high performance collaborative computing (HPPC) JAVA framework has been developed to facilitate ecomodeling application development with spatially and temporally complex datasets and hydrological modeling output. Three primary goals of the framework are to reduce future programming effort on tedious and repetitive tasks, take advantage of distributed computing when available and eliminate or reduce the need to copy and move large datasets by allowing them to be accessed and shared over the Intranet.

High-Performance Computing refers to the use of supercomputers or computer clusters to solve advanced computational problems. The HPPC framework takes advantage of distributed computing to divide an applications processing among all the computers in a cluster or network that are announcing to the framework that they have processors available for use. This capacity is as useful in a work environment of small desktop and laptop computers as it is in a large research facility with powerful servers. Cloud computing capabilities allow information in large datasets to be delivered to a remote application on-demand and without physically moving the dataset to the local device. The HPPC framework also provides standard libraries for file input and output (IO), mathematical and statistical routines and visualization. IO includes netCDF, spreadsheets, and specific binary formats that are used in Everglades ecomodeling applications. These are generic, but time-consuming tasks to most modeling applications that often cluster program code. Use of the HPPC framework encourages a standardized IO format and minimizes programming errors. The first application of the HPPC framework is an Everglades landscape vegetation succession (ELVeS) model designed for flexible user parameterization.

The SFNRC HPCC framework has been released for active development by many contributors throughout the scientific community under the GNU Public License as open source software. The framework has been specifically created for the purpose of rapid scientific application development, however it is flexible enough to be applied to other applications such as data warehousing and business.

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Prevalence of a Parasitic Isopod, *Probopyrus* spp, on Palaeomonid Shrimp along a Marsh-Estuarine Gradient in the Southern Everglades

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Parasites negatively affect their hosts by causing reduced resource intake rates, cessation of reproduction, and even death. These effects reduce overall host fitness, and have important consequences for host populations, species interactions, and food web dynamics. Branchial parasites of crustaceans, such as *Probopyrus* spp*,* have been shown to reduce host fitness by reducing oxygen intake and by castrating or feminizing males in the population.

In the Everglades, grass shrimp are an important resource for both fish and avian consumers. These decapod crustaceans are widely distributed throughout the freshwater, estuarine and marine regions of the ecosystem. Previous work has shown that five species of Palaemonid shrimp occur across the Shark Slough-Shark River system: *Palaemonetes paludosus, P. pugio, P. intermedius, Palaemon floridanus and Leander paulensis.* These species vary seasonally in relative abundance across the estuarine part of the system, presumably in response to freshwater flows and corresponding changes in salinity. In this study, we sought to investigate the parasitic prevalence of *Probopyrus* spp on these five species of shrimp. We collected shrimp from three marsh sites, five sites located on the marsh-mangrove ecotone (Rookery Branch), and three estuarine sites using unbaited minnow traps deployed overnight. We repeated sampling in the early and late dry seasons.

Interestingly, of the five species collected, the riverine grass shrimp (*P. paludosus*) was the only one parasitized by *Probopyrus spp*. We also detected a marked pattern of incidence of the parasite in *P. paludosus*, where almost all shrimp collected at ecotonal sites were infected, but parasitism dropped to zero at the marsh sites. The mechanism for this pattern is unknown, possible related to the presence or abundance of intermediate hosts or to abiotic conditions. This high parasitic prevalence should have a negative effect on populations of *P. paludosus* at the ecotone, and may act to limit its distribution. Fluctuation in shrimp populations due to parasitism may also have negative cascading effects on other trophic levels and ecosystem structure and function, thus there is a need to better understand parasite-host dynamics, and how parasitism may be affected by hydrological disturbance.

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Digital Aerial Sketch Mapping (DASM) for Invasive Plant Survey and Mapping in the Everglades Cooperative Species Management Area (ECISMA)

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State and federal agencies are collaborating on an ongoing invasive exotic plant mapping project for the Greater Everglades region. With 2.7 million acres of combined management area, land managers within the Everglades Cooperative Invasive Species Management Area (CISMA) require a financially-efficient and rapid monitoring method to assist with weed management strategies and to provide early detection of new infestations. Digital Aerial Sketch Mapping (DASM) is the US Forest Service's preferred way to detect and monitor forest pest outbreaks because of its reliability and relatively low cost. The system consists of two networked, user-interface, tablet PCs with touchscreens, which are linked to a GPS receiver. Using specialized mapping software (GeoLink™, Baker, Inc.), the user draws points, lines and polygons with attributes on a moving background map. This system allows for rapid, "on-the-fly" spatial data collection, typically from low-flying aircraft. The South Florida Water Management District, the National Park Service's Florida/Caribbean Exotic Plant Management Team and South Florida/Caribbean Inventory and Monitoring Network have adopted DASM to aerially map six major invasive, exotic plant species within the Everglades CISMA. These are Australian pine (Casuarina spp.), Brazilian pepper (Schinus terebinthifolius), Burma reed (Neyraudia reynaudiana), melaleuca (Melaleuca quinquenervia), Napier grass (Pennisetum purpureum), and Old World climbing fern (Lygodium microphyllum). We will present an overview of this novel mapping invasive plant method and results of recent mapping efforts.

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Automation of the Estimation of Missing Water-Level Data for the Everglades Depth Estimation Network (EDEN)

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The Everglades Depth Estimation Network (EDEN) is an integrated network of 253 real-time water-level gaging stations, ground-elevation models, and water-surface models designed to provide scientists, engineers, and water-resource managers with current (2000-present) water-depth information for the entire freshwater portion of the greater Everglades. A spatially-continuous interpolated water surface across the greater Everglades is generated from daily median water-level values. However, missing or erroneous data can compromise the quality of the modeled water surfaces. To increase the accuracy of the daily water-surface model, a database application was developed to estimate water levels to fill data gaps.
Missing data are estimated by developing linear regression equations for each gage. To minimize the inability to estimate data due to missing data from a single input site, three or four regression equations were developed for each site using different input sites. For each site, a priority was established for the order of regression equation to be used to fill a data gap. The equations (over 700) were incorporated into a database application that automatically estimates missing water-level records. A protocol was established to turn off a site from either being estimated or used to estimate another gage when gaging stations are dry.

The challenges of developing the application will be presented along with future plans for the application to EDEN and similar use for this methodology for other hydrologic networks. To improve the quality of the water-level estimates, shifting techniques are applied to the data similar to the techniques used for computing continuous water-level and water-quality data records. Estimates for the missing records are manually evaluated and shifts applied. For very short periods (less than 8 hours), linear interpolation is automated in the application to fill data gaps.

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Use of Remote Cameras to Detect Small and Medium-sized Mammals in Everglades National Park and Big Cypress National Preserve

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Remote camera trapping has been utilized since the 1920s in wildlife surveys. Cameras are now being deployed as a tool for detecting wildlife, including mammals, for inventories and site-specific occupancy studies. Game cameras offer several advantages over live-trapping and on-the-ground surveys, as they are minimally invasive to the habitat and can be deployed in remote locations for long periods of time. We used remote camera trapping as our main method of detection during an inventory of small and medium-sized mammals in Everglades National Park (ENP) and Big Cypress National Preserve (BICY) from 2007-2009.

We utilized 4 types of cameras: Stealth Cam STC-V450 35mm, TrailMAC Olympus D-435, Moultrie Gamespy I40, and Cuddeback Capture IR. We deployed “permanent” and “temporary” cameras that we baited with call lures, wet cat food, and fatty acid discs. To detect species of interest, we used species-specific camera methodology during the second year of the inventory.

In BICY, we detected 1,939 individuals of 14 mammal species across 2,218 permanent and 3,236 temporary trap nights (TN). We obtained >1300 photos of sufficient quality to accurately identify the “captured” species (827 from permanent cameras, 531 from temporary cameras). Seven skunk/cottontail sessions over 665 TN produced 149 pictures, 17 squirrel camera sessions over 1,017 TN produced 220 pictures, and two mink sessions over 334 TN produced 7 pictures. In ENP, we detected 2,720 individuals of 5 mammal species across 1,840 permanent and 2,758 temporary camera trap nights. We obtained >900 pictures (488 from temporary cameras, 436 from permanent cameras). Six skunk/cottontail sessions over 560 TN produced 27 pictures, 20 squirrel sessions over 1,696 TN produced 614 pictures, and 49 mink sessions over 8,610 TN produced 1,116 pictures. However, we detected 4 species in BICY and 8 species in ENP via opportunistic sightings that were not detected by camera.

In total we detected 4,659 individuals in ENP and BICY by camera. The Moultrie and Cuddeback cameras took higher quality photos than the other two camera types, and the Moultrie camera in particular provided an easy-to-use display. Cameras were very useful for capturing both diurnal and nocturnal mammal species. They also allowed us to sample a large study area with minimal disturbance to habitats. These results show that although camera trapping is a valid and useful method for detecting small and medium-sized mammals, it is useful to combine camera trapping with other methods such as opportunistic sightings, as methods differ in their effectiveness for capturing certain species.

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Photo-Induced Generation of Dissolved Organic Matter (DOM) from Floc in the Shark River Slough of the Florida Coastal Everglades (FCE)

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The Florida Coastal Everglades (FCE) is an oligotrophic wetland characterized by very low quantities of suspended particulate organic matter (POM). The majority of the POM in this environment occurs at the water-sediment interface as flocculent material (floc) which has been characterized as detrital and rich in organic matter. Although it is known that floc is an important component of the food web in the Everglades, still little is known about its biogeochemical dynamics in this environment. Floc has been thought to be a potentially important source of dissolved organic matter (DOM). In the shallow waters of the FCE, floc is naturally re-suspended through wind and bioturbation, and can therefore be exposed to intense sunlight. This photo-exposure may result in DOM generation through photo-dissolution processes.

To quantify and characterize the DOM generated from floc by photo-irradiation, samples were collected at two sites along the Shark River Slough, a freshwater site and a mangrove site. The floc was incubated in a solar simulator (exposed and dark controls) for different periods of time (up to 7 days). The incubated floc was filtered and the filtrate was characterized using elemental analysis and Excitation Emission Matrix (EEM) Fluorescence coupled with Parallel Factor Analysis (PARAFAC). To investigate the seasonal variations of DOM photo-generation from floc, this experiment was performed in the dry season (April) and the wet season (October) of 2009.

Our results show that the dissolved organic carbon (DOC) and fluorescence intensity of humic-like and protein-like components for samples incubated under dark conditions remained constant, suggesting that microbial degradation and/or leaching might be minor processes for the generation of DOM from floc. On the other hand, these parameters increased substantially for samples exposed to artificial sunlight, indicating the release of chromophoric DOM (CDOM) as well as DOC through photo-induced alterations of floc. Humic-like components generated from floc were found to be the main contributors to the CDOM pool, while protein-like components comprised a relatively small percentage of the total CDOM. Simultaneously to the generation of DOC, both TN and TP also increased substantially. Thus, photo-dissolution of floc might not only be an important source of DOM to the FCE environment but influence nutrient dynamics.

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An Evaluation of the CERP Florida Bay Salinity Performance Measure

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Over the past century, water management practices have disrupted freshwater flows to Florida's southern coastal systems, significantly altering salinity conditions and resulting in the degradation of estuarine flora and faunal communities. The Comprehensive Everglades Restoration Plan (CERP) aims to restore freshwater flows to this estuarine system to reestablish appropriate salinity conditions. CERP planners have developed salinity restoration targets for the southern estuaries based primarily on conditions that are optimal to the physiological needs of the native flora and fauna. Targets have been developed separately for 21 zones in Florida Bay, Whitewater Bay, and the southern end of the Biscayne Bay system. These zones were delineated based on distinct geophysical and ecological characteristics as part of the Florida Bay/Florida Keys Feasibility Study.

This paper uses salinity data from an extensive monitoring network in the southern coastal system to establish a current-condition baseline that can be compared to restoration targets and the effects of water management changes due to CERP. Time series data from 2004 to 2008 were used as the baseline period of record because this was the time period common to all monitoring sites used in the analyses. Output from predictive models was also used to compare historical conditions to restoration targets and current conditions, which can be used to help determine target suitability.

Results are presented as mean annual salinity ranges, as well as exceedances above and below the target range. Results indicate that current salinity conditions meet targets in only 3 of the 11 zones for which both empirical and simulated data are available. Salinity in southern Biscayne Bay and northeast Florida Bay deviate greatly from restoration targets, with only 1 to 27% of values falling within the target range. Model predictions of historical conditions meet restoration targets in only about half of the zones, suggesting that restoration targets for these areas may not be appropriate. As the salinity performance measure and targets for the bay are updated using the findings of current research and ongoing paleoecological work, and as additional empirical data become available, analyses such as those presented here should continue in order to evaluate baseline conditions relative to restoration targets and water management changes.

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Revisiting Ecological Integrity on the Kissimmee River: Are We There Yet?

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The Kissimmee River Restoration Project is reaching its culmination. With nearly 100% of the necessary real estate acquired, 13 of 22 miles backfilled, and planning and design underway for the remaining work, most of the project's budget has been spent. We present monitoring results from completion of the backfill of the first reach (2001) to present. While observations are promising, the ecological response has been limited. Only completion of the project, coupled with the restoration of flows from the headwater lakes, can certain properties of the ecosystem "emerge". The concept of ecological integrity was the focal point during the planning phase of the project, because they knew in 1991 that the benefits of piecemeal restoration were not worth the cost of the project. The temptation to accept a positive response as sufficient, in lieu of a system that provides exponentially more benefits, should be avoided.

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Groundwater-Surface Water Interactions in Taylor Slough – Everglades National Park

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Understanding groundwater-surface water interactions is important for quantifying water budgets. This research contributes to the understanding of groundwater-surface water interactions in Taylor Slough, Everglades National Park between January 2008 and July 2009. Four methods were used to quantify groundwater-surface water interactions including, a water budget, hydraulic gradient, geochemical tracers, and temperature. Groundwater and surface water levels were monitored using piezometers and pressure transducers at three Florida Coastal Everglades (FCE) sites along Taylor Slough (TS/PH-3, TS/PH-6, TS/PH-7). Site TS/PH-3 was located in the freshwater region of Taylor Slough dominated by sawgrass. The other two sites were located in the mangrove ecotone with TS/PH-7 located closest to Florida Bay. A meteorological tower was established at TS/PH-7 and recorded data every 30 min. In addition, surface water and groundwater samples at each site were collected and analyzed for major anions, cations, and the stable isotopes of oxygen and hydrogen.

The diverse methodological approaches used in this research provided evidence of groundwater discharge to the surface water in Taylor Slough. Although, there were periods when groundwater discharge or recharge was the dominant process, measured fluxes underwent reversals in direction on a daily basis. Groundwater discharge was the dominant process between January 2008 and July 2009, while groundwater recharge was significant between October 2009 and March 2009. Groundwater discharge accounted for 949.7 mm water input to Taylor Slough over the course of the 19 month study, equivalent to 60% of the precipitation received across the Taylor Slough watershed. Evapotranspiration was the dominant loss of water from the watershed. Surface water inflow (Q_{in}) and outflow (Q_{out}) of the watershed varied substantially from day to day and seasonally, but were roughly equivalent on an annual basis. Between January 2008 and July 2009, the volume of water that entered Taylor Slough was equivalent to 233.6 mm representing 14.8% of the input by precipitation. Similarly, the volume of water that left Taylor Slough to Florida Bay was 207.1 mm equivalent to 8.7% of the water lost by evapotranspiration. There was a poor correlation between rainfall and Q_{in} and Q_{out} ($R^2<0.1$) indicating that regional precipitation was not mainly responsible for surface water flow patterns. On the other hand there was a good correlation between Q_{in} and Q_{out} ($R^2=0.69$), signifying that smaller and larger inflows and outflows were registered during the same time periods.

Average discharge (↑) and recharge (↓) rates estimated with the water budget method were 14.58 (↑) and 13.07 (↓) mm/day in the period from January until September 2008; 6.01 (↑) and 9.30 (↓) mm/day for the period between October 2008 and March 13 2009; 15.29 (↑) and 7.78 (↓) mm/day for the period between March 14 and July 2009. Proximity to Florida Bay affected the magnitude and timing of the groundwater surface water interactions. Water fluxes were higher and more variable closer to Florida Bay. (18.25 (↑) and 27.73 (↓) mm/day), as compared to further upstream (5.07 (↑) and 0.79 (↓) mm/day). Discharge and recharge rates differed between the water budget and hydraulic gradient methods because they differed in spatial and temporal scales. Although each of the four methods used more or less confirmed the timing of the groundwater-surface water interactions, the temperature and water level measurements were the simplest and least time consuming approach.

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Origin of High Salinity Groundwater in the Surficial Aquifer System at the Herbert Hoover Dike, Southeastern Shore of Lake Okeechobee, Florida

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As part of a U.S. Army Corp of Engineers (USACOE) study to determine aquifer characteristics of the surficial aquifer system along the Herbert Hoover dike in support of seepage studies along the eastern and southern shores of Lake Okeechobee, the U.S. Geological Survey (USGS) is collecting borehole geophysical logs. High salinity groundwater has been observed at shallow depths in the surficial aquifer system at one of the aquifer tests sites, and this saline water, defined as having a dissolved-solids concentration of above 10,000 milligrams per liter, has the potential to increase the salinity in the upper part of the aquifer system above drinking water limits. The purpose of this investigation is to determine the origin of this saline water.

To investigate the origin of saline groundwater at this site and other inland areas of central Palm Beach County geochemical samples were collected and borehole geophysical logs were analyzed. Water samples were collected from 19 constructed wells in inland Palm Beach County and at three depths in a production well open over a long screened interval at the USACOE site. Samples were analyzed for concentrations of major ions, strontium, boron, and dissolved solids, and for isotopic ratios of strontium, boron, hydrogen, and oxygen. Borehole geophysical log data collected by the USGS in USACOE wells include gamma ray, caliper, induction resistivity, flow meter, fluid properties (temperature and resistivity), water-quality, optical image, acoustic image, and full waveform sonic. Flow meter and fluid property logs were conducted under ambient and stressed (pumping) conditions.

At the aquifer test site, which is near the toe of the dike on the eastern landward side, upwelling of saline water is strongly indicated by geophysical logs and water samples, including measurements of ambient upward flow of saline water in the borehole. The depth below land surface of the top of saline water in the formation is 60 ft, as defined by the induction resistivity log, and saline water is present in the lower part of the shallow, more permeable section of the system, as well as in the deep, less permeable section. This depth is 60 to 100 ft shallower than typically observed in the surficial aquifer system in central Palm Beach County. The strontium isotope ratios of water samples from four depths at this site indicate an age older than the probable ages of the formations from which the water came, but probably not older than the age of the deepest sediments in the surficial aquifer system. Based on the salinity of this water, which can approach that of seawater (the deepest sample had a dissolved-solids concentration of 32,900 milligrams per liter), and the strontium, hydrogen and oxygen isotope data, this water is indicated to have a residual, shallow origin rather than a deep origin. It may have resulted from invasion of the aquifer system during high stands of sea level. These data do not provide good evidence for the upwelling of brackish or saline water from a deeper aquifer system, such as the Floridan, but some contribution from a deeper aquifer cannot be ruled out.

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South Florida Ecosystem Restoration Outreach and Strategic Communication

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Public outreach is a process by which interested and affected individuals, organizations, agencies and governmental entities are informed of a project and its goals, and have the opportunity to participate in the decision making process. Public outreach supports the exchange of ideas and information among interested individuals and groups, which is critical to resolving the challenges involved in implementing the CERP. Outreach also creates and builds partnerships, involves the community, helps form mutual understanding, engenders trust, reduces conflict, and ultimately leads to a more complete project. Public outreach activities for CERP have a number of goals:

- Increase general public awareness and support for the CERP with effective outreach activities, including environmental education
- Involve stakeholders, agencies, tribes and other interested communities in the CERP decision making process to incorporate public values into the program
- Develop and implement outreach strategies to better serve minority communities, persons with limited English proficiency, and socio-economically disadvantaged individuals
- Provide focused outreach activities for traditionally under-served communities, especially those that may be affected by the project
- Improve the substantive quality of decisions as a result of public participation
- Increase trust in public institutions
- Reduce conflict among interested and affected parties by building agreement on solutions to emerging issues
- Provide effective internal communications and support for individual project teams to increase efficiency and provide support and guidance for project-level public participation activities

In addition to these outreach goals, federal and state laws and agency policies also require the Corps of Engineers and the South Florida Water Management District to provide effective public participation in the implementation of the CERP. These include the NEPA, the Federal Advisory Committees Act (FACA), the WRDA 2000, and the One Florida Initiative.

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Effects of Abiotic Drivers on the Distribution and Abundance of Fishes at the Marsh-Mangrove Ecotone: What are the Implications for Predator-Prey Interactions?

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The species composition of ecological communities reflects interactions among organisms as well as between organisms & the abiotic landscape they experience. At small spatial and temporal scales, abiotic conditions influence patterns of species movement and habitat use. At larger scales, abiotic factors affect patterns of species abundance and distribution. Abiotic parameters also 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 habitats.

In the southwestern Everglades, mangrove-lined creeks link freshwater marshes to estuarine habitats. In this study examined the spatiotemporal dynamics of fish communities along the upper Shark River in Everglades National Park, where conditions are oligohaline to mesohaline. Ten sites in the tidal creeks were sampled during the wet, early-dry, and mid-dry seasons of 2004-2009, utilizing electrofishing as a primary sampling methods. In particular, we focused on the response of different functional groups to seasonal hydrological conditions (e.g., marsh water levels and salinity).

Our results show that fish abundance varies markedly yearly and seasonally in response to hydrological conditions, but functional groups are affected differently. Marsh fishes move into estuary in the dry season, locally increasing prey and predator abundance, but limited to the upper estuary, perhaps by salinity. Marine and estuarine predators seem to move to the upper estuary matching increases in freshwater prey, but appear limited by oxygen conditions. Freshwater prey taxa make large contributions to the prey base in the dry season, and their abundance is negatively related to marsh water levels.

Our 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 respond spatially and temporally to abiotic conditions. Increases in freshwater inflows into the southern Everglades may affect this linkage by prolonging the pooling of freshwater in upland marshes and changing abiotic conditions at the ecotone.

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Effect of Water Management Changes to the Stage-Discharge Relationship in Upper Taylor Slough

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Taylor Slough, the most significant natural drainage feature in the eastern part of Everglades National Park, provides important habitat for a number of species and is an essential source of freshwater to Florida Bay. Water flow in the Slough is strongly influenced by water management activities in the 2 major drainage canals that border the Park, the L31W and C-111. Operations in these canals have a strong influence on the slough and impact freshwater flows and resultant salinities in Florida Bay.

The U.S. Geological Survey (1960-1985) and Everglades National Park (1985-present) have taken flow measurements at the intersection of Taylor Slough and the main park road (SR 9336) for the past 50 years. The two agencies have collected more than 600 discharge measurements spanning the various water delivery schemes including the excavation of the L-31W canal in1968, the installation of the S332 pump station in 1981, increased capacity at S332 in 1992, and the relocation of the pump to the S332D in 2000, which takes advantage of the acquisition of the Frog Pond agricultural areas as it delivers water to Taylor Slough.

The purpose of this investigation is to examine the changes in discharge relative to stage and rainfall at the Taylor Slough flow section over the 50 year period of record. The analysis includes spatial and temporal alterations in flow distribution. Results indicate that discharge in upper Taylor Slough relative to rainfall and stage has been influenced by water management activities in the L31W basin and beyond. Interestingly, increased flows per unit rainfall beginning in 1993 have coincided with slight decreases in flow relative to water level in the slough. Analyses of other changes, such as the increased gradient between Taylor Slough and the C-111 Canal and the installation of new bridges and culverts that have also affected these relationships are presented.

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Comparison of Everglades Slough Vegetation Hydrologic Suitability from Scientific Literature, and Experimentally Determined Plant Species Responses, with Natural System Model Hydrology

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We examined the ability of hydrologic computer models to simulate natural hydrologic conditions representative of the pre-drainage Everglades ridge and slough landscape.

Pollen cores and seed core data collected in the central Everglades indicate that vegetation communities within the ridge and slough habitat of the central and southern Everglades shifted from water lily sloughs (Nymphaea odorata) to sawgrass (Cladium jamaicense) dominants following drainage of the Everglades. Extensive historical accounts describe a landscape dominated by water lily. Historical accounts of observed water depths are also consistent with the presence of white water lily. Therefore, white water lily is considered representative of pre-drainage slough plant communities in the ridge and slough landscape.

Simulation models of the regional pre-drainage hydrology help us to understand the natural processes that created and maintained the Everglades ridge and slough habitat. The hydrologic conditions needed to support the historical vegetation communities and form peat soils can also be determined experimentally. While models often allow us to examine a longer and more varied climate/hydrologic record than can be evaluated through experiment, all simulation models have uncertainty, errors and bias in their predictions. As a result, model simulations alone are not recommended as target conditions for ecosystem restoration. Experimentally determined plant community hydrologic suitability for water depths, drydown frequency and hydroperiod greatly increase our confidence in hydrologic restoration targets.

Altered water flow and hydropatterns, caused by compartmentalization of the landscape with levees and canals, and managed water depths, have increased the frequency of dry-outs in the historic ridge and slough landscape. This drying of the organic soils results in subsidence, through soil oxidation. Sources of uncertainty, and key differences between some natural system models, are the estimated pre-drainage (pre-subsidence) topography and several other input parameters which will be discussed in detail.

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Characterizing Plant Community Hydrology Using the Everglades Depth Estimation Network

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Data on plant community hydrologic requirements are often limited in spatial and/or temporal extent and frequently use either a single species or a limited set of hydrologic parameters to define community optima and tolerances. Combining remote sensing techniques that classify and map plant communities across large spatial extents with hydrologic models that can increase temporal extent has the potential to more clearly define plant community hydrologic requirements. We have used points in WCA 2A that have known elevation and whose vegetation has been classified by three methods (visual observation, photointerpretation and remote sensing) to test the feasibility of this approach. We used the elevation data to correct hydrologic parameters generated by the Everglades Depth Estimation Network (EDEN) for 9 years of data. We determined hydrologic parameters for sawgrass (MFGc), cattail (MFGt), open marsh (MFO), freshwater floating emergent marsh (MFF) and swamp shrub (SS) communities.

The length of the hydrologic record let us determine a number of biologically important hydrologic parameters for each community type. Rather than defining yearly averages, we calculated the number and length of wet and dry events, the number and percent of days wet and of days dry, the average length of wet events and of dry events, the average water depth when the locations were wet and when they were dry, and the maximum water depth during wet events and minimum water depth during dry events. Because repeated wetting and drying represents a unique hydrologic stress, we also calculated a Dry Event Index (DEI) that allowed us to compare sites for the amount of wetting and drying they experienced; the DEI equals the number of dry events divided by the number of years being analyzed. This index is > 1 if the site dries and re-wets on average more than 1 time per year, and it is < 1 if the site does not dry out on average once every year.

Our data showed that the open marsh and freshwater floating marsh closely resembled each other in hydrology, having the longest hydroperiods, fewest dry events, and greatest water depths. The cattail community was intermediate between the open marsh and sawgrass communities for most hydrologic parameters, but differed in maximum water depth and mean water depth. For maximum water depth, the cattail mean and median exceeded the open marsh values, and for mean water depth, cattail mean and median values more closely resembled sawgrass. Sawgrass and the swamp shrub communities occupied shallower, drier sites, although the sawgrass hydrologic means and medians were longer and deeper for wet events and shorter and wetter for dry events. Both the open marsh and freshwater floating marsh communities had mean DEIs of 1.1 and median DEIs < 1, while the sawgrass and cattail communities had means and medians > 1. None of the swamp shrub sites had a DEI < 1.

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The Public Face of Everglades REMAP 2005: An Interactive Mapping Application for Sampling Data Retrieval of the 2005 Everglades Ecosystem Assessment Program

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The Environmental Protection Agency's Region 4 Everglades Ecosystem Assessment Program, or Everglades Regional Environmental Monitoring and Assessment Program (R-EMAP), has been monitoring ecosystem health in southern Florida since 1993. The Everglades R-EMAP goal is to provide critical, timely scientific information that is collected throughout the ecosystem to managers. The program uses a probability-based sampling design, samples a variety of media, and has extensive spatial coverage (2,063 mi^2 of freshwater marsh in 2005). Everglades R-EMAP has had three major iterations that sampled a suite of biogeochemical parameters, while biological parameters were added in the last two iterations. The datasets collected for REMAP 2005 include biogeochemical (surface water, pore water, floc and soil nutrients and mercury concentrations), fish, invertebrate, periphyton, and plant data collected at 232 sites, with sampling spread between the spring (biogeochemical and plant data) and fall (entire suite of parameters). Photographs that provide a general overview and impression of each site are associated with the biogeochemical and biological samples. In addition, vegetation in the square km centered on the sampling point were mapped from aerial photographs.

In order to make this data widely available to both the scientific community and general public, Florida International University's Geographic Information Systems and Remote Sensing Center has created a central repository that provides long-term storage of the project's data in an enterprise database and a website that provides easy and quick access to retrieve and visualize that data (http://digir.fiu.edu/gmaps/EverMap.php). This data management and access system is designed to allow easy integration of new sample data as it becomes available and thus provides a framework for future sampling iterations. The database has a spatial data layer of point features that provide access to the spatial component of the data for retrieval and visualization purposes. All other data are stored in attribute tables related to the sample locations. The website has an interactive map based on the Google Maps API; this map provides a selectable satellite, map or hybrid (satellite & map) background, with indicators for each R-EMAP data site superimposed. Users can access data and site-specific photographs by clicking on a particular site on the map. Data forms allow the user to select multiple attributes to appear in a report, or to select a single attribute whose values are then mapped on the interactive map. The data form also allows users to filter the data based on one or more attributes. When individual sites are enlarged on the map the photo-interpreted km^2 is displayed around each site. Finally, while allowing ready access and visualization of a variety of data and images for professionals, the website also displays ancillary photographic and video material that can appeal to a wider audience

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Temporal and Spatial Patterns of Juvenile Pink Shrimp, *Farfantepenaeus duorarum*, in South Florida Estuaries

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As an important ecological and commercial species dependent on south Florida estuaries, the pink shrimp, *Farfantepenaeus duorarum*, has been establishedis a as a biological indicator of estuarine responses to the Comprehensive Everglades Restoration Project (CERP). Estuaries downstream from CERP will be affected by changes in the quantity, timing, and distribution of freshwater inflows; changes in estuarine salinity regimes and subsequent, longer-term changes in benthic vegetation are anticipated. Juvenile pink shrimp are ubiquitous in south Florida coastal waters where they are and are strongly associated with seagrasses benthic vegetation. Thebeds. The relation of pink shrimp with salinity, based on long-term data from western Florida Bay and laboratory experiments, indicatessuggests that water management will affects inshore shrimp juvenile pink shrimp abundance. With the regional perspective provided by the South Florida Fish and Invertebrate Assessment Network (FIAN), field observations to date show that shrimp abundance in relation to salinity is more complicated than previously thought.

The South Florida Fish and Invertebrate Assessment Network (FIAN) is a monitoring element of CERP that supports the pink shrimp indicator by quantifying change and trend in juvenile density in relation to habitat and environment. FIAN includes 19 sampling locations, among which are six pink shrimp performance assessment areas, distributed among three south Florida regions: Florida Bay (8 locations), Biscayne Bay that includes Card and Barnes Sound and Manatee Bay (7 locations), and the southwest mangrove coast that includes Whitewater Bay (4 locations). A 30-cell sampling grid of equally sized hexagonal cells defines each location; grid size differs among locations. Within each cell a single randomly located 1-m^2 throw-trap sample is used to collect seagrass-associated faunaish and shrimp, including the pink shrimp, and crabs. Five separate passes with a 1-m wide sweep net samples the throw-trap. Each sweep is processed separately providing a removal sample of the animals initially trapped in the throw-trap. Water depth, salinity, water temperature, turbidity, sediment depth, and SAV are measured with each throw-trap sample.

Both pink shrimp and seagrass habitat exhibit distinctive patterns across south Florida estuaries. The pink shrimp is most abundant in the euhaline salinity regime of western Florida Bay and next in abundance in the mesohaline salinity regime of Whitewater Bay. Patterns of abundance in south Florida estuaries reflect regional differences in late summer/early fall in-migration of pre-settlement postlarvae. Seagrasses are distinctively sparse to absent in the southwest region while well developed seagrass beds characterize the Florida Bay and Biscayne Bay regions.Hierarchical modeling is used to analyze the removal sample (consecutive counts) of pink shrimp from each throw-trap. The multilevel model formally accounts for the sampling design, whi

Performance of the pink shrimp indictor varies both spatially and temporally. Inshore salinity and habitat conditions may influence the current status of the pink shrimp as compared to historical data. The unavailability of sufficient historical record at four of the six assessment areas limits interpretation of the pink shrimp's response to salinity and habitat in relation to the historical record for these areas. A primary objective of FIAN is to extend the historical record.

The abundance of pink shrimp occurring under both mesohaline and euhaline conditions suggest the need for further research to better interpret pink shrimp response to the changes in salinity expected with Greater Everglades restoration. Laboratory experiments are ongoing.ch includes removal counts from each throw-trap (n=5), the clustering of observations within each location (n=30), and stratification of locations (n=19) between mangrove and seagrass-dominated regions. Our goal is to estimate "true" shrimp abundance and to quantify associations between shrimp and salinity and benthic habitat while accounting for unobserved sources of variation in abundance and capture rate.

FIAN provides the first regional view of the distribution of the pink shrimp in South Florida. The density of juvenile pink shrimp varies regionally, from location to location, and seasonally, being most abundant in the fall. Pink shrimp abundance is greatest in Johnson Key Basin in western Florida Bay. Estimates of pink shrimp density are comparable among sampling locations and years. Variation in benthic vegetation, salinity regime, and accessibility to settlement-stage larvae are thought to account for density differences among locations, although this needs confirmation.

- FIAN provides the first regional view of the distribution of the pink shrimp in South Florida, where densities vary by location and regionally.

- FIAN provides estimates of mean density, spring and fall, for the pink shrimp performance measure, evaluating the effect of CERP in South Florida estuaries.

- Removal sampling, an integrated element of FIAN, improves estimates of shrimp abundance by accounting for unobserved sources of variation in abundance and capture rate.

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Mercury in Sentinel Fish from Coastal Regions of the Greater Everglades

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The Comprehensive Everglades Restoration Plan (CERP) anticipates changes in freshwater delivery to the coastal marine environment. These delivery changes are likely to alter already high mercury concentrations in coastal marine fish in south Florida through both changes in mercury deliveries and the coastal processes that may enhance mercury bioavailability.

We monitored mercury concentrations in several species of coastal marine fish from 13 regions stretching from the Indian River Lagoon on the Atlantic coast to San Carlos Bay on the Gulf coast. Over the three years of the study, the primary sentinel species were gray snapper (*Lutjanus griseus*) and crevalle jack (*Caranx hippos*). Historical concentrations of mercury in these species were also gathered to provide a reference database establishing a baseline against which to measure changes resulting from CERP projects as they go online. Comparable efforts were made in freshwater parts of the Everglades, but are not reported here.

We analyzed 1958 sentinel fish from the coastal marine environment. In addition, 1229 fish of the same species were in the historical database from the same region. For both crevalle jack and gray snapper, the contiguous regions at the south end of Florida, Biscayne Bay, Card and Barnes Sounds, Florida Bay, and Whitewater Bay exhibit the highest mercury concentrations in sentinel fish. In these regions, average mercury concentrations in crevalle jack exceeded 0.7 ppm, above the Florida level of concern of 0.5 ppm. Mercury concentrations in gray snapper were about three-fold lower, but well above the 0.1 ppm criteria of the EPA for wildlife protection. These are regions of limited circulation, freshwater input, and flushing. As such, these regions are most vulnerable to changes in freshwater inflows.

Besides the differences among the regions we sampled, mercury concentrations varied with size of fish, and among sampling sites within regions. Thus, we can use statistical procedures to reduce the variability in mercury concentrations when comparing over time. We observed difference in average mercury concentrations across the three years we sampled, but without a clear temporal trend. There were sufficient historical data to explore longer-term temporal trends in only two of our regions, Florida Bay and Indian River Lagoon. We have not yet discerned any change in mercury concentrations in data going back to 1989.

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Movements, Habitat-Use, Thermal Biology, and Diet of Burmese Pythons in the Everglades

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Native to Southeast Asia, Burmese pythons (Python molurus bivittatus) are a recently-established invasive species in south Florida. Burmese pythons are generalist predators that consume a wide variety of mammal and bird species, as well as reptiles, amphibians, and fish. The purpose of this project is to provide science support to develop control measures for Burmese pythons and to evaluate impacts of pythons on native biological diversity. We are using radio telemetry to determine habitat use, extent and timing of movements, and find aggregations of pythons during the breeding season, and surgically-implanted temperature data-loggers to characterize thermal biology of pythons at-large in Everglades. We also carry out investigations on the diet of Burmese pythons, using gut-content analysis.

Since December 2005, 23 adult pythons have been captured and surgically implanted with VHF radio transmitters in Everglades National Park. Distances traveled by pythons varied from shorter movements of several hundred meters associated with breeding, to larger distances resulting in movement rates of as much as 1.7 km/d. The unique dispersal capabilities of Burmese pythons and affiliation with water indicate that effective management of the rapidly expanding python population in south Florida requires cooperation and involvement of all land managers and relevant agencies. Thermal biology profiles showed the longest periods of basking during winter months, which may allow for increased visibility of pythons for control efforts. Gut content analyses allowed for identification of hair, bone, and teeth of prey species in the digestive tracts of Burmese pythons. To date, we have detected the presence of fifteen species of mammals, twenty-three species of birds, and alligators, including several federally- listed species.

Finally, in January 2010, we had 10 radiotagged/implanted pythons at-large in the Everglades. During the extremely cold weather of January 9-11, nine of 10 radiotracked pythons died. Thermal profiles showed regular fluctuations in body temperature (Tb) for all nine snakes before the extremely cold two-day weather event, and then irregular fluctuations after the cold event and before death. Knowledge gained from radio-telemetry, diet, and thermal studies will be used to work towards our primary goal of developing control methods for Burmese pythons.

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The Northern African Python (*Python sebae*) in South Florida

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Invasive Burmese Pythons (*Python molurus bivittatus*) are established across a large area of south Florida, including the majority of the Everglades. Individuals of several additional species of giant constrictors (including Green Anacondas *Eunectes murinus*, Reticulated Pythons *Broghammerus reticulatus*, and Boa Constrictor *Boa constrictor*) have been discovered at intervals in south Florida, but of these only the Boa Constrictor was known to have established a small reproductive population in south Miami. However, between 2002 and December 2009, there were seven specimens or credible sightings of the Northern African Python (*Python sebae*) along the western verge of Miami. This large python is closely related to the Burmese Python, and observations were alarmingly close to the eastern edge of the Everglades, raising fears that a second large python might spread into natural habitats. This spatial cluster of sightings prompted the Exotic Animal Strike Team of ECISMA to organize an intensive 3-day search effort in January 2010, involving 30-55 participants per day. The search produced five adult *P. sebae*, ranging from 3.0 m to 4.4 m, from the vicinity of Krome Ave and US-41 in west Miami. Since then, several additional *P. sebae* have been removed from the same area. We evaluate effects of the January 2010 cold snap on this population, discuss characteristics of the pythons discovered thus far, and assess prospects for eradication. The January 2010 search effort can serve as a model for the use of short-term intensive survey efforts to verify an established population of a cryptic vertebrate. Recent captures of two *P. sebae* east of Sarasota may warrant a similar search effort to determine whether an additional population is present in that location. If an incipient population is identified early, then efforts can be focused on its potential for eradication before the species becomes as widespread as the Burmese Python.

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Contemplating the Fate of Fresh-water Dependent Florida Keys Ecosystems: What to Do about Species Threatened with Extinction due to Sea Level Rise?

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Within the Greater Everglades Ecosystem, fresh-water dependent Florida Keys species and the ecosystems they represent are surely those most immediately threatened by sea level rise. Isolated by long distances from the south Florida mainland and higher islands of the Caribbean, the endemic plant and animal taxa of the Keys lack feasible means of retreat to locations free from the sea's influence. Pine forests and associated wetlands are restricted to several lower Keys islands, where the presence of fresh ground water enables them to persist close to the ocean's edge, despite the intolerance of most resident species to salinity. Fire also plays a critical role in preserving ecosystem function, by controlling shrub growth, remineralizing nutrients, and promoting an open canopy structure. Fire and the pine overstory are intimately linked as pine needles are a vital component of the fuel bed. Sea level rise thus represents a two-pronged threat to these ecosystems, because it limits fresh water availability and reduces fire frequency and intensity. In response to the slowly rising seas of the last century, pine forests slowly retreated toward the center of Sugarloaf Key, leaving much of the island dominated by hardwood forests or halophytic communities. More recently, this gradual recession accelerated suddenly when prolonged ponding of storm surge from Hurricane Wilma left a salt crust on all but the most elevated surfaces. Mortality of pine trees on Sugarloaf Key and at lower elevations on nearby Big Pine Key approached 90%. In the near term, maintenance of pine forests on these islands will require carefully planned prescribed fires, as well as more intensive management actions, e.g., planting, ex-situ collections, and within-island translocations. In the longer term, with sea levels poised to rise much more rapidly during this century, the need to preserve endemic plant and animal forms will cause the conservation community to consider assisted migration to more distant locations, inside or outside the historical range of the species, as a management option. In this paper, we evaluate the current threats to the rare flora and fauna of the Keys, and employ a decision framework to explore some of the issues that assisted migration would raise.

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Linking Soils, Hydrology, and Forest Structure in Everglades Tree Islands

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Tree islands are endemic to many wetland landscapes, often comprising nutrient-enriched patches, or resource islands, in oligotrophic marshes. For a resource island to develop, the long-term balance between input and export of the limiting nutrient must be weighted toward the former. In the Florida Everglades, where phosphorus (P) is highly concentrated in tree islands compared to the surrounding marsh, several mechanisms by which P may reach the islands have been proposed; all involve positive feedbacks between the presence of trees and P input. However, less attention has been given to the soils within which P becomes sequestered, or to the influence these soils may have on forest development, which could feed back on P retention. In this study, we examined variables representing the soils, physiography, hydrology, and stand structure of 75 hardwood hammocks distributed throughout Everglades National Park and Water Conservation Area 3B. We used Principal Component Analysis to reduce the dimensionality of the physical data, and then applied regression analysis to examine the relationships of the most important of these composite factors with several structural variables that may be indicative of site productivity, i.e., basal area, biomass, and canopy height. Hardwood hammocks in the southern Everglades grow on two distinct soil types. The first, consisting of shallow, organic, relatively low-P soils that develop directly on limestone bedrock outcroppings, is common in tree islands in the seasonally-flooded Marl Prairie landscape. In contrast, hammock soils on islands embedded in long hydroperiod marshes in the central Everglades peatland are deeper, with much higher mineral content, alkaline pH, and extremely high P concentrations. Though PCA Factor 1 was largely defined by soil P, this composite variable was unrelated to all measures of forest structure, as was Factor 3, defined by mean annual depth to water and tree island height. Factor 2, representing the non-carbonate component of the mineral soil fraction, exhibited a strong positive relationship with canopy height. Our data show that Everglades tree islands vary by orders of magnitude in the concentration of P, the resource limiting production in the landscape as a whole. However, the data also suggest that, beyond a certain stage of forest and landform development, and beyond a threshold concentration of P, tree island production becomes insensitive to this variation, and hence limited by other resources.

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Factors Affecting Exotic Fish Distribution at Babcock Ranch, Charlotte and Lee Counties, Florida

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Fish and aquatic macroinvertebrate communities were monitored across the 91,000+ acre Babcock Ranch between October 2006 and February 2010. A total of 31 sites, 24 of which are water quality sampling stations were sampled three times per year to document seasonal fluctuations in community structure. These sites include: cypress strands, cypress domes, marshes, drainage ditches, and small streams. Sampling methods were adopted from the baseline assessment of aquatic fauna for the Picayune Strand Restoration Project (PSRP 2005). Ten clear plastic fish traps (Breder 1960) were deployed for one hour at each site to sample fish communities. Supplemental fish sampling was also conducted using dip nets, seines, modified crayfish traps, and cast nets in order to build a complete species list for each site. A total of 26 fish species, representing 14 families have been collected including seven non-indigenous (exotic) fish species from four families. The most dominant species in terms of total abundance were the native eastern mosquitofish (*Gambusia holbrooki*; Poeciliidae) and the invasive exotic jewelfish (*Hemichromis letourneauxi*; Cichlidae).

As an invasive species, *H. letourneauxi*, relies on stochastic events, such as floods for migration and spawning activity and to expand its distribution. Over decades, anthropogenic activities including construction of canals and agricultural drainage systems at Babcock Ranch have altered natural hydropatterns and facilitated the expansion of invasive fishes, especially the jewelfish. While disturbance and other factors aid invasive fish species, others environmental factors limit their distribution and abundance. These environmental factors include 1) limited cold tolerance of tropical and subtropical species that ultimately limits their northern distribution in peninsular Florida and 2) seasonal dry-down in wetland habitats. To better understand patterns of invasive fish movements and distribution across the Babcock Ranch watershed we are modeling the effects of hydrologic and cold weather events and their effects on fish community structure and distribution. The model is currently being field calibrated using fish sampling data collected prior to and immediately after floods, seasonal dry-down, and extended cold weather events between 2007-2010.

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A Compartmental Screening Model for Stage and Water Quality in a Large Everglades Wetland

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The Simple Refuge Screening Model (SRSM) version 4 simulates coupled hydrodynamics and water quality within the 58,000-ha Arthur R. Marshall Loxahatchee National Wildlife Refuge. The SRSM is implemented using the ordinary differential equations solver Berkeley Madonna (www.berkeleymadonna.com). The compartment size and arrangement in version 4 are identical to earlier versions of this model, whereas the constituent modeling approach has become more refined. Concentrations are calculated for chloride as a conservative tracer, sulfate using a Monod relationship, and total phosphorus dynamics as described by Walker and Kadlec in their Dynamic Model for Everglades Stormwater Treatment Areas (DMSTA).

Stage and constituent concentrations modeled by the SRSM are comparable with observed data from the marsh and canal areas of the Refuge. However, the generalized and spatially aggregated scheme used in the SRSM allows for only average assessments of large areas. Because of the limitations of this highly aggregated model, the SRSM has been developed as a component in a suite of models used for various applications concerned with Refuge restoration and management. We conclude that the SRSM and similar approaches is of great value in many applications, but must be applied with judgment and technical understanding of the limitations of spatially aggregated modeling. Additionally, we find that the relative flexibility and speed with which this model can be applied and modified allows it to lead and instruct development of our more complex spatially-explicit model.

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Everglades Invasive Species Early Detection and Rapid Response Plan: A Coordinated Framework of Partners and Procedures

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The Everglades Cooperative Invasive Species Management Area (ECISMA) is a formal partnership of Federal, State, and local government agencies, tribes, individuals and various interested groups that manage invasive species within the greater Everglades area. An early detection/rapid response (EDRR) plan was developed in 2009 to provide a conceptual design, framework, and set of strategies to respond to new biological invasions within the ECISMA through a coordinated framework of partners and processes. The plan provides many pre-determined management responses, and establishes a decision-making infrastructure that will facilitate rapid resolution of response issues. The plan contains a number of objectives and related tasks, along with a rapid response action planning protocol. The rapid response action protocol is evolving after consideration of several real-life rapid response scenarios for several new invasive species, including the northern African python (*Python sebae*), tegu lizard (*Tupinambis* spp.), or Kripa (*Lumnitzera racemosa*).

Successful ECISMA EDRR procedures will include: (1) a thorough and efficient detection system combined with immediate implementation of control/eradication measures for known invasive and deleterious species; (2) a monitoring system for priority species known to be invasive so that new introductions can be detected in a timely manner; (3) emergency funding for a rapid response from the existing control programs; (4) a mechanism to provide funding, authorized staff, permits, and other resources needed for immediate response to invasive species which do not fall within an existing control program; (5) a reporting system for invasive species observations by the public; (6) a designated pool of experts and risk managers to quickly decide whether a newly discovered, potentially harmful invasive species deserves rapid response; (7) a system for smoothly transitioning to ongoing control from rapid response efforts when eradication has failed or when the species is discovered to be wider spread than initially believed; and (8) an adaptive management system so that lessons learned from past efforts guide future activities. Invasive species detection and response actions will include education and awareness about invasive species, identify research needs, and promote cooperation and partnership across government and private sector programs.

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Fine Scale Spatial Variation in Total Mercury Levels in Molluscan Bivalves from Southwest Florida

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Methylmercury production and biomagnification is known to be spatially highly variable leading to "hot spots". In South Florida, regional variability in methylmercury biomagnification has been shown from finfish surveys along the coast, done by others. The objective of this study is to use molluscan bivalves, either sedentary or with very limited home ranges, to better assess the fine scale spatial variation in mercury (Hg) availability. A secondary objective was to begin to assess the potential species-specific differences in mercury accumulation of different bivalve species including the Eastern Oyster (*Crassostrea virginica*) and Calico Scallop (*Argopecten gibbus*). While the former was principally sampled from estuaries, the latter was collected from nearshore coastal waters. The spatial patterns in measured Hg concentrations in the bivalves are also discussed in the context of results from the biomonitoring mercury in gray snapper (*Lutjanus griseus*) and crevalle jack (*Caranx hippos*) for the Comprehensive Everglades Restoration Plan (CERP). Both oysters and finfish showed a north-south gradient with higher Hg concentrations in biota collected further south in Naples Bay and the Ten Thousand Islands.
Spatial patterns in Hg bioaccumulation differed, however, among species. Some of this variation likely resulted from species-specific differences in home range size. Bivalves exhibited the greatest spatial variability while crevalle jack, with the largest home range, grouped into only two distinct regions making them better biomonitors on a regional scale; oysters are better for locating fine scale spatial patterns or "hot spots". In general, Calico scallops collected offshore contained less Hg than oysters collected from estuaries. Although species-related differences in bioaccumulation cannot be ruled out as a driver for this spatial pattern, similarities in Hg levels ($p=0.902$) in co-located bay scallops (*A. irradians*) and oysters suggests the observed pattern may reflect less mercury availability offshore.

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Source Identification of Florida Bay's Methylmercury Problem: Mainland Runoff versus Atmospheric Deposition and *In situ* Production

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The first advisory to limit consumption of Florida Bay fish due to mercury was issued in 1995. Studies done by others in the late 1990s found elevated water-column concentrations of both total Hg (THg) and methylmercury (MeHg) in creeks discharging from the Everglades, which had its own recognized mercury problem. To investigate the significance of allochthonous MeHg discharging from the upstream freshwater Everglades, we collected surface water and sediment along two transects from 2000 to 2002. Concentrations of THg and MeHg, ranging from 0.36 ng THg/L to 5.98 ng THg/L and from <0.02 ng MeHg/L to 1.79 ng MeHg/L. On average, dissolved (<0.45 µm) forms accounted for 80% and 73% of the THg and MeHg, respectively. Water-column concentrations of THg and MeHg were elevated in the mangrove transition zone when compared both to upstream canals and the open waters of Florida Bay. Concentrations were highest during the summer wet season. Sediment concentrations ranged from 5.8 to 145.6 ng THg/g and from 0.05 to 5.4 ng MeHg/g, dry weight. MeHg as a percentage of THg was occasionally elevated in sediments from the open bay (up to 8% at one site). ^{202}Hg methylation rates in intact cores were also elevated, as high as 15% day^{-1}, in sediments from the open bay. These data indicate that MeHg bioaccumulation in the bay may be driven, in part, by *in situ* production. Assessment of mass loading suggests that canals delivering stormwater from the northern Everglades are not as large a source as direct atmospheric deposition and *in situ* methylation, especially within the mangrove transition zone. However, the weighted average Hg methylation rate in the sediments of the transition and open areas of Florida Bay cannot be calculated with the required accuracy to complete the mass budget with the available data, so these semi-quantitative inferences need to be supported with a more spatially intensive, multi-year study spanning these areas.

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Spatial and Temporal Patterns in Mercury Concentrations in Blood and Hair of Florida Panthers (*Puma concolor coryi*): 1978 – 2007

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The Florida panther *(Puma concolor coryi)* is a federally listed endangered species occupying the Everglades and Big Cypress ecosystems of southern Florida. Environmental stressors, including environmental contaminants, low genetic variability and habitat loss may have contributed to the decline of this sub-species. The Florida Fish and Wildlife Conservation Commission (FFWCC) has monitored mercury (Hg) levels in the Florida Panther since 1978. Hair and blood were collected for analysis through live capture and liver, brain, muscle and kidney were collected during necropsies of salvaged dead cats. Concurrently, other metrics including body condition, genetic defects as a result of low genetic variability, blood chemistry analysis and reproductive success were also assessed as part of a larger investigation on the impact that various environmental stressors, many stemming from habitat loss and fragmentation, are having on the health of individuals and, as a consequence, the population. All recently collected blood samples (2000-2007, n =158) had measureable amounts of mercury, with concentrations ranging from 0.009 mg/kg to 5.3 mg/kg. Likewise, all recently collected hair samples (2000-2007, n=321) had measureable concentrations of mercury, with values ranging from 0.086 mg/kg to 100 mg/kg. These data demonstrate that while average Hg levels have decreased in panthers in most areas, some individuals continue to attain high mercury burdens. Equally disturbing is an apparent increase in mercury levels, albeit small, in panthers from certain areas. Here we will evaluate spatial and temporal patterns in hair-Hg and blood-Hg over the period-of-record and examine hydroperiod as an explanatory variable as it relates to methylation potential and habitat quality for prey species.

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Recent Vegetation Changes in Taylor Slough, Everglades National Park

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Ongoing vegetation monitoring in Taylor Slough, Everglades National Park (ENP), Florida, initiated in 1979, has shown that natural and anthropogenic changes in hydrology can rapidly result in changes in dominant vegetation cover. Monitoring data have provided resource managers with a means of tracking changes in wetland plant communities within an ecologically sensitive and frequently visited area of ENP. We analyzed vegetation monitoring data from the last 7 years in Taylor Slough and compared vegetation changes to changing hydrology. We present general trends in vegetation cover, species occurrence, and the initial appearance and subsequent expansion of cattail (*Typha domingensis*) and other previously undocumented plant species immediately adjacent to water management structures and detention areas on the boundary of ENP. In addition to providing a long-term dataset for evaluating the influence of existing watershed management features on ENP plant communities, results may also be informative in refining expectations of the influence of proposed features on similar communities.

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Changing Cape Sable Seaside Sparrow Habitat Conditions in Marl Prairie Landscape and their Implications for Everglades Restoration

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Cape Sable seaside sparrow (CSSS), a federally listed endangered species, has been a pivot point for water management operations in the Everglades for a decade or more. The species, originally described from brackish coastal marsh habitat, currently inhabits freshwater short hydroperiod marl prairies present on both flanks of the Shark River and Taylor Sloughs. Its marl prairie habitat has gone through many transitions in hydrologic and fire regime due to management-induced changes in water flow pattern in the southern Everglades. Such changes in habitat conditions during 1990s resulted in an unexpected decline in sparrow population in four of six sub-populations. With a goal of understanding response of landscape-level processes to hydrological restoration, we have been monitoring vegetation structure and composition throughout the marl prairie landscape. We first characterized vegetation structure and composition in relation to existing hydrologic regime and fire history during 2003-2005, and subsequently assessed vegetation change by re-sampling the sites during the next four years (2006-2009). Patterns of vegetation change within the sparrow habitat were spatially differentiated, primarily responding to variable hydrology and its interaction with fire events. East of the Shark Slough, vegetation in the southwestern edges of sub-populations B and E was indicative of slightly wetter conditions, and in a part of sub-population B, post-fire flooding changed the vegetation recovery trajectories. West of the Shark Slough, the vegetation in the eastern part of sub-population A showed a drying trend, while vegetation in the extreme west became wetter in the late 2000s than earlier in the decade. This spatial pattern in sub-population A was consistent with a change in the hydrologic regime estimated from EDEN data and a recent trend of convergence of water levels between P-34 and NP-205 stage recorders. The wetting trend in the western part of sub-population A is indicative of deteriorated sparrow habitat, and it continued despite achievement of the mandated regulation water levels at NP-205 ($\leq$ 6 ft NGVD for a minimum of 60 consecutive days between March 1 and July 15). Wetter conditions in western sub-population A appear to be the result of increased flow across the Forty Mile Bend-Monroe Station section of the Tamiami Trail. Since the management strategies aimed at maintenance of simply NP-205 stage is inadequate to restore the vegetation throughout the recent range of CSSS in sub-population A, formulation of strategies that are in compliance with the ecosystem-wide restoration goals of CERP and would also achieve desired water levels at NP-205 during sparrow's breeding season while reducing stages in prairies further west is needed to improve conditions for the sparrow.

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Understory Vegetation Composition and Biomass on the Tree Islands in the Loxahatchee Impoundment Landscape Assessment (LILA) Experimental Site

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Maintenance and restoration of ecologically imperiled tree islands are one of the major objectives of Everglades Restoration. With a broader goal of understanding the effects on understory vegetation dynamics of spatial and temporal variation in canopy characteristics in a developing forest, we initiated long-term vegetation study in Loxahatchee Impoundment Landscape Assessment (LILA) experimental site. We studied understory vegetation on eight tree islands in relation to different hydrologic (ground elevation), substrate (peat or limestone), stand density (spacing among trees) and stand age (time since plantation) conditions, sampling 192 1 m^2 plots. On each island, 6 plots were established in each of four stand densities (1, 1.67, 2.33 and 3 m spacing at planting, 2.5 or 3.5 years earlier). We used non-metric multidimensional scaling (NMDS) ordination and analysis of similarity (ANOSIM) to analyze the species composition data, and analysis of variance to examine differences in species richness and biomass between different stand ages, substrate types, and stand densities.

The results showed that species composition differed significantly between tree islands, stand age, and substrate types. Within an island, the vegetation was strongly influenced by hydrology and stand density. Vegetation composition in the high density stand (1m spacing) differed from the medium to low density stands, which did not differ among themselves. Understory vegetation was lower in cover and much less diverse in high density than in more open stands, suggesting the strong influence of planted trees on the availability of resources for understory vegetation. Like species diversity, mean understory biomass was significantly higher in open stands (2.33 and 3.0 m spacing) than in the densest stand, ranged from 222 g m^{-2} to 326 g m^{-2}. Plant diversity did not differ among islands, and did not show a significant relationship with elevation, though the species assemblages turned over completely from the bottom to the top of the slope. In summary, as in other successional studies, our results corroborate the strong influence the developing woody canopy exerts on understory vegetation. Our findings also show the spatial differentiation of this effect with hydrologic and substrate conditions similar to those experienced in Everglades tree islands. We plan to monitor these understory:overstory dynamics in the small, created LILA islands over the next few years, in the expectation that processes exhibited there will be relevant to tree island restoration efforts pursued at a larger scale in the Everglades.

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Everglades Based College Level Field Courses: A Way of Utilizing the Living Laboratory for Educating Floridians on Ecosystem Services

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Promoting people's exposure to ecosystem services that the Everglades can provide is critical to public support for the success of Everglades Ecosystem Restoration Plan (CERP). This presentation reviews the benefits of field-based instruction, particularly its implementation to the study of ecology of South Florida at Florida International University. It suggests that direct observation and hands-on learning associated with field-based instruction raise students' level of interest as well as improve their perception concerning long-term preservation of the Everglades ecosystems.

The topics covered are as dynamic as the changing Everglades, the historical use and evolution of the Everglades as well as changes in land-use and urban sprawl. Practical experience gained by students leads to increased awareness regarding the level of degradation of the Everglades. For instance, students are able to experience firsthand the effect that invasive species such as Burmese python and *Lygodium* have had on the Everglades ecosystem. It is a living classroom where students examine the current ecosystem problems and evaluate the Everglades Restoration Plan, applying knowledge gained from a variety of disciplines, such as chemistry, biology, economics, and architecture. This approach of teaching leads to a more relatable experience which serves to enhance relevancy of the materials presented in lecture courses. The successes of these strategies are effectively demonstrated by the Ecology of South Florida Lab field course (EVR 3013L) offered in fall, spring and summer semesters at the Florida International University. This course is an introduction to the plants and animals of South Florida, their natural habitat, and the ecological processes supporting their subsistence. This lab course complements the lecture course Ecology of South Florida (EVR 3013) and includes six field trips throughout the semester. By the end of the semester, students are expected to be competent in recognizing the major biological communities of South Florida, characteristic species found in each habitat, and the biological and physical factors that affect them.

In addition, the planning, implementation, and evaluation strategies are provided and outlined in a customized guide for instructors at Florida International University as well as instructors interested in organizing or improving a field course at their learning institution.

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Development of a Hydrological Budget for Shark River Slough, Everglades National Park for the Period 2002-2008

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A monthly and annual water budget has been created for Shark River Slough (SRS) within the Everglades National Park (ENP) over 2002-2008. Inputs considered are surface water inflows via water delivery structures (S12s and S333) and precipitation, while outputs consist of evapotranspiration, discharge to the Gulf of Mexico (Lostman, Shark, Broad, Harney and North rivers) and seepage losses from the eastern part of the slough under levee L31. Using a mass balance approach, monthly change in volume of SRS (from water level changes) is equated to the sum of inputs, outputs and a residual term, that includes error in each of the inputs and outputs as well as net groundwater exchange. Seepage losses have been estimated from an algorithm that takes the groundwater head differential across the levee and regresses that with seepage estimates obtained by the model MODBRANCH. Evapotranspiration (ET) has been estimated using the vapor transport-based Shuttleworth Penman Monteith model using meteorological data from the 4 eddy covariance towers located in ENP, with a sinusoidal function included to constrain dry season ET values due to plant water stress caused by soil moisture deficits or salinity in groundwater along the coast. Results for 2002-2008 indicate that precipitation is the largest input to the SRS, while ET is the largest output, with ET being equal to or greater than precipitation. A net groundwater discharge to freshwater flow is seen and this supports earlier hydrological and geochemical findings of coastal groundwater discharge in the mangrove zone. The small quantity of inflows relative to precipitation and ET highlights the necessity of gradually increasing surface water inflows to restore ecosystem processes in terrestrial, freshwater and marine portions of the ENP.

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Water Utilization in Woody Plant Communities in the Everglades Indicates that Hardwood Hammocks are the Most Hydrologically-Sensitive

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Hardwood hammock forests in the ENP are composed of neotropical flood-intolerant tree species, and occur only on the smattering of limestone outcrops always above the water table: tree islands in the Shark River Slough and the Miami Rock Ridge. Hammock plant communities are thought to consolidate their position in a flooded landscape by formation of a litter-based unsaturated soil horizon over limestone bedrock, from which they may also access water and nutrients. Using stable isotopes of water ($\delta^{18}O$ and δD), we examined seasonal variation in water sources of 3 woody plant community types: hammocks, pine rocklands and swamp forests. Hammocks on the rock ridge were found to rely upon a mix of rainwater (60-80%) and groundwater (20-40%) in the wet season; rainwater being trapped in the above-mentioned soil layer. They use increasing amounts of groundwater in course of the dry season, with almost 90% by late dry season. They also get water stressed over the dry season, as seen from an earlier study on leaf water potential, and in this study from the stable isotope of carbon ($\delta^{13}C$) in leaves. This suggests that the falling water table redirects active roots downward, or reactivates roots which were probably dormant while inundated, leading to greater fraction of groundwater uptake; at the same time the existence of limestone bedrock implies a limited set of pathways for roots to tap groundwater. Hardwood hammocks on tree islands have a similar rainwater-regional (ground and marshwater) utilization pattern in the wet season that shifts to greater regional water usage in the dry season. Unlike rock ridge hammocks, tree island hammocks do not show signs of water stress in the dry season, ostensibly due to a longer period of water availability in the slough. This is also seen in species composition with the presence of deciduous trees such as *Lysiloma latisiliquum* in the rock ridge. Nutrient acquisition being coupled with water uptake, we see that hardwood hammocks have higher foliar P than adjoining pine rockland and swamp forest communities on the ridge and tree islands respectively, with greater foliar P levels in tree island hammocks over rock ridge hammocks once again suggesting a longer period of water uptake in tree islands. We thus suggest that hardwood hammocks on the ridge are susceptible to drought stress caused by lower than normal water levels, indicating a similar fate for tree island hammocks upon further lowering of the water table during droughts. Reliance upon groundwater for part of the year also suggests further stresses in the event of increased salinity due to salt water intrusion/sea level rise.

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Ecosystem CO_2 Exchange in Short- and Long-Hydroperiod Everglades Marshes

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Wetlands are among the most productive ecosystems in the world, but little is known of long-term carbon dioxide (CO_2) exchange in tropical and subtropical wetlands. Extremely high rates of primary production have been reported in the freshwater marshes of the Everglades. Past studies of productivity have focused on individual ecosystem components, so there is limited knowledge of the magnitude and direction of CO_2 fluxes in Everglades marshes. Hydroperiod and active water management are key factors determining productivity, thus CO_2 exchange, in these marshes and both are expected to change in the future as Everglades restoration proceeds.

To evaluate CO_2 exchange and its response to seasonally changing water levels in the Everglades, eddy covariance towers were established in short- and long-hydroperiod marshes during 2008. The short-hydroperiod marsh is flooded for ca. five months yr^{-1} while the long hydroperiod marsh is typically flooded year-round. *Cladium jamaicense* and periphyton are key primary producers at both sites, and co-dominant macrophytes include *Muhlenbergia capillaris* at the short-hydroperiod site and *Eleocharis cellulosa* at the long-hydroperiod site. In keeping with micrometeorological conventions, negative values reported below denote CO_2 uptake by the ecosystem and positive values indicate CO_2 loss from the ecosystem.

At the short-hydroperiod marsh, the maximum rate of daytime net ecosystem exchange (NEE_{max}) varied seasonally from -5.54 µmol CO_2 m^{-2} s^{-1} in the dry season to -1.75 µmol CO_2 m^{-2} s^{-1} in the wet season. NEE_{max} was -1.91 µmol CO_2 m^{-2} s^{-1} at the long-hydroperiod site under conditions of continuous inundation. Mean ecosystem respiration (ER) rates at the short-hydroperiod site were 1.18 and 0.61 µmol CO_2 m^{-2} s^{-1} in the dry and wet seasons, respectively, while ER was 0.76 µmol CO_2 m^{-2} s^{-1} at the long-hydroperiod site. These data highlight a similarity in NEE_{max} and ER at both marshes during periods of inundation. Water depth was significantly related to half-hourly NEE at both sites ($p < 0.001$), such that deeper water reduced NEE. Evidence from the short-hydroperiod site indicated that depressed flux rates in the wet season relative to the dry season were related to the quantity of submerged leaf area, as well as a physiological response of the dominant macrophytes to flooding.

In general, fluxes of CO_2 were small at both sites relative to values reported in other wetlands, as well as expectations created by prior research conducted in the Everglades. Although wetlands tend to be highly productive ecosystems, the low rates of CO_2 exchange reported here reflect on the oligotrophic nature of Everglades wetlands. Nonetheless, these data indicate that impending changes in Everglades water management leading to longer hydroperiods and increased water depths may reduce net CO_2 uptake by these marshes. Changes in water management have the potential to substantially influence the CO_2 source/sink dynamics of these extensive wetlands.

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Why Ecophysiology Matters: Tools to Assess Invasiveness of Non-Native Aquatic Fauna in the Everglades

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Herein we provide an overview of various techniques used to assess ecophysiological attributes of aquatic fauna and discuss their use as tools to assess potential invasiveness of non-native species.

Why do we need to know an invader's ecophysiology? When a new introduction is detected, we often know little about its biology or ecology. Ecophysiology studies provide rapid assessments of physiological tolerances that can be used to estimate the potential for spread of the organism across the landscape. Ecophysiology research addresses the question "What natural barriers limit a species dispersal?" This in turn helps predict the effects of invasive species on native ones. Even for species that have been present in the Everglades for years, knowledge of physiological tolerances is also important. The Everglades is a "Living Laboratory of Change", and as habitats are restored, non-native species may be exposed to new conditions that may either hinder or facilitate their success. Together with literature surveys and studies of life-history, behaviour and ecology, research into ecophysiology lends insight into the potential invasiveness of non-native species.

Why perform studies in the laboratory? Field studies provide essential information on distribution, abundance and movement of species, and form the foundation of our knowledge regarding non-native species. However, field studies provide mainly correlative information on the relationship(s) of non-native species to environmental variables such as salinity, temperature or dissolved oxygen. By bringing non-native species into the laboratory, we can measure precisely their tolerances to specific environmental factors by holding all other variables constant.

What is measured? Traditional physiological studies focus primarily on cellular-level mechanisms (e.g., changes in hormone levels, haemoglobin levels, number of chloride [i.e., mitochondria-rich] cells). We tend to use whole-animal, integrated-response measures such as survival, growth and cessation of feeding. These measures integrate multiple responses (e.g., metabolism, blood chemistry, immunology) and provide results that are useful to natural-resource managers.

What kinds of results are found? We will illustrate results through summaries of findings from some of our recent ecophysiological work, including:

- Hypoxia (low-oxygen) tolerance of non-native cichlid species, and how it allows these species to persist in aquatic refuges during the dry season.
- Salinity tolerance of non-native fishes and reptiles, and how tolerance allows them to inhabit estuarine areas and potentially use them as "salt bridges" to access new watersheds.
- Low-temperature responses of non-native fishes, and why it may be their Achilles heel.

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Decomposition of Flocculent Detrital Organic Matter (Floc) in Everglades Ridge and Slough

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The flocculent detrital organic matter (floc) found above the peat soil surface and at the bottom of the water column in long-hydroperiod ridge and slough landscape is thought to play important roles in detrital food-webs, carbon and nutrient biogeochemistry, water quality and topographic development over large areas of the Greater Everglades Ecosystem (GEE). These ecological functions of the floc are thought to be important to the structure, function, and restoration of the GEE. In particular, the fate of slough floc following entrainment and redistribution must be determined to improve models of ridge and slough dynamics that are being used to guide restoration. The objective of this study was to determine the decomposition rates, and influencing factors, of Everglades floc in the slough, wet prairie, and ridge communities of central Water Conservation Area 3A (WCA-3A); an area that contains one of the best-preserved ridge and slough landscapes of the GEE.

A litter bag transplant study was initiated in November 2009. Floc was collected from sloughs at five sites (EDEN5, 3A5, W15, SITE64, and W14) along a northwestern to southeasterly direction (along the dominant direction of flow) along the regional hydrology gradient in WCA-3A. Litter bags were constructed of 10-µm polyester screen (nominally 20.3 x 25.4 cm) and initially filled with a known mass (nominally 500 g) of coarsely-screened (6 mm) wet floc. To simulate slough floc redistribution associated with flow in the ridge and slough landscape, litterbags containing slough floc from each site were returned to within the floc layer in the slough, wet prairie, and ridge at that site. A total of 330 litter bags were constructed and arranged with seven sampling times of three replicates at each of the three communities for the 5 sites (15 bags were used for initial analysis). Bags will be or were collected at 0, 0.5, 1, 2, 4, 6, 8, and 12 months after deployment. Floc litterbag samples will be analyzed for mass loss, nutrient content (C, N, and P), and occasionally for enzyme activity and CO_2 production. We will test for differences in floc decomposition rates between communities (sloughs vs wet prairies vs ridges) and among the five sites along the regional hydrology gradient.

Although litter bags will be collected through November 2010, preliminary analysis of the data from the first 2 months show that there was very little mass loss and that mass loss did not depend on community within a site or between sites. However, all locations continued to be inundated; dry season conditions (and presumably higher rates of oxidation) have yet to occur. It is expected that data through the first six months of experimentation will be presented.

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Mangrove Shoreline Fishes of Biscayne Bay and Adjacent Waters

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Biscayne Bay's mangrove shoreline fish assemblages have been monitored seasonally, without interruption, since 1998. Fish taxonomic composition, diversity and species-specific abundance and size structure continue to be quantified via visual, belt-transect surveys. These surveys have utility for evaluating status and trends at both local and system-wide spatial levels. At the local level, the surveys provide before-after indices of fish diversity and abundance directly downstream of specific hydrological alternations associated with the Comprehensive Everglades Restoration Plan (CERP). At the system level, the surveys allow evaluation of CERP effects on offshore fishery resources because mangroves serve as nursery habitats for several economically-important species that migrate to coral reefs at maturity. In principle, the surveys conducted prior to CERP implementation provide data for predicting fish responses to both natural and/or anthropogenic changes, including variation in freshwater flows. However, reliance on correlations derived strictly from field observations can be misleading. The incorporation of behavioral laboratory studies as a means of validating relationships suggested via analysis of field data is discussed.

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Land-Clearing Treatments Indicate Differences in Total Phosphorus in Soils Following Soil Removal in the Hole-in-the-Donut; Implications for Improving the Restoration Process through Adaptive Management

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The Hole-in-the-Donut (HID) is an area of previously farmed land within Everglades National Park that is currently being restored to wetland. By 1975 all agriculture ceased, leading to the invasion and dominance of Brazilian pepper *(Schinus terebinthifolius*) on 6,600 acres of fallow fields. In order to effectively restore the HID to native vegetation, heavy equipment is used to remove *Schinus* and completely scrape the nutrient-rich soil to limestone bedrock. This process consists of a bulk scrape, where both *Schinus* and soil are pushed into windrows and the material is hauled to a soil disposal mound. This is followed by a more thorough final scrape to remove as much soil as possible. Upon final scrape, shallow pockets of soil and limestone rock remain and native plant colonization occurs. In 2007, land-clearing efforts were cut short with the onset of the rainy season. Though the 100 acre site was cleared and the bulk scrape was completed, the final scrape did not occur. It was known that heavy rates of phosphorus were applied to the historically oligotrophic marl prairie soils and that failing to remove all soil to limestone could result in the reinvasion of Brazilian pepper. Two years post-scrape vegetation data indicated a higher percentage of less desirable species like *Typha* and *Baccharis* when compared to other restored areas. We hypothesized that the vegetation that colonizes a bulk-scraped site is mining phosphorus from the soil and a delayed final scrape would lower soil total phosphorus levels. If so, would laboratory results for phosphorus change the HID restoration process for final scrape?

In 2009, a delayed final scrape was completed for the area of interest, along with a same-year final scrape for an adjacent, newly cleared site. Ten soil samples were taken from each land-clearing treatment, such that soils were collected from the actual vegetation plot locations. Soils data indicated that total phosphorus (TP) in the delayed final scrape was significantly lower at 1081 mg/kg when compared to 1679 mg/kg in the same-year final scrape. These soils were higher than the experimental control value of 173 mg/kg and background levels for TP in Everglades marl prairie wetlands. It has been shown that less desirable plant species contain higher TP contents than dominant marl prairie species. Since this was a pilot study, further evaluation of these preliminary observations is necessary. Additional, more detailed data will be used to investigate whether a delayed final scrape will lower phosphorus levels in soils. Future work warrants a larger sample size and replicate plots distributed within a block design across the landscape for same-year and delayed final scrape analyses. Testing of soils in the lab will be important in determining the availability of phosphorus for plant uptake, and may support post-restoration vegetation cover data. The implications of this research are potentially significant for the HID restoration process. Adaptively managing the Hole-in-the-Donut via delayed final scrape could reduce soil phosphorus, improve species composition, and save money over time.

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Promoting the Reestablishment of *Cladium jamaicense* and *Muhlenbergia capillaris* in the Hole-in-the-Donut Restoration Area of Everglades National Park

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Within Everglades National Park is the Hole-in-the-Donut (HID), an agricultural area invaded by *Schinus terebinthifolius* that is undergoing wetland restoration. The removal of *Schinus* and nutrient-rich soil to limestone bedrock promotes colonization by native wetland vegetation. HID is a mitigation bank and successful restoration is defined via permit as a short-hydroperiod marl prairie community dominated by sawgrass (*Cladium jamaicense*) and muhly (*Muhlenbergia capillaris*). In 2009, an adaptive management study was conducted to determine if sawgrass and muhly could be reestablished by seeding a newly scraped restoration area. The objectives of this study were to 1) determine the best time period to collect potentially viable *Cladium* fruit for seeding restored areas of HID and 2) evaluate the feasibility of seeding newly restored areas of HID with *Cladium* and *Muhlenbergia.* Sawgrass seeds were collected at four, 2-week intervals beginning July 14. Seeds from each collection were debracted and inspected for intact endosperm, or potentially viable seed. Muhly seeds were collected in October, as based on the highest phenological germination rate from a previous experiment. In November, seeds were scattered by weight into sawgrass or muhly plots, while control plots were not seeded in a site restored in May 2009. All plots were observed for sawgrass and/or muhly seedlings every two weeks for the first three months and monthly up to one year. During the development of this seeding project, it was suggested that *Cladium jamaicense* does not produce viable seed uniformly throughout the reproduction season. Our study supported this hypothesis and it was determined that *Cladium* seeds collected on July 28, 2009 had the highest percentage of intact endosperm at 40% and intact endosperm was indicative of potentially viable seed. Given this data, late July is an optimum time for seed collection and harvesting fruits during this time will increase the likelihood of successfully seeding a newly restored site. The second hypothesis was that scattering seeds collected during the time of highest potential seed viability would guide a successful *Cladium* and *Muhlenbergia* seeding program. We cannot yet test this, given that no sawgrass/muhly germination was observed in any of the test or control plots as of March 2010. It is most likely a heavy rain event that occurred immediately after the seeds were scattered in the field redistributed the seeds outside the plots or even drowned them. Seeding and planting of *Cladium* and *Muhlenbergia* in newly restored and older, established restored areas will help determine the best method for increasing sawgrass/muhly abundance in the Hole-in-the-Donut.

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Assessing Sea Level Rise Impacts to CERP Coastal Projects: Practical Application of CERP and Corps Guidance on Sea Level Rise Assessment

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Corps planning guidance (EC 1165-2-211) and the Comprehensive Everglades Restoration Plan (CERP) guidance each calls for evaluating the effects of SLR under multiple scenarios. The scenarios recommended include analysis of sea level rise at low, intermediate and high levels at 20, 50, and 100 years following the completion of project construction. The Draft Final Project Implementation Reports published in the spring of 2010 for the C-111 Spreader Canal Western and the Biscayne Bay Coastal Wetlands projects were the first CERP authorization documents to include an analysis of Sea Level Rise in accordance to the primary requirement of EC1165-2-211 which is to evaluate the ability of the project to produce the expected benefits. In the case of CERP projects, the benefits are usually limited to ecosystem restoration benefits.
The assessment of potential sea level rise impacts on coastal restoration projects is ideally done using complex simulation tools such as density dependent hydrodynamic models for estuaries and bays, vegetation succession models for saltwater and freshwater wetland areas, coastal sediment accumulation/erosion models, density dependent groundwater models, and surface/subsurface hydrology models. Ideally, these models would be set up with boundary conditions (tidal data and operational criteria) representing future sea level rise scenarios. The output from the SLR scenario model runs would be post processed such that potential impacts to the expected project benefits could be determined. Without such tools, the analysis of sea level rise impacts to project benefits is limited to a comparison of static sea level projections and benefited area maps. Given the expense and time required to prepare sophisticated tools to assess the impact of SLR, the C-111SC and BBCW project teams elected to utilize static mapping of future sea level rise to estimate SLR impacts on project benefits. The C-111 Spreader Western Features and the Biscayne Bay Coastal Wetlands projects are both located in Southern Miami-Dade County. Both of these projects target freshwater wetland rehydration and estuarine salinity improvement. Projected future sea level rise will reduce the ability of both of these projects to provide the ecosystem benefits upon which the projects are justified. This poster provides a short summary of the sea level rise impact analyses prepared for these two projects and discusses sources of uncertainty. Methods of decreasing uncertainty in benefit loss predictions are also discussed.

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Picayune Strand Restoration Project: From Planning to Construction, Lessons Learned in Project Implementation

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Picayune Strand Restoration Project is authorized under the Comprehensive Everglades Restoration Plan (CERP). The project will encompass over 55,000 acres of land that was originally drained in the 1960's for a failed housing development and will restore that land to its pre-development hydrologic condition. As the first CERP project to go to construction, Picayune Strand Restoration Project has had many "firsts" and many lessons learned. The project, as with other CERP projects, is cost-shared equally between the Federal Government (U.S. Army Corps of Engineers-USACE) and a local sponsor (in this case, South Florida Water Management District-SFWMD). What makes the implementation of the project so unique is the team approach involvement of the stakeholders—namely, U.S. Fish and Wildlife Service, Florida Department of Environmental Protection, Collier County, and the Florida Division of Forestry. The stakeholders were encouraged to participate in all aspects of the project and were involved in many of the key decisions that were made. The Project Delivery Team, made up from representatives of USACE, SFWMD and the stakeholders, was able to successfully take the project from the planning phase through construction while satisfying the needs of all involved. Both, major accomplishments and "firsts" of CERP were completing the Master Agreement (for all of CERP), the Project Partnership Agreement and the Transfer Agreement between USACE and SFWMD. The presentation will share the dynamic effort of the Project Delivery Team in steps leading from planning through construction.

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Project Implementation: A Case Study of Picayune Strand from Planning Through Construction

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The Picayune Strand Restoration Project encompasses approximately 94 square miles in Collier County and is part of a failed real estate development project of the 1960s (Southern Golden Gates Estates). Prior to development, the area was characterized by seasonal flooding during several months of the year and broad, slow moving sheet flow which sustained wetland vegetation and rejuvenated freshwater aquifers. The network of roads included in the development intercepted the historic flow ways while four major canals over-drained the landscape. Shock load of freshwater point discharges has damaged the ecology of the Ten Thousand Islands estuary. The purpose of the hydrologic restoration plan is to reestablish the historic flow ways, sheet flow and hydro periods of wetlands; reduce point discharges to improve the health and productivity of downstream estuaries; improve aquifer recharge for water supply and prevention of salt water intrusion; and maintain flood levels of service in the developed areas north of the project. The Picayune Strand Restoration Project consists of acquisition of approximately 55,000 acres of land, construction of spreader basins and three pump stations, installation of canal plugs and the removal and re-grading of 227 miles of roads.

As the first CERP project to go to construction, Picayune Strand Restoration Project has had many “firsts” and many lessons learned. The project, as with other CERP projects, is cost-shared equally between the Federal Government (U.S. Army Corps of Engineers-USACE) and a local sponsor (in this case, South Florida Water Management District-SFWMD). What makes the implementation of the project so unique is the team approach involvement of the stakeholders—namely, U.S. Fish and Wildlife Service, Florida Department of Environmental Protection, Collier County, and the Florida Division of Forestry. The stakeholders were encouraged to participate in all aspects of the project and were involved in many of the key decisions that were made. The Project Delivery Team, made up from representatives of USACE, SFWMD and the stakeholders, was able to successfully take the project from the planning phase through construction while satisfying the needs of all involved. Both, major accomplishments and “firsts” of CERP were completing the Master Agreement (for all of CERP), the Project Partnership Agreement and the Transfer Agreement between USACE and SFWMD. The presentation will share the dynamic effort of the Project Delivery Team in steps leading from planning through construction.

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Improved Water Quality Sampling Methodology and Comparison with Conventional Grab and Auto-Sampling Methods at the S-332D Pump Station

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A fully automated and remotely controlled Integrated Sampling System (ISS) was used to provide measurements of total phosphorus (TP) concentrations in water pumped into the S-332D Detention Basin from the C-111 Canal, which is part of the South Dade Conveyance System in South Florida. The ISS collected both interval specific grab samples and continuous flow proportional composite samples over a 24-hour period from five bays at pump station S-332D. All samples were analyzed on-site by a fully automated TP analyzer, an integral component of the ISS. The TP measurements in water samples collected by the ISS were compared to TP measurements from grab and composite samples from an autosampler collected at an adjacent sampling location (S-332DX).

The statistical analysis showed the following trends: i) Same sample aliquots analyzed by both the ISS on site and at the laboratory provided statistically equivalent measurements, ii) ISS flow proportional samples were statistically different from S-332DX time proportional samples, iii) ISS grab samples were statistically equivalent to S-332DX time proportional samples, and iv) ISS daily flow proportional composite samples were statistically different from S-332DX weekly grab samples.

Nutrient loads from the S-332D pump station were computed using different data streams. The TP loads estimated from the flow proportional samples collected with the ISS were as much as ~22% higher than those loads estimated with the time proportional samples collected at S-332DX. The TP loads estimated from S-332DX weekly grab samples underestimated TP mass loads by as much as ~39% that of the ISS flow proportional loads. This study indicates that current grab sampling methods underestimate nutrient concentrations and loads in inflows to the S-332D Detention Basin. The ISS appeared to provide suitable samples for accurate concentrations and loads discharged from pump station S-332D into the detention basin because the ISS sampled water continuously collected when the pumps were in operation.

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Simulation of Water Flow and Phosphorous Transport in a Highly Interactive Surface Water Groundwater System in the Series of S-332 Detention Basins Upstream of Taylor Slough, Everglades National Park

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A three-dimensional integrated surface water groundwater flow and transport model, MODHMS (MODFLOW-based Hydrologic Modeling System) from HydroGeoLogic (2001), was used to investigate groundwater flow patterns and water quality in and around the series of S-332 detention basins adjacent to Everglades National Park in response to the operation of the system of canals, levees, and pumping stations, as well as climatic conditions. The MODHMS model is a state-of-the-art Hydrologic Modeling System that performs comprehensive simulations of conjunctive surface-water/groundwater flow and chemical transport. MODHMS does integrated hydrologic analysis using a fully coupled solution of the diffusion wave equations governing overland flow and channel flow with the Richards' equation governing unsaturated/saturated groundwater flow. Available data on total phosphorus (P) concentration, potentiometric elevation, canal and detention areas stages, and flow through canals between 2000 and 2007 were used as quantitative calibration targets. The model simulations were used to examine the movement of pumped water and associated total P from the detention basins and in the surrounding areas.

Most of the water and P tend to flow out of the S-332 detention basins in an easterly direction towards the L-31N and C-111 Canals. In the L-31W Canal, most of the water (~ 95 %) and P fluxes that enter the Biscayne aquifer migrate in the easterly direction, and the remaining 5 % in the westerly direction, on an average. However, the westerly water flow and P migration is episodic, and all the water and water-borne P that flow into the Everglades National Park get flushed out to the east eventually. A sensitivity analysis was performed and the results indicate that the two most sensitive transport parameters are the distribution coefficient and the dual-porosity mass transfer rate. The current model is capable of simulating salient characteristics and long-term P trends. However, the current model's predictive capability is limited to simulating the behavior of P transport in a macro-scale sense. The major sources of uncertainty in P transport were thought to include behavior and transport of P in soil and limestone and P source identification.

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Carbon Cycling in a Big Cypress National Preserve Marsh

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The evidence linking secular greenhouse gas emissions, specifically carbon dioxide (CO_2), with increasing temperatures and rising sea-level is growing. Of particular concern are rates of sea-level rise, and carbon cycling including CO_2 emissions or "footprints" of urban areas and the capacity of plant communities to absorb and release CO_2. Measurements of carbon cycling are sparse and uncertain over plant communities within Department of Interior (DOI) managed lands in south Florida. Specifically, the quantity of CO_2 absorbed or released annually by forest and wetland plant communities as well as carbon-cycling variability in response to changes in hydrology, salinity, forest-fires and/or other factors are poorly known. To reduce these uncertainties, net ecosystem exchange (NEE) and net ecosystem production (NEP) of CO_2 were determined using the eddy covariance (EC) method at a marsh site in Big Cypress National Preserve for more than two years. The years beginning June 2007 and June 2008 are herein referred as Year 1 and Year 2, respectively. Ancillary data collected at the site included latent-heat flux, sensible-heat flux, rainfall, air temperature, wind speed and direction, solar irradiance, net radiation, soil-heat flux, relative humidity, and water distance relative to land surface. The EC system (including a 3D sonic anemometer and LICOR open-path gas analyzer) was mounted 3.6 meters above land-surface which was roughly 2 to 2.5 meters above the marsh saw-grass canopy. At night, storage of CO_2 below the flux measurement height was considerable (up to 3 μmol (CO_2) m^{-2} s^{-1}) as a result of large fluctuations (up to 650 ppm) in the CO_2 mixing ratio. Quantifying night-time ecosystem respiration (R_E) was particularly challenging due to the frequency and duration of non-turbulent ($u^* < 0.2$ ms^{-1}) conditions due to low wind speeds. On an annual basis, the site represents a net sink for atmospheric CO_2 with NEP of about 68 and 75 g C m^{-2} per year for Year 1 and Year 2, respectively. Seasonal NEP may be sensitive to the timing and duration of inundation. During Year 1, land-surface remained dry during the entire wet season, and NEP peaked at 24 g C m^{-2} in October. Rainfall for Year 1 totaled about 1000 millimeters (mm). During Year 2, which was wetter than Year1, NEP peaked at 48 g C m^{-2} during July, and annual rainfall exceeded 1150 mm. These data suggest a functional relationship may exist between inundation and NEP. Quantifying this functional relationship is a first step towards understanding variability in carbon-cycling imposed by both natural processes and human-induced water-management practices.

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Modeling Hydrologic Flow across a Marsh-Mangrove Ecotone in Ten Thousand Islands National Wildlife Refuge

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Ten Thousand Islands National Wildlife Refuge (TTINWR) is part of a project to restore freshwater flow across the Tamiami Trail into the Northern Everglades. As sea level rises and saltwater intrudes inland, TTINWR's mangrove vegetation has been migrating north, thus gradually taking over the marsh estuary and potentially disrupting foraging patterns of resident and migrant water birds. Hydrologic analysis is essential for understanding how the proposed freshwater flow can be used by refuge managers at TTINWR to aid refuge-specific restoration objectives and to predict attributes of future change in the balance of marsh and mangrove.

Monitoring stations were placed across TTINWR in a quasi-grid formation that extends from Pumpkin Bay and Santina Bay northward to just south of the Tamiami Trial and from the Faka Union River westward. Stage was measured at all stations hourly. Precipitation and salinity well data were collected in the northeast, south central and center portions of the refuge, while meteorological data were collected from a station in the northwestern portion of TTINWR. Stream flow data were collected under two Tamiami Trial bridges by the USGS Florida Water Science Center in Ft. Myers. Water depth data at Pumpkin Bay and Faka Union Bay were acquired from Rookery Bay NERR water level recorders.

The model domain of the refuge is partitioned into ten hydrologically and geographically designed cells. Their arrangement results from comparing the stage data, digital elevation model (DEM), and the vegetation map. The simple hydrologic model conserves mass, while the flow exchange between the various cells is represented by a variation of the Power Law (Kadlec and Knight[1]). We use the model platform Berkeley Madonna, which is proprietary software that solves ordinary differential equations (www.berkeleymadonna.com). Model simulation is driven by the input data (precipitation, stream flow, well data and tide). Evapotranspiration is estimated using the Penman-Monteith equation supported by the available meteorological data. To date, the model has been calibrated for 336 days starting from 2 April 2007. Parameters included in the calibration are the soil hydraulic conductivity and the transport coefficients of the inter-cell flow exchange equations. Stage and salinity are the variables simulated.

The model will provide a better understanding of the flow dynamics in the TTINWR. Our efforts will result in a fully hydrodynamic model available for use by refuge managers in 2011.

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[1] Robert H. Kadlec and Robert L. Knight 1996, Treatment Wetlands

Quantifying and Predicting Vegetative Flow Resistance in the Everglades

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The complex interaction between flow and vegetation plays a critical role in the hydroecology and geomorphology of many environmental systems such as wetlands and floodplains. Vegetative flow resistance alters the distribution and magnitude of shear stress in the flow, which can result in regions of higher and lower flow energy. Variations in flow energy create heterogeneous zones of erosion and deposition of fine sediment and particles as well as particle-associated contaminants and nutrients. Over longer timescales, geomorphology and landscape patterns of these systems adjust to altered flow caused by vegetative flow resistance. Predicting these landscape scale changes requires information integrated across a variety of temporal and spatial scales as well as efficient and reliable methods of establishing flow resistance through empirical predictive relationships and innovative field and laboratory techniques. These leading edge research imperatives are especially true in the Everglades, where a host of data at various scales has been acquired but not integrated. Real-time water depth data is collected throughout the Everglades and biomass data has been gathered by numerous researchers. However, flow resistance parameters (i.e. frontal area and stem diameter) are limited, being based on quadrats that are lacking in extensive spatial coverage. Conversion of biomass data to resistance parameters remains a critical advancement in predicting flow.

The complex interplay between vegetation and flow is exacerbated by a long history of human impact through water management and eutrophication in the oligotrophic Everglades. This research focuses on the role of hydrology, plant community and architecture, phosphorus, and seasonality in governing the spatial and temporal variations in vegetative flow resistance. We have developed empirical predictive relationships between biomass, frontal area and stem diameter by applying statistical treatments including stepwise multiple regressions and repeated measures ANOVA to vegetation quadrat data. These data were collected using both standard methods and a novel photographic technique developed by others adapted to the Everglades field setting that is an improvement with respect to both efficiency and the level of flow depth-specific information that can be obtained from the canopy. Our results suggest that biomass is directly related to frontal area and stem diameter. This is generally true across various plant communities, but when a vegetation classification (Gunderson, 1994) is applied, the relationship improves considerably. Furthermore, vegetation biomass and frontal area are dependent upon location, plant community, water depth, total phosphorus concentration in soil, species richness, and seasonality. We also explore the implications of using these predictive relationships to scale from quadrat biomass estimates to broader areas through remote sensed vegetation indices. These significant results will improve parameterization of flow resistance for ongoing hydrologic modeling efforts, which will ultimately guide future restoration efforts.

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Manatee Telemetry Data Leads to Discovery and Delineation of Seagrass Beds in the Ten Thousand Islands

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The Florida manatee (*Trichechus manatus latirostris*) is an endangered species that inhabits coastal waters of the state. They are excellent indicators and sentinels of estuarine health, and are being used as a gauge of success in the Comprehensive Everglades Restoration Plan (CERP). Manatees forage on seagrasses and other aquatic vegetation. Documentation of the extent and availability of seagrass forage is valuable for assessing habitat suitability and change. Within the Ten Thousand Islands (TTI) area, waters are generally turbid, and attempts to map available seagrass beds from aerial imagery have been largely unsuccessful. We analyzed GPS telemetry records from radio-tagged manatees tracked in the TTI region to delineate possible foraging areas. We then performed stratified field-sampling to correlate the manatee use areas with seagrass or other submerged aquatic vegetation (SAV).

Fourteen manatees carried GPS radio transmitters during 2002-2005, set to record a GPS location every 20-30 minutes, with a median tracking period of 69 days. From these tracks, a total of 45,916 GPS locations were recorded. We used point kernel density filters to score cells on a 0.0001°×0.0001° (approx. 11×11m) grid as “High”, “Medium”, “Low” or “No” manatee use along a 2km-wide swath along the coastline of the Ten Thousand Islands. We then developed a stratified sampling plan, and visited selected cells from Hogg Key to Round Key during either April (spring) or October (fall) of 2008 and 2009. The cells were visually scored using eight random drops of a low-light, high resolution camera mounted to a submerged frame.

Results from the stratified field sampling showed striking patterns. The most abundant seagrasses found were *Halodule wrightii* and *Thalassia testudinum*. At least one of these species was found in 90% of the High manatee use cells, 80% of the Medium use cells, and 50% of the Low use cells. *Halodule wrightii* was found mostly in <1.5m depth at mid-tide, and *T. testudinum* was found in <2.5m depth, but generally >1m depth. Macroalgae was common across all manatee use classes and depths, including the No use cells. Other seagrasses that were found in low numbers in the Low-High manatee use classes were *Halophila engelmannii, Halophila decipiens* and *Syringodium filiforme*. A few shoots of *H. engelmannii, S. filiforme* and *T. testudinum* were also found in No use cells. There was a strong seasonal component, with all vegetation being more common in the spring than the fall. The results indicate that the manatee locations were a good fit to seagrass beds, but not to macroalgae. This strongly supports the initial assumption that manatee use patterns in shallow water reflect foraging efforts targeted at seagrasses.

The methods presented here can be used for efficiently monitoring changes in seagrass beds that may result from CERP efforts or sea level rise. They can also be used with existing or future manatee telemetry data from other regions.

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Vectors of Change in the Coastal Everglades: Sea Level Rise, Storms, Freezes and Fire

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Everglades restoration is proceeding in a changing climate. Sea-level has been rising since ~1900. Temperatures have risen and storminess may increase. Rainfall patterns and sea-breezes have changed in south Florida due to urbanization. Canals were dug in some coastal areas (i.e. Cape Sable). How have, and how will, these changes influence the coastal wetlands of the Everglades?

Historical charts and aerial photos were used to develop an early 20th century picture of the coastal Everglades. In selected areas, habitats have been mapped over multiple periods, and areas of change, and no change, determined. Historically, the intertidal area was dominated by mangrove forests. Embedded within the forests were pockets of brackish marsh. Many mangrove forests adjacent to the Gulf of Mexico have been converted to intertidal mudflats. Seven major hurricanes have impacted the region since 1910, a return interval of <15 yrs, which is too short to allow mangrove recovery. Hurricane Wilma alone destroyed >1,250 ha of coastal mangroves. On Cape Sable, the combination of canals from the gulf into the freshwater marshes and storm surges have increased salinity and coastal erosion, leading to the conversion of >2,000 ha of marsh to open water. An equal area of marsh converted to mangrove forest. This area has thus "tipped" in two different directions. As sea-level continues to rise, these ecosystem regime shifts are likely to be permanent. In more upstream marsh locations, mangroves are migrating into and replacing marsh. Along these marsh-mangrove ecotones, factors other than sea-level rise may play a role in controlling rates of mangrove advance. Preliminary observations along the ecotone following the January 2010 freeze event revealed major mortality of mangroves. Additionally, our analyses have revealed areas where no change has occurred. Reasons for this are unclear at present, but may be related to soil type and fire history, factors we are currently investigating.

These habitat and landform changes have consequences for numerous endangered species in the region. The Cape Sable Seaside Sparrow was first described in the now-vanished marshes. Ironically, the endangered Small-tooth Sawfish and Roseate Spoonbill both use the newly formed open water habitats. Resource managers have only recently begun to incorporate climate change scenarios into restoration planning. As restoration proceeds it is clear that multiple vectors of change must be considered. Our habitat change analyses will be used in ecological and hydrological modeling studies being conducted as part of the USGS project Future Impacts of Sea level rise on Coastal Habitats and Species.

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Sediment Accumulation in Everglades National Park Mangrove Forest

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Mangroves exist on sediments with gentle shore gradients and a small rise in mean sea level would shift the location of suitable habitat unless the sediment surface were to rise along with sea level. Therefore mangrove vegetation can only persist in a fixed location if the sediment accumulation rate matches sea-level rise. However, rarely have sediment accumulation rates in mangrove ecosystems been determined on an appropriate time scale to examine recent sea-level change (i.e., 100 years). We use ^{210}Pb dating models to examine sediment accumulation rates from cores collected in the Shark River area of Everglades National Park. Lead-210 is an ideal tracer to examine sediment accumulation rates on this 100 year time scale.

Mangrove forests in Everglades National Park receive a continual supply of sediment from leaf litter and debris generated from within the mangrove forest. Some locations may receive additional pulses of marine sediment during storm events. A well-documented example occurred during hurricane Wilma in 2005. Hurricane Wilma deposited a 30-60 mm thick layer of marine derived fine grained material within the mangrove forest of southwestern Everglades National Park. These storm events are a potential mechanism for mangrove sediment accumulation to keep pace with sea-level rise.

Sediment dating models indicate an average accumulation rate of 3 mm yr^{-1} over the last 120 years. This slightly exceeds the global eustatic sea-level rise during the same period by approximately 1 mm yr^{-1}. The additional 1 mm yr^{-1} may not persist over the long term due to compaction. The peak accumulation rate was approximately 8 mm yr^{-1} occurring between the years 2004 and 2005 in the dating model. This enhanced accumulation rate corresponds to the Wilma derived storm deposit. The model shows accumulation rates exceeding the 120 year average back to the year 2000. The storm deposit extends into deeper sediment layers than the original deposit due to sediment mixing. The storm derived material had a lower percentage of organic matter which spread into the deeper layers via sediment mixing. In addition we use the short-time scale (i.e., 100 days) radionuclide ^{234}Th to examine the sediment mixing. The sediment mixing is likely the result of biological activity as extensive burrowing was observed at the coring site. Considering potential changes in mangrove forest environments corresponding to climate change we also calculate organic matter accumulation rates. Organic matter accumulation averages 27 mg cm^{-2} yr^{-1} over the last 120 years. The organic matter accumulation rate is slightly enhanced in the upper intervals but these values may decrease over time due to degradation.

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Experimental Study of Post-Fire Recovery of Short-Hydroperiod Prairies

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We conducted a series of experimental burning treatments in short-hydroperiod prairies of Everglades National Park to examine the importance of the timing of burns and the interaction between fire and flooding in the post-fire recovery of these grasslands. This vegetation type is important as habitat for a federally listed endangered species, the Cape Sable seaside sparrow. We were interested in observing the response of prairie vegetation to experimental burns occurring from the dry season into the wet season, examining both community-level responses of vegetation and species-specific responses of sawgrass and muhly grass, often the dominant species in this habitat. Because large-scale prescribed burns are difficult and expensive to use in replicated experimental treatments, we performed a series of micro-burns inside a cylindrical sheet-metal barrier (1.2 m diameter x 0.7 m tall) to constrain the burn area. This procedure enabled us to do a large number of burns in a single day.

In the first year of the study, 2006, we carried out three seasonal burning treatments (dry season, transition from dry to wet, and wet season) at three sites in Everglades National Park. At one site, we included three additional burn treatments during the spring transition period to increase the chances of burning near the beginning of the summer rains. Each seasonal treatment consisted of burning 15 prairie points and 15 muhly plants at each site. Before burning we measured overall canopy height and total cover in the 0.5 x 0.5 m vegetation plots centered on each prairie point and initial height of the muhly plants. After treatment we measured the height of resprouting sawgrass (in the prairie points) and muhly weekly.

We found that post-burn growth rates varied by site and season of burning. Muhly had more rapid initial post-fire regrowth than sawgrass. Sawgrass regrowth was more sensitive to drought than muhly, and muhly regrowth was more sensitive to flooding than sawgrass. We observed no mortality from flooding after the first year treatments, so in 2007 we carried out a second series of eight treatments from February to June at one site. In 2007 water levels rose rapidly in mid-June, resulting in 80% mortality of muhly plants burned on June 12 because the site was flooded by 12 cm of water within a week of the burn. At the community level, burns during a very dry period in 2006 and those followed soon by flooding in 2007 inhibited the recovery of total vegetation cover one and two years after burning.

Prescribed burning is avoided during extremely dry periods because of control issues, but because rapid recovery of vegetation after burning is beneficial to the CSSS, prescribed burning should generally avoid the spring, when prairies are likely to get flooded.

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Seasonal and Spatial Distribution of Freshwater Flow and Salinity in the Ten Thousand Islands Estuary, Florida, 2007-2010

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The watershed of the Ten Thousand Islands (TTI) estuary has been substantially altered through the construction of canals and roads for the Southern Golden Gate Estates (SGGE), Barron River Canal, and U.S. 41 (Tamiami Trail). Two restoration projects designed to improve freshwater delivery to the estuary are the Picayune Strand Restoration Project and the Tamiami Trail Culverts Project; both are part of the Comprehensive Everglades Restoration Plan. To address hydrologic information needs critical for monitoring the effects of these restoration projects, the U.S. Geological Survey initiated a study in October 2006 to characterize freshwater outflows from the rivers, internal circulation and mixing within the estuary, and surface-water exchange between the estuary and Gulf of Mexico. The effort is conducted in cooperation with the South Florida Water Management District and complemented by monitoring performed by the Rookery Bay National Estuarine Research Reserve.

Surface salinity was measured during moving boat surveys using a flow-through system that operated at planing speeds averaging 20 miles per hour. The data were logged every 10 seconds by a data recorder that simultaneously logged location information from a Global Positioning System. The major rivers, bays, and nearshore Gulf of Mexico region of the TTI area were surveyed in approximately 5 hours by two boats traversing about 200 total miles. Salinity and coordinate data were processed using inverse distance weighted interpolation to create salinity contour maps of the entire TTI region.

Thirteen maps were created from salinity surveys performed between May 2007 and January 2010 and illustrate the dry season, transitional, and wet season salinity patterns of the estuarine rivers, inner bays, mangrove islands, and Gulf of Mexico boundary. The effects of anthropogenic activities are indicated by exceptionally low salinities associated with point discharge into the estuary from the Faka Union Canal and Barron River during the wet season. Low salinities in Faka Union Bay may cause reduced diversity and density of submerged aquatic vegetation, fish, and benthic organisms compared with neighboring Fakahatchee Bay. Minimal river discharge and high evaporation caused hypersaline conditions to develop throughout the entire TTI region during the dry season. The salinity maps, coupled with data from the monitoring stations, provide baseline information of seasonal and spatial distribution of freshwater flow and salinity in the TTI estuary, and a means of monitoring the effects of restoration in improving freshwater delivery to the estuary.

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Inter-Annual Variation in Hydroperiod Affects Periphyton Standing Crop and the Associated Macroinvertebrate Community in the Everglades

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Aquatic macroinvertebrate community composition and periphyton standing crop are measures that indicate how the basal portion of the foodweb in the Everglades ecosystem responds to inter-annual variation in hydroperiod. We monitored periphyton standing crop and macroinvertebrate community composition during the 2004 – 2008 water years at short-hydroperiod sites in the eastern Everglades (EEG), which are influenced by the recently constructed S332 impoundments, and long-hydroperiod sites in Shark River Slough (SRS). We found the response of periphyton and macroinvertebrates to inter-annual differences in the duration of inundation was different at short-hydroperiod sites than at long-hydroperiod sites. Periphyton standing crop and the associated macroinvertebrate community was sampled with a coring device, and the macroinvertebrate community was more comprehensively sampled with a D-frame net. Sampling events took place once at each site in the wet season and dry season during each water year. A time series of water depths was interpolated from the Everglades Depth Estimation Network (EDEN) for all sampling sites, corrected with field measurements, and used to estimate the proportion of each water year during which the sites had surface water. For all water years, SRS sites were inundated for a longer proportion (0.65, ±0.02 s.e.) of the year than EEG sites (0.26, ±0.02 s.e.). However, 2005 was significantly wetter than any other year of the study, and a post-hoc (Tukey's HSD) test showed hydroperiod estimates for EEG sites during 2005 (0.48, ±0.03 s.e.) were more similar to estimates for SRS sites in the drier study years (0.60, ±0.02 s.e.) than EEG sites in drier years (0.20, ±0.02 s.e.). The increased period of inundation during the 2005 water year corresponded with a marked decrease in periphyton standing crop and change in macroinvertebrate community composition at EEG sites, but not SRS sites. Generally, periphyton standing crop was negatively correlated with hydroperiod, and > 400 g AFDM m^{-2} at EEG sites and < 400 g AFDM m^{-2} at SRS sites, but there was no difference (EEG and SRS sites had ~ 300 g AFDM m^{-2}) in 2005. The first axis of a principal coordinate analysis of the composition of the macroinvertebrate community shows a trend similar to that of periphyton standing crop. Zooplankton, amphipods, and aquatic Diptera were present in greater relative abundances in the periphyton mat at SRS sites than EEG sites all years except 2005, when SRS and EEG sites had similar community composition. The ecological patterns emerging from this empirical assessment show inter-annual variability in hydrology affects short hydroperiod (EEG) sites differently than long hydroperiod (SRS) sites. This monitoring study provides a general prediction of how ongoing and proposed restoration projects, meant to alter local hydrologic regimes, will affect periphyton mats and macroinvertebrates, which make up an important basal component of the food web in the Everglades ecosystem.

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Changes Observed in Flow and Water Level Patterns of Hydrologic Data Collected along the I-75 and State Road 29 Bridges and Culverts in the Big Cypress National Preserve, 1970, 1971 and 2006 to 2009

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The Big Cypress National Preserve (BCNP) is one-third of the Everglades watershed. Alteration to water flowing into and through BCNP is a concern to the Comprehensive Everglades Restoration Plan (CERP) projects such as Big Cypress / L-28 Interceptor Modifications, Miccosukee Tribe Water Management Plan and the Southwest Florida Feasibility Study. The quantity, timing and distribution of flows along the western and northern BCNP are critical to ecosystem models and performance measures established by CERP. The U.S. Geological Survey (USGS) collected synoptic flow and water level measurements at all bridges and culverts along I-75 and State Road (SR) 29 which are the northern and western boundaries, respectively, of the BCNP. Additionally, continuous stream velocity and water level data were collected at selected sites along the I-75 corridor to produce continuous flow data.

This study compared water level and flow data collected across I-75 and SR 29 bridges and culverts during 1970, 1971, 2006, 2007, 2008 and 2009. The distribution of flow and water level varied across I-75 from Snake Road to SR 29 and changed over time in response to the addition of culverts and bridges, plugs in the borrow canal parallel to I-75 and the Turner River Canal restoration efforts. Project data showed the flow distribution change across SR 29 along the boundary of the Florida Panther Refuge to the Fakahatchee Strand in response to seasonal water level and control structure regulation.

Everglades restoration efforts benefit from hydrologic data collection along I-75 and SR 29 due to:

- Quantification of flows across I-75, addressing the issue of deviations in the natural movement of water within Big Cypress National Preserve.
- Flow pattern of the Okaloacoochee Slough between Big Cypress National Preserve and the Florida Panther Wildlife Refuge, across SR 29.
- Assess the effects of on-going restoration efforts to the flows across SR 29.
- Support of modeling surface water dynamics to evaluate the impacts of hydrologic restoration projects, particularly with regards to the Seminole Water Conservation Plan and L-28 Interceptor Modification Project.
- Baseline data to measure restoration efforts, such as the restoration success of L-28 Interceptor Basin.

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A Hydrologic Model to Evaluate Seepage beneath Levee 31N from Northeast Shark River Slough

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The management of seepage from northeast Shark River Slough, located at the northeast corner of Everglades National Park, is among the many goals of both the Modified Water Deliveries Project and the Comprehensive Everglades Restoration Plan. The Slough is separated from the developed areas of Miami-Dade County by Levee 31N and the L31N Canal. Stage in the L31N Canal is regulated to provide flood protection for the developed areas to the east. This lowered canal stage along with additional drainage canals to the east results in a water-level gradient which induces significant seepage of water from the Slough into and beneath the L31N Canal. Various methods, including pump stations, detention basins, subsurface seepage barriers, and modifications to the existing canal and structure operations are being considered to limit seepage.

A three-dimensional, numerical ground-water flow model of the Slough was developed in 2000 by the US Geological Survey to simulate hydrologic conditions in the area and to estimate seepage beneath Levee 31N. The model was developed using the MODBRANCH version of MODFLOW and was calibrated to conditions existing in 1996. The model was modified to conditions in 2009 to account for changes in the region. The rock mine lakes constructed immediately east of the L31N canal were added to the model, as these lakes represent a significant change in the hydrology of the region. Additionally, the MODFLOW river package was used instead of MODBRANCH to represent the L31N Canal. These modifications required recalibration of the model prior to use for evaluation of seepage management techniques.

An additional factor was taken into account in the model recalibration. A geologic component of the area is a regionally extensive low permeability layer approximately ten feet below the land surface, separating the surficial Miami Limestone from the underlying Fort Thompson formation. Water level records indicate a head gradient across this layer in the Slough in the vicinity of Levee 31N. However, the model was only calibrated to water levels in the Miami Limestone. Modification to the vertical leakance coefficient was required to ensure that this vertical gradient was properly represented in the model.

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Role of Mycorrhizal Fungi in Supporting Invasiveness of Old World Climbing Fern in South Florida Natural Areas

Krish Jayachandran and ***Pushpa Soti***
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An invasive category I biological pollutant, Old World Climbing Fern (*Lygodium microphyllum*) poses a serious threat to the Everglades ecosystems. Managing *L. microphyllum* has been a biggest challenge for land managers and researchers due to its extensive rapid invasion in natural areas of South Florida. Much of the research effort has been focused on reproductive potential, spore release, belowground rhizome dormancy and survival to explain its invasiveness. However, an important mutualistic association, arbuscular mycorrhizal fungi's role in promoting nutrient uptake for the successful invasion of *L. Microphyllum* has not gained research interest. Mycorrhizal fungal interaction with plant communities and the benefits has been well documented. Rhizosphere soil samples and roots of *L.microphyllum* were collected from the Tree Tops County Park in Davie, Florida. Soil samples were sieved to enumerate the mycorrhizal fungal spores. Roots were stained with trypan blue to determine the percentage of root colonization by the fungi. The soil at this site was loamy sand with pH 5.2 and organic matter 37%. The soil sample had a high population of VAM spores. Similarly, *L. microphyllum* roots are colonized by mycorrhizal fungi at or above 95% level. A detailed study is in progress to understand soil biogeochemical properties and mycorrhizal fungal relationship with *L.microphyllum* and other native ferns. We believe mycorrhizal fungi could provide a competitive advantage to *L. microphyllum* in South Florida natural areas aiding its rapid invasion.

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Application of Adaptive Management for Everglades Restoration (Panel Session)

Andy LoSchiavo[1] and ***Tom St Clair***[2]
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Congress recognized the many uncertainties associated with Everglades restoration by authorizing use of adaptive management (AM) in the Water Resources Development Act (WRDA) of 2000. The use of AM helps address uncertainties and guides CERP implementation. The CERP AM program takes information generated through monitoring and assessment and uses those results to iteratively adjust project/program implementation as well as operations. The purpose of this panel session is to describe the advances made in implementation of the CERP AM Program over the past two years and describe how the program is contributing to restoration success.

Panel Moderator – Agnes McLean, Everglades National Park

CERP AM Integration – Andy LoSchiavo, USACE Jacksonville District
The AM program has transitioned from development to implementation and is being embraced by CERP leadership. An update on recent accomplishments will be presented.

AM Application at the Project Level – Laura Mahoney, USACE Jacksonville District
New AM guidance has been issued by the USACE requiring that each CERP project develop an AM plan; however, many challenges exist regarding implementation, including details about monitoring, data synthesis, assessment, and reporting. The features of an AM plan required throughout the life cycle of a project will be presented.

Linking Learning with Future Decision-Making – Ernie Marks, Florida Department of Environmental Protection
The approach for using science to inform decision making is critical to the success of CERP. CERP managers are currently enhancing the decision-making process to accommodate new information and address performance issues.

Resolution of Competing Objectives – Steve Traxler, U.S. Fish and Wildlife Service
Once it has been determined that information can be used improve CERP performance, options for adjustment need to be developed and evaluated. The evaluation process requires resolution of competing objectives such as the maintenance of critical habitat for endangered species versus restoration of a degraded ecosystem. Addressing these types of tradeoffs for CERP will be discussed.

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Comparison of Everglades Restoration with Other Large-Scale Ecosystem Restoration Programs

Tom St Clair
PBS&J, 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 mid 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 seven other large-scale programs, including:

- Missouri River Recovery
- Louisiana Coastal Area
- Bay Delta in California
- Upper Mississippi River
- Chesapeake Bay
- Great Lakes
- Klamath River Basin

These programs will be compared and contrasted based on a number of topics pertinent to large-scale restoration and include:

- Authorization
- Lead agency(s)
- State involvement
- Funding
- Geographical scale
- Implementation strategy
- Restoration objectives
- Restoration targets
- Stakeholder engagement
- Governance structure

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Implications of New Scientific Knowledge for Everglades Restoration (Panel Session)

Kelly Keefe[1] and ***Tom St Clair***[2]
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After ten years of ongoing monitoring and research on the south Florida ecosystem a large body of new scientific information is now available. An effort to employ this knowledge to better articulate the goals and objectives of the CERP is being initiated. Summarizing these findings and conveying their meaning to management and stakeholders is an essential component of the CERP adaptive management program. As the science arm of CERP, RECOVER is responsible for developing the Scientific Knowledge Gained (SKG) report, which will consist of a series of two page summaries of new information on over 50 different topics. The SKG is organized around five components of CERP identified by the National Academy of Sciences Committee as essential to restoration success during conduct of their Independent Scientific Review of Everglades Restoration Progress:

- Water storage capacity
- Mechanisms for delivering and distributing water
- Barriers to eastward seepage
- Methods for securing water quality conditions
- Retention, improvement, and expansion of habitats

The purpose of this panel session is to highlight new knowledge deemed pertinent to Everglades restoration and to solicit input from the scientific community. Another session will be conducted during GEER to solicit input from stakeholders and the general public. Each panel member will provide a brief statement at the beginning of the session stating their view of the most important scientific findings and will then respond to a series of questions from the moderator. Listed below are panel members and their affiliation. Significant time is allocated for interaction between panel members and conference attendees.

Moderator – Tom St Clair, EPJV

Panel Members: Don Deis, EPJV
Matt Harwell, U.S. Fish & Wildlife Service
Eric Hughes, Environmental Protection Agency
Kelly Keefe, USACE Jacksonville District
Jed Redwine, EPJV

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Improving Estuarine Conditions in Biscayne Bay by Optimizing the Timing and Distribution of Freshwater Discharge

Erik Stabenau and *Kevin Kotun*

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Historically, Biscayne Bay was an estuarine environment with daily (tidal) and seasonally (precipitation) driven freshwater regions in the southern basins and along the mangrove shoreline. These regions supported a rich and diverse ecosystem, providing essential habitat for at least a portion of the life cycle of several species. Currently, the Bay and its surrounding area have been significantly altered from its natural state, including the elimination of natural runoff along the western coast of the bay. Freshwater discharge is highly managed through water control structures, leading to large volume yet short duration flow to the coastal system rather than natural prolonged and diffuse combined groundwater and sufacewater discharges. Biscayne National Park and the South Florida Natural Resources Center have analyzed the status of discharge to Biscayne Bay and estimated the quantity of water necessary to restore mesohaline conditions to 10,000 acres of the Bay. While the different methods agreed as to the total quantity of water necessary to maximize mesohaline conditions, the timing, distribution and duration of water deliveries have been difficult to resolve. In the current presentation, an improved estimate of the quantity and timing of water delivery and its resultant affect on salinity in Biscayne Bay are presented.

The Biscayne Bay Simulation Model is a fully hydrodynamic model that calculates salinity and flow in an irregular grid, with higher resolution spatial coverage in coastal regions, from boundary tide, wind, rainfall and freshwater discharge parameters. This model was used to evaluate alternatives to water delivery practices, primarily by redistributing the currently available water released through managed structures and releasing it into broad regions in a more diffuse manner. Modifications in freshwater deliveries included mimicking the natural system by timing peak flow to match the wet season and allowing reduced flow rates to extend into the dry season. Additionally, the impact of freshwater release due to several features in the Biscayne Bay Coastal Wetlands Phase 1 project was modeled. The resultant mesohaline region varies in extent and duration dependent on differences in freshwater outflow between model alternatives revealing a clear selection preference. For instance, it was determined that outflow at structure S-21A had a larger relative impact on salinity than equivalent outflow directed to structure S-20F, likely due to differences in residence time at these two sites. It is anticipated that this work will help optimize freshwater management practices and be part of a larger discussion on freshwater needs for a sustainable and healthy Biscayne Bay ecosystem.

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Status and Trends in Marine and Estuarine Conditions, Florida Bay, 1992 – 2010

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Everglades National Park, as part of its responsibility to preserve and protect Florida Bay has collected, in cooperation with the South Florida Water Management District, a broad range of salinity, bottom temperature, rainfall, and stage data. In 2009, the marine monitoring network was expanded to include its first real-time measure of biological activity with the addition of chlorophyll A and turbidity sensors at two locations. Freshwater influx from surface water discharge and rainfall, relative to evaporative losses and basin outflows, affects salinity and influences the distribution of species within each basin. The central basins are known for long residence times and extended hypersaline events while the eastern basins have shorter residence times and larger fluctuations in salinity. Restoration efforts, in particular the C-111 Phase I project begun in 2009, are expected to influence the quantity and distribution of surface water inflow along the northern boundary of Florida Bay, redistributing fresh water to the west, thereby lowering the extent and duration of hypersaline events in the central region of the bay. To determine the effect of future changes on the salinity regime of the bay, it is necessary to understand the current conditions and recent past. Presented are the marine and estuarine conditions in Florida Bay for 2009 and trends in those conditions over the 18 year period of record.

For 2009, Florida Bay rain data shows less total rainfall (bay wide average = 40.66”) than the neighboring freshwater marshes (Everglades National Park average = 48.75”) while within the Bay, there was a trend toward higher rainfall in the northeast. This is mirrored by the relative distribution of creek discharge, which was also higher in the northeast. Consequently, freshwater deliveries have relatively short residence time leading to greater variability in salinity while leaving the central region subject to hypersaline events. The central region hypersaline event of 2009 was in the upper 75% of the period of record, with salinity peaking at 62.75 on May 1st. The onset of the rainy season brought a rapid drop in salinity coinciding with unusually early seagrass sloughing and several fish mortality events. The relatively mild wet season was followed by higher than average rainfall during the early dry season (Nov. – Dec.), likely related to the 2009 – 2010 El Niño event. Management considerations with respect to seasonal events and other long term climatic cycles, including salinity fluctuations and observations of sea level rise, are presented.

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CERP Master Recreation Plan – A Living Document Overview

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An overview of the Comprehensive Everglades Restoration Plan (CERP) Master Recreation Plan (MRP) will be provided to include: a CERP introduction, CERP recreation use and future needs, purpose of a the MRP, an overview of the MRP goals, objectives and perspective, performance metrics, development of the three main components of the MRP, completed product and its application for a living laboratory of change, the greater Everglades.

The CERP was approved by Congress in 1999 to enact a comprehensive plan for the restoration, protection and preservation of the water resources of the central and southern Florida utilizing Federal, State and local expertise. Water supply, flood protection and other water related needs are also authorized. The CERP contains over 60 project features with potential creation of 217,000 acres of new reservoirs and wetland based water treatment areas.

The MRP focus is to provide planning level guidance to develop balanced CERP recreation proposals for public access and resource stewardship for present and future generations by promoting the protection, conservation and enhancement of natural, cultural and man-made resources. The MRP study team is a multi-agency and inter-disciplinary team that worked with other agencies, stakeholders and the public in a collaborative master planning process.

The primary MRP goal is to develop a living document that guides future recreation planning for CERP, addresses recreational needs within the CERP; is consistent with the project's authorized purposes. Objectives include: ecosystem compatible recreation, addressing regional recreational needs, developing metrics to assess change in recreation opportunities and others.

The three task orders within the MPR include: GIS analysis, synthesis and the development of recreation suitability maps, public outreach and the development of regional conceptual recreation plans. The three task orders are inter-related, build on each other and are critical components of the MRP. Corps contractors assisted with all three.

The MRP will provide recreation planning guidance to CERP Project Delivery Teams for the project implementation reports for further detailed analysis and planning.

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Scale Dependent Feedback as a General Mechanism For Vegetation Pattern Formation in Wetland Ecosystems

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Wetland ecosystems in North America and Eurasia are often characterized by maze patterns and vegetation bands. Various hypotheses have been invoked to explain the formation of these vegetation patterns: peat accumulation, water ponding and anisotropic environmental conditions. While the evolution of the maze patterns and vegetation bands oriented perpendicular to the prevailing flow directions have been described mathematically, the evolution of vegetation bands parallel to prevailing flow directions have remained a challenge. Recently, short-distance facilitation and long-range competition between vegetation (a.k.a scale dependent feedback) has been proposed as a generic mechanism for pattern formation. Here we show that a single modeling framework that encompasses a scale dependent feedback between biomass and nutrient flow can be used to explain maze patterns, vegetation bands that are oriented both perpendicular, and parallel to the prevailing flow direction. We modify an existing, spatially explicit, advection-reaction-diffusion type model to include for a regional hydraulic gradient and anisotropic hydraulic conductivity. The model reproduces the various vegetation patterns, including maze, and vegetation bands which form both perpendicular and parallel to prevailing flow directions. We examine the behavior of this modified model to a range of plant transpiration rates, regional hydraulic gradients, and degree of anisotropy in the lateral hydraulic conductivities. Results from this study provide a more general understanding of the evolution of vegetation patterning in wetland ecosystems.

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Science Communication: Evolution of the CERP System Status Report from Paper Document to Interactive Website

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Communicating scientific information to multiple audiences with various interests and degrees of technical expertise (e.g., scientists, local agencies, stakeholders, managers, and the public) is a challenge faced by many large-scale restoration efforts. For the Comprehensive Everglades Restoration Plan (CERP), the challenge has been how to best present formal assessments of data generated from the RECOVER Monitoring and Assessment Plan (MAP) in the biennial System Status Report (SSR). The SSR plays an important role within CERP and represents the accumulation of multiple years of data on the status, condition, and trends of hydrological, water quality, and biological ecosystem attributes critical to restoration. The current SSR (2009) discusses the validity of the hypothesis cluster concept, its component metrics and functional relationships, the status/trend of key ecological indicators, management issues that communicate high priority areas of concern to the decision makers and managers, and how hypothesis-based assessments provide the science foundation for evaluating interim goals and adaptive management.

To facilitate better communication, Restoration Coordination and Verification (RECOVER) has initiated evolution of the SSR from a paper document (reaching over 600 pages) to an interactive web page accessible from www.evergladesplan.org. Key findings will be presented in a hierarchical way and will be accessible directly via the SSR homepage or by each geographic module's (e.g., Lake Okeechobee, Northern Estuaries, Greater Everglades, and Southern Coastal Systems) page. Users will be able to access high-level assessments (*i.e*., general trends in wading birds), slightly more detailed information *(i.e*., location and number of wading bird nests in Big Cypress), or very detailed information (*i.e.,* specific wading bird survey techniques by location) by exploring various components of the web-based report. Additional links will be provided for information on adaptive management, performance measures, interim goals and targets, and management issues. Overall, this interactive webpage approach provides the opportunity for more frequent updates (than biennial) and ongoing presentation of real-time assessments and trends in Everglades restoration.

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Manatees, Restoration, and Severe Winters: How Haloclines Shelter Manatees from Cold in Southwest Florida

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The protected waters of the Ten Thousand Islands (TTI) and Everglades National Park (ENP) harbor a large population of manatees. Despite the southern location, this region of Florida has been identified as an area that may provide poor winter habitat for manatees, in part because there are no major springs or power plants to provide warm water refugia. The severe winter of 2010 provided partial confirmation of the region's poor suitability during severe winters. Manatees in ENP suffered substantial mortality during January 2010, with at least 76 carcasses found in southwestern ENP (Cape Sable to Cross Bay). In contrast, the large overwintering population of manatees in the adjacent waters of TTI fared much better -- only 11 carcasses were found (Chokoloskee to Marco Island).

The small carcass count at TTI can be readily explained by the availability of warm water at a few passive thermal refugia (PTR). Synoptic surveys (January 14, 2010) counted 135 and 25 individuals at the 2 largest PTRs, both consisting of artificial canal systems. Our research has shown that the most heavily used PTR at Port of the Islands (POI), Collier County, can provide warm water that persists during cold periods, but the warm water persists only on the bottom. Manatees take advantage of this temperature inversion by bottom-resting below the cooler surface water. Our monitoring showed that this warm bottom water disappeared unless a significant halocline was present. Density calculations showed that the bottom water remained substantially denser than the surface water when a halocline was present, even when the surface water was much colder. A detailed 3-D hydrology model of POI showed that the halocline inhibited vertical convection induced by the cooling of surface water; without the halocline, mixing rapidly eliminated the beneficial warm bottom layer.

We found a strong positive correlation at POI between halocline strength and the discharge of freshwater from the upstream portion of the Picayune Strand Restoration Project. POI appears to function as a PTR when adequate freshwater inflow stratifies over a persistent tidal wedge. Without adequate freshwater inflow, salinity stratification disappears. Discharge rates at POI during winter 2010 were sufficient to maintain a substantial halocline, providing an explanation for the small number of carcasses found at POI and the TTI region. Managing restoration projects at POI and ENP to provide temperature inverted haloclines during winter may be an important strategy for manatees and other temperature sensitive aquatic species.

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Common Peat-Over-Marl Sedimentary Sequences in South Florida—A Much Different Hydrologic History than Better-Known Examples from Temperate Climates

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Freshwater marl is a calcareous (calcitic) mud or silt, often shelly, that now forms in certain lakes and marshes. The lakes are mostly temperate and the marshes mostly tropical or nearly so. Older marl is widely found as layer below peat in bogs in several parts of the world, including temperate North America and parts of Europe and in nearly tropical South Florida.

In the southern Everglades, in parts of Big Cypress Swamp, and in the Fresh Creek portion of Andros, Bahama Islands, freshwater marl forms in marshes that are seasonally flooded for many months each year but dry for an extended period as well. Critical thresholds of hydroperiod may not be known with precision but, for example, 7-8 month flooding per year would be generally suitable for marl formation. Seasonal dryness (1) helps select for sparsely vegetated marshes and thus sunny water for the photosynthesizing blue-green algal mats that precipitate the calcite crystals, and (2) helps degrade organic matter from the plants and prevent peat formation. Here, the common upward transition from marl (mid-Holocene age) to peat (late-Holocene age) implies a succession to peatland by increasing wetness (longer annual flooding) and thus a rising average water table (water surface). External forces are implied: a direct climatic shift to an increased rainfall rate, or a sea level rise (i.e., acting as drainage base level). Interlayerings of marl at mid-levels within peat of the southern Everglades also suggest some shifts or stages in climate (to ~1000-year magnitude).

Along the mangrove coast of South Florida there similarly occurs basal freshwater marl overlain by peat, here mainly but not exclusively mangrove peat of a saltwater environment. A rise in water level took place here too, mostly under direct sea level control. Artificial hydrologic change (reduced marsh runoff) apparently explains some modern shifts to mangrove peat.

In more northern lakes (e.g., upper midwestern states), marl forms in open water, either by precipitation in the water column (“whitings,” also facilitated by algal photosynthesis) or as an encrustation on attached colonial algae (*Chara*, stonewort). In that region, many peat bogs also have a basal marl layer beneath an upper peat layer (there, a midlevel organic-rich muddier sediment may be present too). Inward peatland encroachment from the shoreline edge is interpreted from many modern mid-succession examples. Note that in strong contrast to the Everglades and Corkscrew Swamp examples, in northern lake basins no change in water level (elevation) or external hydrologic force is necessary for the shift from marl lake to peat bog.

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Seedbank, Germination and Abiotic Factors Control *Ruppia maritima* Dynamics across the Freshwater-Marine Transition Zones in Florida Bay

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The marine transition or ecotone zone of Florida Bay is an extremely unique habitat that provides foraging grounds and a prey base for both terrestrial and marine species of ecological and economic importance. The highly productive and critical habitat characteristic of this zone is highlighted by the fact that it is a key component of Everglades' restoration. One of the major goals of Everglades' restoration is to restore the functionality of the submerged aquatic vegetation habitat at the Everglades-Florida Bay ecotone with *Ruppia maritima* as an explicit CERP restoration target. However, we understand very little about the biology, life history and abiotic factors controlling this species dominance and variable presence in Florida Bay. In fact, at several ecotone locations where *R. martima* was in the recent past a dominant SAV, it has been absent over the last few years.

Our research group at FAU has been conducting laboratory and field experiments over the last decade to support CERP and MFL planning by determining the salinity thresholds of various seagrass species in Florida Bay. We are examining the mechanisms controlling *R. maritima* establishment from seed and the factors driving the overall distribution of this species in Florida Bay in support of the SFWMD seagrass ecosystem model and ENP landscape habitat model. Model-driven scenarios of water management operations and forecasting require a mechanistic understanding of factors that promote SAV species shifts because a majority of these species are recruiting from seed and/or spores. Thus, both the factors controlling recruitment and germination are critical to understanding SAV dynamics at the Everglades-Bay ecotone.

Based on our results, we have shown that, although *R. maritima* in its adult form can tolerate salinities up to 60 psu, seed germination appears to be limited to salinities <25 psu with optimal germination at 0-5 psu. Further, we determined that high salinity exposure, even up to 45 psu, did not negatively affect *R. maritima* seeds, rather high salinity exposure had a stimulatory effect on subsequent germination once salinities were lowered to freshwater conditions. These results indicate an osmotic effect on seed coat stratification. We also present data on a large spatial analysis of the *R. maritima* seed bank and seed viability encompassing six transects across the ecotone. Finally, we present preliminary results from data recorders at three sites in Joe Bay where detailed life history and SAV dynamics are being assessed. We have developed a conceptual model on the biotic and abiotic factors controlling *R. maritima* and the SAV community at the Everglades-Florida Bay transition zone and incorporate climate change and Everglades' restoration influences on this species ability to be sustained in the Greater Everglades Ecosystem.

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Determination of Nutrient Limitation on Trees Growing in LILA Tree Islands

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Tree islands are important centers of biodiversity in the Florida Everglades and considered key indicators of the health of the Everglades ecosystem, but their number and area have been declined in some portions of the Everglades. With the loss of large numbers of tree islands the local redistribution of nutrients in the Everglades also changes which may effect on nutrient availability for the tree island trees. Variation in availability of nutrients at various sites affects the growth and productivity of tree species. As N and P are the most frequent limiting factors for plant growth in wetlands, less nitrogen and more phosphorus are taken up when supplemental quantities of both nutrients are made available to plants growing under background conditions of relatively low P supply and high N supply. Under conditions of low nutrient supply, most species have lower concentrations of nutrients in their tissues. Fertilization experiments have proved successful in determining the growth-limiting nutrient in various ecosystems including wetlands. Plant species generally react to the increased supply of the limiting nutrient, but not the non-limiting one, with higher biomass production. The goals of this study are to determine the general patterns of response by tree species when conditions limiting optimal growth for the plant species are improved by fertilization and the nature of nutrient limitation in a tree species growing on contrasting substrate i.e., limestone and peat.

Loxahatchee Impoundment Landscape Assessment (LILA) features artificially created islands in a controlled hydrologic framework, M2 and M3 macrocosms provided the setting for my experiment which included two islands in the cell. One island per cell had a peat substrate and the other one had a limestone substrate. Eighteen trees of each species, *Annona glabra* (AG) and *Chrysobalanus icaco* (CI), were selected randomly along the elevation gradient for a total of 36 trees per island, 72 trees per microcosm, and 144 trees overall. One of three nutrient treatments was applied to each tree: Nitrogen (N), Phosphorus (P), or control(C). Two techniques, foliar N:P ratio and plant growth rate (height, base diameter and crown area) were used to determine the response of two species. Results showed that P-treated trees on limestone islands had a higher growth rate than N and C-treated trees. Moreover, foliar N:P ratios were found to be relatively high at the base of the islands and low at the highest elevation of the islands. Thus, it can be concluded that the availability of P for trees increases distance from the water table and that trees on limestone islands may become limited by P.

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A New Approach in Geostatistical Modeling to Capture Stratification of Macroporosity in the Biscayne Aquifer using Borehole Imagery for Improved Groundwater Flow Prediction

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Accurate characterization of porosity and pore space geometry are important in developing models that predict the response of the Biscayne aquifer to Everglades restoration projects. Optical borehole images (OBI) and variogram-based geostatistical methods have been applied to develop 3D models of the rock and its pore space for use in computation of groundwater flows and estimation of hydraulic conductivity of the Biscayne aquifer. The variogram-based approach successfully captured the gross macroporosity of the rock and its spatial distribution. However, it failed to reproduce the vertical cyclic changes in 0.4 x 0.4 m square by 17 m tall simulations of the carbonate rock mass surrounding a borehole. Variogram analysis of the data suggested a nearly isotropic macroporosity network at OBI variogram sample separation distances (geostatistical “lags”) less than the nominal borehole diameter of 0.2 m. Biases in the structure of the data set led to a situation in which the horizontal correlation was strongest at lags greater than the nominal borehole diameter. This is due to the continuity of macroporous bedding-plane vugs, which are visible in the OBI data and detected by the caliper log, across the borehole.

Variogram analysis of caliper-corrected OBI data provides a two-point statistic that is limited in its ability to capture the geometric shapes of pore spaces and their spatial distributions. Multiple-point statistics, an emerging geostatistical approach, uses observation-based “training images”, which are datasets that provide the statistical information needed to characterize the pore space more fully. Multiple-point statistics techniques simulate matches to multiple observations simultaneously and thereby reproduce more realistic patterns. These methods require that the observation data to be used as a training image be gridded in 3-D space however, and this poses computational challenges for utilization of the caliper-corrected OBI data. Multiple-point statistical simulations will use digital OBI and caliper data obtained from Biscayne aquifer boreholes at the L-31N (L-30) Seepage Management Pilot Project in Miami-Dade County and could lead to more realistic simulation models for the macropore network and subsequently for groundwater flow present at this critical Everglades restoration project. Success should help stakeholders to better predict changes in groundwater flow at seepage management sites and elsewhere in the Greater Everglades hydrologic system.

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Hydrodynamics of Recently Planted Tree Islands: Implications for Shallow Groundwater Nutrient and Ion Concentrations

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Across the low topographic relief of the Everglades, variation in evapotranspiration rates may be one factor driving the ridge-slough-tree island landscape pattern. Evapotranspiration in wetlands strongly influences the interaction between groundwater and surface water and thus the distribution and concentration of ions and nutrients in the shallow groundwater that is accessible to plants. In the oligotrophic Everglades, the soil, pore water and groundwater of tree islands contain elevated concentrations of ions and nutrients as compared to the adjacent marsh but the influence of groundwater-surface water interactions on the distribution and concentration of these constituents is unclear. To gain a better understanding of these relationships, water levels at 32 groundwater wells and 8 surface water stages were monitored on constructed tree islands at Loxahatchee Impound Landscape Assessment (LILA) from July 2007 through June of 2010. Groundwater and surface water samples were collected in the wet and dry season and analyzed for major ions, oxygen and hydrogen isotopes. LILA is a large physical model of the Everglades that contains eight tree islands, constructed either entirely of peat or of a thin peat layer over a limestone rubble core. Each tree island was planted with 10 species of tree saplings. During the first year of the study, groundwater and surface water levels indicated that the groundwater table within the tree islands was domed as would be expected in an island setting. The dominant direction of groundwater flow in the tree islands was from the center of the island outward toward its edge and to the surface water. By the second year of the study, the trees had grown substantially, and a depression developed in the groundwater table in the center of the island due to the increased transpiration rates. Along the edges of the tree islands, the groundwater table was still higher than the adjacent surface water levels. The result was a hydraulic divide along the edges of the islands, which acted to isolate the groundwater in the center of the islands from the surrounding surface water. Stable isotopes of oxygen and hydrogen groundwater and surface provided further evidence that the groundwater in the center of the island was isolated from the surface water. The results of this study indicate that evapotranspiration within tree islands does not cause surface water from the surrounding slough to flow into the tree islands as has been suggested by other researchers. Instead, the results of this study suggest that continued isolation of the groundwater from the surface water in the center of a tree island combined with the exclusion of ions by transpiration processes could explain the concentration of ions and nutrients within the center of the tree islands.

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Recent Degradation of the Vegetation Community in Taylor Slough Wetlands (Everglades National Park)

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Upper Taylor Slough (UTS) is one of the two main drainages at the southern end of the Everglades in Everglades National Park (ENP). Recent spreading of *Typha domingensis* (cattail) within UTS, first recorded in 2007, indicates a degradation of wetland habitat value. *Typha* expansion can be an indicator of marsh eutrophication in the Everglades and was observed only as sparse, thin patches in UTS prior to 2007. Historically, the largest source of water to UTS was rainfall and sheet flow from upstream marshes. Construction for flood control throughout the Everglades has resulted in significant changes in water delivery to UTS. A large fraction of the water now reaching UTS comes from agricultural and urban runoff – a source of nutrient and ion-enriched waters. Major water management operational changes occurred: (1) in the early 1980s with the installation and operation of a structure (S332) to pump water into UTS from the adjacent canal; (2) in 1992 with increased pump rates from S332; and (3) in 2000 with the shift of pumping operation to an upstream location (S332D) in the canal. In order to investigate the potential causes of the observed vegetation changes in Taylor Slough, we analyzed historic hydrology, water quality, and soil data and related these data to the various water management changes over the recent decades. These analyses suggest that: (1) hydroperiods in UTS after 1992 are significantly longer than prior to 1992; (2) surface water total phosphorus (TP) concentrations have not increased over the period from 1985 through 2008; (3) post-1992 nutrient load deliveries to UTS from the adjacent canal are significantly greater than loads pre-1991, even considering the loss of direct discharge into UTS from S332 in 2000; (4) some fraction of canal TP delivered to UTS is likely removed in the first 0.3 km of marsh downstream from the canal, and (5) recent (2007) soil TP data show substantial nutrient enrichment (a five-fold increase since 2005) in the slough within the first km from the canal, and sediment concentrations above 500 mg kg^{-1} 6.5 km downstream from the canal source. The combination of increased hydroperiods and nutrient loading likely have provided *Typha* a competitive edge over other species (i.e., *Muhlenbergia capillaris*; muhly grass) acclimated to short hydroperiods (2 – 3 months) and oligotrophic conditions, resulting in *Typha* spread of more than 0.2 km^2 in UTS.

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Predicting Coastal Landscape Changes by Modeling Long-Timescale Impacts of Hydrodynamic Fluctuations on Salinity and Hydroperiods

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Long-term hydrologic effects on coastal landscapes in the Greater Everglades are influenced by hydrodynamic transients such as tides, wind-driven seiches, and storm events. Many representations of sea-level rise effects take a static approach or use simpler forms of the flow equations. This is useful in showing average water levels, but factors like flooding and saltwater intrusion, which affect the coastal landscape, are heavily influenced by short-term events. Flow and Transport in a Linked Overland/Aquifer Density-Dependent System (FTLOADDS) is a coupled surface-water/groundwater flow simulator designed to represent transient conditions for a range of temporal scales.

The capabilities of the FTLOADDS simulator were required for an ongoing integrated science project to estimate the potential for vegetative changes and determine the effects of short-term events on the coastal landscape and topography. FTLOADDS was used to develop the BIscayne and Southern Everglades Coastal Transport (BISECT) model, which extends from Everglades National Park to the Biscayne Bay coastal area. Surface-water time steps are on the order of minutes, and large amounts of short-time scale stage and salinity output data are converted to representative statistics, such as percent of time inundated, hydroperiod length, and salinity mean and variance. Pre- and early development conditions, and other configurations including various storm intensities and climatic conditions, are simulated with BISECT. Results from these hindcast simulations are correlated to areas with historically-observed vegetation changes. These correlations are used to develop a landscape-change forecasting technique and determine the model's predictive capabilities.

The hindcast simulations need to make use of a variety of historic information as standard datasets are minimal. Information on the hurricanes of 1926, 1929, and 1935 lack necessary detail, so information from the National Oceanic and Atmospheric Administration's 20th Century Reanalysis was used to develop model input for historical storm events. Simulation results provide the inundation and salinity statistics for the time periods that historic landscape information was collected, including aerial photography from 1929-1952.

In conjunction with the hindcast simulations, BISECT is also used to simulate fixed sea-level rise, progressive sea-level rise and ecosystem restoration implementation. These simulations provide insight into flooding in urban areas and saltwater intrusion hazards to wellfields. All simulations show that periodic inundation transports saltwater inland, with a net effect on the underlying groundwater saltwater interface. These effects cannot be represented by static techniques, which simply use topography to determine the inundated area at a given sea level.

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Experimental Determination of Soil Heat Storage Depth for the Simulation of Heat Transport in a Coastal Wetland

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In order to determine potential temperature variations important to a variety of temperature-sensitive biota in the South Florida coastal wetland areas, heat-transport capabilities have been incorporated into the hydrodynamic surface-water flow formulation of the FTLOADDS simulator. Model applications have shown that the predicted daily temperature fluctuations are sensitive to heat exchange with the underlying soil. This soil heat flux, however, is poorly known and one of the major sources of uncertainty in the model. Although the volume and heat capacity of the thermally connected-soil depth (the depth of soil that can be represented with the same temperature variation as the overlying water) was estimated through calibration of the model, a more direct quantification of soil heat storage effects would improve model confidence and predictive capabilities.

In order to better quantify soil heat storage effects, several physical experiments were developed to represent the thermal interaction of wetland overland flow and the underlying soil layer. The experimental apparatus consisted of two 52-inch (1.32 m) diameter by 36-inch (0.914 m) tall well-insulated tanks, one filled with soil and water and the other with only water. A peat/sand mix was used to represent the underlying soil and emergent vegetation was simulated with constructed surrogates based on documented plant size and densities observed in the field. The tanks were instrumented with thermocouples to measure vertical and horizontal temperature variations and placed in an outdoor environment subject to solar radiation, wind, and other factors affecting the heat transfer. Instruments also measured solar radiation, relative humidity, and wind speed. Both tanks were observed simultaneously for a period of 15 days.

Tests indicated that heat transfer through the sides and bottoms of the tanks was negligible, so the experiments appropriately represented vertical heat transfer effects only. The temperature fluctuations measured in the vertical profile through the soil and water were used to calibrate a one-dimensional heat-transport model in order to determine the relevant soil properties. A thermally connected soil depth of 2 inches (5.1 cm) of soil seemed to represent the heat storage needed to match the field data. The measurements indicated that the low-density sawgrass represented in the experiments, which is ubiquitous in the study area, reduced the solar energy absorbed by 14 inches (0.356 m) of water in a coastal wetland by less than 5%. The experiments also showed that the maximum heat transfer into the soil underlying wetlands lagged behind maximum solar radiation by approximately 2 hours. These findings indicated that the FTLOADDS-calibrated soil depth was too high, resulting in underestimated solar energy reflected or intercepted in the wetlands. This additional insight helps reduce heat-budget uncertainties and supports more accurate numerical modeling of heat transport.

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A Nitrogen Isotopic Study of Greater Biscayne Bay: Implication for Sources of Nutrients

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In the period 2006-2008, a study was carried out in order to determine spatial and temporal variations in the $\delta^{15}N$ of organic material within Biscayne Bay. This study was carried out in order to assess whether there were any patterns of $\delta^{15}N$ which could be used as indicators of anthropogenic addition of nitrogen from the large adjacent population in Miami-Dade County. The dataset consists of approximately 100 grab samples of sediments and benthic flora collected from Greater Biscayne Bay. This was followed by a quarterly study (2006-2008) based at 15 stations, largely within Biscayne National Park. During the quarterly studies a range of benthic organisms (mainly benthic algae and seagrasses) were collected in addition to samples of size fractionated particulate organic material and water samples. All organic samples were analyzed for their $\delta^{13}C$ and $\delta^{15}N$ values. Selected water samples were analyzed for the $\delta^{15}N$ of DIN and DON as well as the $\delta^{18}O$ in the NO_3^-. Finally the $\delta^{15}N$ and $\delta^{18}O$ of NO_3^- was analyzed in the freshwater inputs (rainwater and canal water). Analysis of these data showed higher $\delta^{15}N$ values within the nitrate of canals such as the Coral Gables Waterway and immediately adjacent to the Miami-Dade County landfill. However, overall the $\delta^{15}N$ values of algae and other organisms are similar to $\delta^{15}N$ values observed within Florida Bay, the Florida Reef Tract, and off the East coast of Florida. It is believed that these differences reflect normal fractionation within the nitrogen cycle related to assimilation and nitrification rather than the source. The principal conclusion which must be drawn is that the $\delta^{15}N$ is not a robust indicator of anthropogenic influences.

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Classification of Marl Prairie and Marsh Vegetation Communities in the Everglades National Park

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The proposed study would develop a robust and repeatable classification and discrimination methodology with quantifiable accuracies for wetland mapping and monitoring, focusing on at risk plant communities in marl prairie and marsh areas. Wet graminoid communities are a prominent factor in evaluating changes in ecotone, wildlife habitats and ecological change overall. As the hydrology changing due to human activities, such as urbanization and farming, as well as natural environmental processes, the ecotone is continuously shifting within vegetation communities. These communities are also among the first indicators of water pollution, particularly phosphorous and nitrogen level changes in the water. Moreover, sea level rise due to global climate change would impact the Everglades including these communities. Successfully mapping these communities baseline spatial distribution with modeling algorithms that allow rapid updating with new imagery is critical. The main tasks are to (a) collect accurate reference ground information and (b) up-to-date airborne imagery, and (c) develop a robust and repeatable method for accurate classification of wetland and invasive species, and (d) perform classification accuracy assessment and cost-effectiveness analysis. Based on the findings, a classification plan/scheme will be developed. Moreover, an accurate, up-to-date map of the graminoid communities will be produced for parts of the Everglades. Thus, the proposed study would develop a means by which these vegetation communities could be monitored in an accurate and efficient manner on a regular basis. The findings of this work also could be incorporated in local, regional or global climate change models.

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MIKE SHE and MIKE 11 Surface/Subsurface Hydrological Model for the Everglades National Park

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An integrated surface and groundwater model was developed using the MIKE 11 and MIKE SHE modeling framework to provide analysis of restoration projects intended to re-introduce water flows into Northeastern Shark Slough and the Rocky Glades regions of Everglades National Park (ENP). The model domain covers 1050 square miles within ENP south of canal L-29 and west of canals L-31N and C-111 and includes 105 miles of primary canals and associated major control structures, pumps, floodgates, culverts along L-29, and retention ponds that discharge water into ENP. The model uses distributed hydrologic parameters with a spatial resolution of 200 meters and a temporal resolution of 1 day. The overland flow in MIKE SHE is represented using the diffusive wave approximation of the Saint Venant equations computed in two dimensions, which accounts for sheet flow across the domain. Observed water levels within ENP and observed water levels and discharge in the primary drainage canals for the period of 1987 through 1997 were used to conduct sensitivity analysis and calibrate the model. Key parameters for calibration and sensitivity analysis were manning's number for overland flow, hydraulic conductivities for subsurface flow, and leakage coefficients which define the coupling between the surface and subsurface flow. The coupled MIKE 11 and MIKE SHE model simulates the spatial and temporal dynamics of water fluxes within the Everglades National Park for prescribed boundary conditions and provides a hydrological tool for analysis of the regional hydrology. In addition, the model can be applied to simulate, analyze, and evaluate the performance of current and proposed restoration projects, including the C-111 South Dade project, Modified Water Deliveries Project, ENP Seepage Management, C-111 Spreader Canal Project, and S-357 Water Control Plan. The integrated hydrological model addresses the challenges to the Park regarding additions to the Central and Southern Florida project and the effects of the restoration activities on the hydrologic resources of ENP.

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Using a Network of Benchmarks to Evaluate and Verify the EDEN Surface-Water Model

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A network of benchmarks is being established in the marshes of the greater Everglades and surveyed to North American Vertical Datum of 1988 in 2009-2010 to test, validate, and improve the Everglades Depth Estimation Network (EDEN) surface-water interpolation model that creates daily water-level surfaces for the Everglades. Twenty-four benchmarks were installed and surveyed in 2009 and 7 additional benchmarks are proposed for installation and survey in 2010. When these benchmarks are combined with the 31 benchmarks established by the Florida Department of Environmental Protection in 2006, the network of 62 benchmarks (2nd order or better) provide a geographically broad distribution of points of known elevation and measured water levels independent of the existing water-level gage network.

The network of independent benchmarks is critical for evaluating the performance of the EDEN water-surface and water-depth estimates. EDEN's surface-water model uses daily median values for up to 240 of the EDEN water-level gages in the freshwater Everglades to create spatially continuous interpolations of the water-surface elevation. When the ground-elevation model for the Everglades is subtracted from the daily water-level surface, an estimate of daily water depth provides scientists and managers with valuable information for monitoring and assessing hydrodynamic changes across the Everglades.

Currently, EDEN's surface-water model is being revised using updated water-level gage datasets with improved gap-fill estimations, longer period of record, and updated datum surveys. Several gages have been added to the network to improve the geographic extent and better define selected areas. Dry season and wet season measurements of water level in 2009 and 2010 at the network of benchmarks will provide independent measures of water level for comparison with the revised EDEN model results. The results of these comparisons will be used to further revise and re-parameterize the EDEN surface-water model. The newest version of the EDEN surface-water model is due to be completed in August 2010 and will be used for updating EDEN daily surfaces from 2000 to current in September 2010.

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Quantifying Freshwater Inflows to the Caloosahatchee River Estuary

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The Caloosahatchee River estuary is a large water body that supports many aquatic species, where saline waters of the Gulf of Mexico interact with freshwaters flowing from control structure S-79 at Franklin Locks, many tributaries, local urban runoff, and effluent from municipal wastewater treatment plants. The water quality of the estuary is highly affected by altered freshwater inflows, nutrient, trace element, and potentially pharmaceutical loads from agricultural activities and urban development.

The objective of this study is to help quantify freshwater inflows to the Caloosahatchee River estuary by establishing several continuous monitoring stations along the main stem of the river and major tributaries. Data collection at these U.S. Geological Survey (USGS) monitoring stations includes water level, salinity, and temperature. Discharge is computed using empirical calibration ratings for velocity and cross-sectional area.

All hydrologic data collected through this study is transmitted via GOES satellite every hour, stored in the USGS database, and can be accessed on a provisional basis via internet at the USGS real-time web pages -
http://waterdata.usgs.gov/fl/nwis/current/?type=flow&group_key=county_cd

Historical data can be obtained through the project web page located at the USGS South Florida Information Access (SOFIA) web site -
http://sofia.usgs.gov/projects/index.php?project_url=flow_caloo

These data provides critical information on the quantity, salinity, and temperature of water entering the estuary on a continuous basis (15-minute time-series data) that will be valuable for the verification of hydrodynamic and watershed models currently in use.

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Mapping the Changing Coastline of Southwest Florida: Cape Romano to Cape Sable from the 1800s to the Present

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The coastal Everglades of southwest Florida is home to many endangered and threatened animals and is vulnerable to the effects of sea-level rise, hurricanes, and human activity. Understanding how this ecosystem responds to these events is crucial to restoration and management planning activities. To facilitate our understanding of shoreline change, we needed to compare historic and modern maps to determine where, and how fast, change has occurred.

We obtained historic (mid 1800s) topographic maps of this region created by the U.S. Coastal and Geodetic Survey (now the National Geodetic Survey). We georeferenced and mosaicked these maps and digitized the historic shoreline. These maps were placed in a geodatabase containing modern maps, shoreline and vegetation data. The processed maps and shorelines from the 1800s were compared with aerial photographs and shorelines from 1928, 1940s, 1950s, 1987, and 2004. Hurricane data (track, wind direction and speed, precipitation and storm surge) were added to the geodatabase to assess how storm events may have influenced this coastline.

By overlaying these layers in ArcGIS, we analyzed how the shoreline configuration has changed over time. The northern part of our study area near Panther Key, for example, has experienced little to no shoreline change. Conversely, the southern part of our study area around the mouth of the Shark River has experienced shoreline retreat in excess of 500 m. We hypothesize that these differences in erosion rates may be related to one or more of the following factors: shoreline configuration, elevation, underlying geology, vegetation structure, sea-level rise, dominant wind and wave direction, as well as hurricane passage.

Additionally, our shoreline change data will be used with hydrologic models being developed for the coastal Everglades as part of the Future Impacts of Sea level rise on Coastal Habitats and Species (FISCHS) project.

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Control Options for the Most Common Invasive Plants in Arthur Marshal and Similar Areas of the Everglades

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Arthur R. Marshall Loxahatchee National Wildlife Refuge (Arthur Marshal) includes 145,800 acres (228 square miles) of northern Everglades habitat. To the south and southwest of the refuge lie **Water Conservation Areas 2 and 3** and **Everglades National Park.** These areas combined are the only remaining portions of the Everglades fresh water marsh. Within the boundary of Arthur Marshall there are 21,915 acres of tree islands, most being infested by non-native plants. Old world climbing fern (*Lygodium microphyllum*) is the most serious invasive. Other invasive plants that inhabit the islands are Brazilian pepper (*Schinus terebinthifolius)*, Melaleuca (*Melaleuca quinquenervia*), Australian pine (*Casuarina* spp.) and Earleaf acacia (*Acacia auriculiformis).* The effort to control invasive plants is intense. Each day throughout the year five to six crews in large airboats leave the ramp at the headquarters near Boynton Beach, at least when water level permits, work is primarily conducted in the tree islands to control invasive plants. The invasives, particularly Old world climbing fern, create large monocultures in the tree islands which should be the center of plant biodiversity as well as provide habitat for more than 250 species of birds. The primary strategy is to precisely target the undesirable exotics with 3-5% Rodeo or Aqua Pro at 20-30 gpa. The vines are so dense that minimal herbicide damage is done to the underlying flora, releasing the native vegetation on the tree islands to again play a part in the biodiversity that makes the Everglades so critical. Melaleuca is usually treated by girdling each tree and applying 10% glyphosate and 40% Habitat to the cambium. The research for this herbicide treatment was conducted by Aquatic Vegetation Control (AVC) personnel in 1974 at the **Arthur R. Marshall Loxahatchee National Wildlife Refuge**. Other invasive tree species are usually cut down and treated with Garlon 3A. The sites are inspected 4 weeks after treatment. Missed or uncontrolled targets get on a punch list to be re-treated later to attain close to a 100% control. The **Arthur R. Marshall Loxahatchee National Wildlife Refuge** is divided into sections by GPS to assure no area is missed. Each section is targeted until treatments are complete and then crews move to the next section. Within a few months to a year, the character to the islands changes back into its natural state of biodiversity but touchup treatments will be conducted as needed, primarily to control new sprigs of Old world climbing fern.

Pal Mar, Loxahatchee Slough, Pine Glade, Cypress Creek and associated basins surrounding the Loxahatchee River are used to capture and store excess surface waters and use it to increase discharge to the **Loxahatchee River**. These areas form a continuous greenway system for wildlife and provide water management options for maintaining or enhancing the existing natural areas (i.e., pine flatwoods and wetlands). These areas have comparable problems to the uplands associated with the Everglades ecosystem and are similarly managed. AVC typically has 10-20 ten man crews in this area. The major non-native invasives in this area are the same as in **Arthur Marshal** but also include Downyrose myrtle (*Rhodomyrtus tomentosa*). Downyrose myrtle is usually controlled with 2 quarts of Vanquish per acre. The research for this treatment has been conducted over the past 5 years by AVC at Cypress Creek. Either 1% Arsenal Powerline or 15% Garlon 4 ultra and oil are often used for spot treatments. Treated areas revert back to a diverse native flora. Annual inspections and/or treatments are made annually to these areas to insure invasives do not get a foothold in these areas again. In the flood plains of the **Loxahatchee River** itself, Java plum (*Syzygium cumini*) can form dense stands. Experiments by AVC indicated that Renovate was an effective cut stump herbicide. Because these trees are located over water, an aquatic herbicide was needed.

Dade, Monroe and Collier counties contain many similar areas in the State and National parks encompassed within their borders. **John Pennekamp Coral Reef State Park** and State lands surrounding **Everglades National Park** are examples. Eight crews are usually busy managing non-natives in this area. In addition to the normal list of invasives, we encounter some other villains. Shoebutton ardisia (*Ardisia elliptica*) and Lead trees (*Leucaena leucocephala*) are most noteworthy. Lead trees in AVC experiments have been treated successfully with Milestone. A 3% solution is effective on cut stump and 7 ounces per acre foliar or 14 ounces spot treatment is 85 -95% effective on trees up to 10 feet tall. Shoebutton ardisia is currently being evaluated by AVC with 2 experiments. So far, 4 foliar treatments are effective: **1.** Arsenal Powerline at 96 ounces + Escort at 3 ounces per acre; **2.** Arsenal Powerline at 96 ounces + 7.5 pints Rodeo per acre; **3.** 64 ounces Vanquish + 4 ounces by weight Overdrive + 42 ounces Vista + 3 gallons of Garlon 3A per acre; **4.** 26 ounces by weight of Lineage/Clearstand + 7.5 pints of Rodeo per acre. Initial data indicates Escort may be effective controlling seedlings, perhaps the major challenge managing this pest. Continued evaluations will determine not only the most effective combination but also the herbicide combination that does the least amount of environmental damage.

AVC is committed to being a leader in restoration and land management and has a research facility (Weed Science Research Station) to develop the safest, most economical method of managing Florida's precious resources.

Herbicide management of these non-natives is one component of integrated pest management that helps restore thousands of acres of compromised but valuable and essential habitat for wildlife. Continued effort in managing our precious recourses and surrounding land will reduce effort needed each year to keep our natural resources productive.

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South Florida Ecosystem Restoration Program Authorities and Project Funding Implications

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This presentation will explain the challenges associated with program authorities, project budgeting and funding, and cost-sharing between project sponsors.

The South Florida Ecosystem Restoration (SFER) program is actually comprised of several other programs from a variety of authorities. For example, the Comprehensive Everglades Restoration Plan (CERP) is from the Water Resources Development Acts (WRDAs) of 1996, 1999, 2000, and 2007; Kissimmee River Restoration is from WRDAs 1986, 1988, 1990, and 1992, Modified Water Deliveries to Everglades National Park is from the Everglades National Park Protection and Expansion Act of 1989 and WRDA 2007, and Herbert Hoover Dike Rehabilitation is from a long list of WRDAs, Flood Control Acts, and Rivers and Harbors Acts dating back to 1930. Each of these authorities represents public law that defines most aspects of the program, including funding levels and cost-sharing requirements for the federal and local sponsors.

Program and project funding are also dependent on the annual budgeting processes of federal and state governments. Although agency staffs submit funding requirements based on program schedules and resources, the actual funding is determined by fiscal and political coordination between the respective executive and legislative branches of government. As can be expected, the final budget does not always match the funding requirements submitted by the agencies.

The SFER program includes individual projects with construction funding requirements in the hundreds of millions and even billions of dollars. Neither federal nor state budgets include annual funding at these levels. Projects must therefore be broken into construction contracts that can be fully funded by the expected budget(s). This is complicated by the federal requirement for each contract to also be a functional element that can provide project benefits even if the rest of the project is not constructed.

Finally, program and project funding are complicated by the need to meet cost-sharing requirements as defined by the governing authorities. For the CERP program, all costs are shared 50/50 by the federal and non-federal partners. This includes planning, engineering and design, real estate, construction, and operations and maintenance. Cost-sharing documentation alone can be a complex and difficult process. To make matters more difficult, the federal partner is not allowed to “get ahead” of the non-federal sponsor, so projects must be scheduled to allow both partners to maintain near equality throughout execution of the program and projects.

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Stakeholder Development of Alternative Futures and Attractiveness models for Resource Agency Planning in South Florida

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The Florida Everglades ecosystem is among the most important natural resources in North America and it is in the midst of perhaps the most complex and ambitious ecosystem restoration planning effort in U.S. history. In this regard, climate change is arguably the most significant and difficult issue to rise to prominence since the original formulation of the Comprehensive Everglades Restoration Plan (CERP) in 2000 and the USFWS has stated that climate change is the greatest threat that we have ever experienced. Climate change will affect a wide variety of human and natural systems, and must be addressed within a context of considerable uncertainty in policy, human responses, and indirect effects. In order to plan and manage effectively in the face of such uncertainties, we are developing a stakeholder-based alternative futures process.

This project has provided a synoptic assessment of the vulnerability of Southern Florida's critical ecosystems and waters resources and developed an adaptation tool for developing Landscape Conservation Cooperatives (LCCs). The team has developed a set of regional-scale "alternative futures" that spatially simulate likely climatic, hydrologic, and land use conditions in 2020, 2040, and 2060 (based on IPCC scenarios). These futures are being evaluated for climate change and other impacts on fish, wildlife, plants, and their habitats. The completed attractiveness modeling will provide numerous maps depicting areas most attractive for land acquisition (fee simple, conservation easements, conservation banking, etc), development (income and density based), etc. The overlay of the MIT alternative futures with the current CLIP prioritization will be the basis for an initial vulnerability assessment. This information could be used to identify critical areas for land acquisition, protection and enhancement of habitats including areas that could be a potential new National Wildlife Refuge in central Florida.

Experience has shown that collaborative decision making reduces conflict among participants, increases the credibility of science-based information underlying environmental decisions, and improves the overall legitimacy of the participation process. Therefore, inviting the stakeholders to be part of the decision-making process in environmental management is at the core of the exploring the consequences of climate change on the Greater Everglades Ecosystem.

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Water Chemistry Effects on Apple Snail (*Pomacea paludosa,* Say) Reproductive Patterns in the Northern Everglades

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Canals surrounding the Everglades carry enriched and polluted water high in minerals and nutrients. These enriched waters impact adjacent marsh habitats, altering flora and fauna species and abundance. Multiple studies have found gradients in nutrient levels as a function of distance from canals and emphasize the sensitivity of some organisms to these changes in water chemistry. Florida apple snails, *Pomacea paludosa* Say, are just one of many Everglades species sensitive to changes in water chemistry. They serve as an important staple in the diets of many Everglades predators including turtles, crayfish, limpkins and most importantly the endangered snail kite, *Rostrahamus sociabilis* which feeds almost exclusively on the apple snail. To examine potential effects of water chemistry on apple snail breeding patterns, we observed snail egg size, egg number per clutch, and C:N ratios along water chemistry gradients and among snail breeding months at the Arthur R. Marshall Loxahatchee National Wildlife Refuge. Egg number per clutch and egg diameters were greatest in the most impacted zones and lowest in the pristine, interior zone. Higher C:N ratios appeared to follow lower nitrogen concentrations; roughly from the transition and perimeter zones, to the interior zones. Significant, albeit weak, negative trends were found between C:N ratios and egg number per clutch, and positive trends between egg number per clutch and egg diameter, but only among specific sites and months. Results from this study suggest canal-water impacted areas of the Refuge may produce greater numbers of apple snail offspring with greater C:N ratios than less impacted areas. However, it is unclear how viable these offspring are and whether they have higher survivor rates than their counterparts within the less-impacted interior zone. Although the ecological implications of these results are not fully understood, the data indicate that water chemistry impacts reproductive process in the native Florida apple snail. The knowledge gained in this study will benefit future apple snail aquaculture and seeding projects and guide future studies exploring environmental effects on this vital primary producer.

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Linking Aquatic-Consumer Biomass to Environmental Drivers and Algal Ecology

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The CERP MAP Trophic Hypothesis proposes a set of causal linkages illuminating the connection between management actions and wading bird nesting success in the Greater Everglades region. In this presentation, we report recent results supporting the hypothesized linkage of hydrological drivers, phosphorous enrichment, periphyton community dynamics, and dynamics of primary and secondary consumers that are, in turn, consumed by wading birds. We used a path analytical approach to evaluate the fit of data to several alternative food-web models using data collected from the 2005 EPA REMAP program. The best fit was for the hypothesis that phosphorus enrichment stimulates change in periphyton community composition to increase the frequency of edible algae species, which are consumed by macroinvertebrate infauna of the periphyton mats. This increase in invertebrate production appears to largely be consumed, because their density does not increase with nutrient enrichment, but the density of secondary consumers know to eat them does increase with enrichment. This causal hypothesis is further supported by analyses of CERP MAP data collected in 2005 and 2006, indicating an increase of the frequency of edible algae taxa in periphyton mats with increases in tissue phosphorus. This increase is accompanied by increases in most species of secondary consumers. The relative abundance of edible algae taxa, green algae and diatoms versus filamentous bluegreen algae, in periphyton better explain changing consumer community composition than did periphyton stoichiometric ratios. These results support the CERP Trophic Hypothesis of causal linkage of management actions affecting hydrological and water quality to primary production, to secondary consumer production. Furthermore, these results indicate that choices made for target groups in monitoring are indicative of ecosystem components causally linked to changes in upper trophic levels.

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Trade-Offs between Nutrient and Predator effects on a Primary Consumer along a Canal Gradient in an Oligotrophic Wetland

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Foragers must balance nutritional benefits against risk from predators. Natural selection should favor individuals who balance risks and benefits in ways that enhance their growth, reproduction, survival, and ultimately their fitness as reflected in population dynamics. Canals that control flooding in the oligotrophic Florida Everglades enrich adjacent marshes with phosphorous that alters community structure; predatory fish increase, many annual fishes increase, and invertebrates exhibit a mixed response. We characterized aquatic communities at sites near and far from a canal with throw traps and tethering experiments before and after a reciprocal transplant experiment designed to examine the interactive effects of nutrients and predators on the diet, growth, and egg production of the pulmonate snail *Planorbella duryi* (Seminole ramshorn). We collected more snail predators and observed more predation near compared to distant from canals indicating that threats of predation were greater near canals. Periphyton C : P ratios were lower and chlorophyll-*a* levels were higher near canals suggesting that resource quality was also greater near canals. Fatty acid profiles revealed that snails assimilated oleic acid (18:1ω9), a fatty acid identified as a biomarker for green algae, which was relatively rare in periphyton, indicating they likely assimilate green algae. Snails grew 3% faster on locally derived periphyton at sites near compared to far from the canal. However, when reciprocally transplanted periphyton was considered, snails grew 10% faster at sites far from the canal on periphyton that originated near the canal. Snails produced more egg masses far from the canal regardless of snail size. Snails benefitted from higher quality resources at the cost of more predators and their cues near canals, while snails at sites far from the canal encountered relatively low quality resources and few predators. Our study builds on prior studies demonstrating that canals alter aquatic community structure. We extend this work by providing evidence that population dynamics of snails are different near compared to far from canals and suggest that the interplay between predation, predator cues, and nutrients could explain why other taxa show only minor or no response to human-impacted ecosystems.

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Interactions of Biological and Hydrogeochemical Processes Facilitate Phosphorus Dynamics in an Everglades Tree Island

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Nutrient concentration within and transfers between ecosystems are complex because they are often mediated by the interaction of a specific set of biological and geochemical conditions that operate at different temporal and spatial scales. Forest patches in semi-arid and wetland landscapes have been shown to exemplify some of these complex biogeochemical patterns and processes in nature. We investigated biological and geochemical factors suggested to contribute to phosphorus (P) movement and availability in an Everglades tree island. The study design characterized spatial and temporal variability in tree island evapotranspiration, local and regional hydraulic and geochemical patterns in ions and nutrients among four tree island plant communities (Dry Head, Wet Head, Near Tail, and Far Tail) and adjacent slough. Highest accumulation of Na and Cl occurred in the driest plant community and lateral transport of total dissolved phosphorus (TDP) to downstream plant communities varied seasonally and inter-annually depending on regional hydrologic conditions. The availability of TDP in downstream communities was associated with distinctly stratified water types along a gradient of chemical saturation relative to calcite and aragonite, with pH suggesting potential dissolution and reprecipitation of P. Recent efforts to determine P mass balance estimates suggest a complex spatial and temporal dynamic, mediated by the orientation of the plant communities and regional hydrology that influences tree island uptake and retention of P. Higher P exports and thus higher residual loss from the WH community in a dry year suggested an upstream or other external source of P. Taken together, these results suggest a complex spatial and temporal dynamic, mediated by the orientation of the plant communities and regional hydrology that influences tree island uptake and retention of P.

In an environmental management context, a nutrient concentration gradient that differentiates a treed patch from the landscape matrix provides good preliminary evidence that the patch landscape feature increases nutrient heterogeneity and consequently habitat heterogeneity. Maintaining or restoring habitat heterogeneity is a key feature of ecological management of the Everglades landscape. Trees are the notable and obvious distinction between these patches and the landscape matrix. Hydrologic variation, intra-annual and inter-annual, is critical not only for the survival of the trees that characterize the patches, but also for the movement of nutrients downstream that maintains tree islands. On the landscape level, the study illustrates that tree islands are nutrient concentration and storage features, suggesting that their disappearance has increased nutrients throughout the landscape.

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Mangrove Forest Soil Respiration: Short- and Long-Term Responses to Hurricane Disturbance

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We are investigating the effects of hurricane disturbance on the carbon and energy budgets of a mature mangrove forest at the Wilma (2005) impact zone. Three related research objectives are being addressed in Shark River Slough (SRS) of the Everglades, FL. First, short- and long-term effects of hurricane disturbance on the net ecosystem exchange of CO_2 (NEE) are under investigation with the installation of an eddy covariance system below the canopy, and through direct measurements of CO2 efflux from the peat surface and coarse woody debris. Second, annual net carbon uptake derived from the NEE data will be compared to estimates derived from changes in stem diameter, stand density, litterfall, root growth, and peat accretion following hurricane disturbance. Thirdly, we seek to model the impact of Wilma on the carbon dynamics in this forest by cross-validating both process-based, soil-plant-atmosphere and individual-based gap models.

We are measuring soil carbon efflux rates at 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. Soil carbon efflux measurements taken at these sites in 2008 and 2009 suggest that lower extent and frequency of tidal inundation is correlated with higher soil carbon efflux at SRS 4 as compared with SRS 5. Soil fluxes were also consistently higher at SRS 4 & 5 in 2008 than 2009, but flux rates at SRS6 were similar between years. After one sampling period (and four years after hurricane disturbance), the presence of an intact vegetation canopy had little influence on soil C efflux as compared with sites with little vegetation cover. While tree mortality and peat subsidence were a consequence of hurricane disturbance, frequent tidal inundation at SRS 6 may now be dampening these effects of tree mortality that have been suggested to increase soil respiration due to higher soil temperatures. We will continue these soil CO_2 flux measurements quarterly over the next two years with DOE funding, and present our most recent soil and woody debris respiration results.

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Creation of a National Community for Ecosystem Restoration

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Summary: The purpose of this session is to inform the GEER community on recent national efforts regarding creating a National Community for Ecosystem Restoration and provide a forum for dialogue and feedback from the audience.

The Need. Recognition of the need for a National Community for Ecosystem Restoration (NCER) is not new, and transcends all political, state and agency boundaries. Recommendations from the National Research Council and the US Army Corps of Engineers Environmental Advisory Board stress the need for **leadership** in the ecosystem restoration arena in order to achieve success. In addition, attendees at past National Conferences on Ecosystem Restoration have requested some form of collaboration bridging their bi-annual conferences.

The Concept. The NCER would be an entity whose membership would consist of individuals from governmental agencies, academia, non-governmental organizations and the private sector. The initial goal of the NCER would be to connect all ongoing ecosystem restoration efforts and fill recognized knowledge transfer and communication gaps. The NCER will help enable a **collaborative and holistic life-cycle approach** to ecosystem restoration.

The Mission. The NCER will foster ecosystem restoration information and knowledge exchange via a web-based Knowledge Gateway. The coalition would also work with a variety of partners to formulate and advocate a national agenda for scientifically and technically sound ecosystem restoration practices. The focus will be on four primary areas with the following themes:

- Technical Tools
- Knowledge Gateway
- Policy and Planning
- Partnerships and Networking

Conclusion. The NCER will connect ecosystem restoration efforts across the nation and ultimately around the world. Effective communication, information exchange and advocacy efforts will promote sustainable ecosystem restoration practices and will ensure leveraging of ideas, data and methodologies. The goal is to move our nation forward as the leader in collaborative, holistic and life-cycle approaches to ecosystem restoration.

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Effects of Hydrology on Growth and Survival of Juvenile *Procambarus alleni* and *Procambarus fallax*

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As keystone or very important species in Everglades food webs, little is known about hydrological effects on juveniles of native epigean crayfish *Procambarus alleni* (Everglades crayfish) and *Procambarus fallax* (slough crayfish). Understanding hydrological influences that affect growth and survival of juvenile crayfish is critical to conservation of this integral component of Everglades food webs. This is the first study of hydrological effects on juvenile crayfish of a known age of both *P. alleni* and *P. fallax.*

Laboratory studies were conducted to determine if either species had a competitive advantage over the other in growth or survival under three different hydrological regimes simulating conditions typical of Everglades wetlands: low water, high water, and drying (declining water levels over time). Berried females were captured from Everglades environments, as were adults of both species that were subsequently mated in the lab. All crayfish young were hatched in the lab and same-age juveniles of both species were tested from birth to 12 weeks.

Slough crayfish young experienced dramatic mortality in drying conditions by week 2, indicating that new hatchlings may have more sensitivity than Everglades crayfish hatchlings to declining water levels. After about 8 weeks, slough crayfish had significantly higher survival in all three water regimes than juvenile Everglades crayfish.

By 12 weeks, the survival of both species was significantly impacted by the water levels tested. Slough crayfish had slightly higher survival rates in low and high water levels and significantly higher survival in drying conditions than Everglades crayfish. Within a closed system, (aquarium) waste products could have accumulated faster from the larger Everglades crayfish. Slough crayfish may have larger gill space and can withstand lower oxygen levels than Everglades crayfish.

Hatchlings of both species initially experienced rapid growth by two weeks. Everglades crayfish were larger than slough crayfish in all water treatments after 4 weeks, and were significantly larger by the end of the experiment. Hydrological conditions significantly influenced growth (total length) rates of Everglades crayfish, but not slough crayfish over 12 weeks. Juvenile slough crayfish in all water levels grew to the same size by the end of the experiment. By 12 weeks, juvenile Everglades crayfish in low and high water levels reached significantly larger sizes than those in drying conditions. Water levels used in this experiment may not accurately reflect the range of depths in natural wetlands, but results indicate that small changes in water levels can affect survival and growth of both Everglades and slough crayfish.

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Natural and Human Factors that Affect Water Quality and Biological Resources in the Everglades Primary Canal System

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A system-wide analysis was conducted by the author as a contractor to the South Florida Water Management District, to assess how concentrations of nutrients (primarily phosphorus) in South Florida's regional canal system are related to natural features, historic construction, ongoing water management activities, and resident aquatic communities. The canal-based water management system in South Florida has developed over the past 100 years into one of the world's largest and most complex civil works projects. The Central and Southern Florida Project for Flood Control and Other Purposes was authorized by the federal government in 1949 and today consists of more than 500 water control structures, 60 pump stations and 2900 km of canals that are operated to provide flood control, water supply, navigation, and management of environmental resources within a 44,000 km^2 watershed. Canals in the Everglades were initially constructed to lower water levels in Lake Okeechobee, drain Everglades wetlands to allow development, and facilitate navigational access. They were not intended to serve as habitat for aquatic organisms and, in fact, are operated and maintained to prevent or minimize growth of organisms that may impede primary water delivery functions.

The process to develop numeric water quality criteria for nutrients should consider the many, often conflicting, functions and designated uses of canals for water management, which are critical for continued urban and agricultural development and survival of the Everglades, and their secondary importance for fishing and other recreational activities. Everglades canals play a vital role to sustain agricultural and urban development in South Florida and are also essential for Everglades restoration. Some canals have highly productive fisheries and others are important recreational resources due to their location in accessible locations. Canals in the Everglades can provide refuge for aquatic organisms, especially large predators, during drought periods, but also act as conduits that enhance the spread of exotic and nuisance species.

This poster will consider the following topics: a) history of Everglades canals, including relationship to historic flow-ways; b) features that make canals different from natural water bodies; c) effects of required operation and maintenance activities on vegetation, wildlife and water quality; d) features of topography, geology, hydrology, groundwater, soils and surrounding landscape that make Everglades canals significantly different from other South Florida canals; e) relationships of plant and animal communities in canals to concentrations of dissolved nutrients; and f) actions that can be taken to improve water quality and biological communities in canals.

Modifications to the canal system that are underway as part of the Comprehensive Everglades Restoration Plan provide opportunities to turn a legacy system, perceived as a liability, into an asset by implementing design and operational changes to improve water quality and ecological conditions in existing canals, remove or partially refill canals, and improve habitat quality by enhancing shoreline conditions and interaction with adjacent wetlands.

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Participatory Scenario Planning for Climate Change in Southern Florida's Greater Everglades Landscape

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There is widespread recognition that climate change will fundamentally affect how conservation planning can and should be done. As Hansen et al. (2010) state: "to be successful, conservation practitioners and resource managers must fully integrate the effects of climate change into all planning projects." Unfortunately, this is much easier said than done. Not only are wildlife habitats likely to shift in complex ways, but also climate changes will affect human beings and our use of land. Those responses potentially alter not only settlement patterns, but also many other sectors and land uses impacting conservation, including fisheries, agriculture and forestry. As supplies of resources such as water veer from historic patterns, ecological systems will likely face additional competition from human consumptive uses. More positively - human choices and policies for climate change mitigation provide an opportunity to alter economic, transportation and land use decisions in ways which might much better support conservation.

Few other landscapes will be so challenged by climate and landscape change as the Greater Everglades Region in Southern Florida. Under climate change, this region will experience significant loss of land, and potentially complex changes to human population settlement patterns. The need to address and plan strategically is critical given the complexity of overlapping systems and competing interests. Multiple scientific, economic and policy strategies have been formulated recently to address the challenges this phenomena poses to society - but sectoral approaches have not been able to provide comprehensive solutions.

In a two-year project funded by US Fish and Wildlife Service (FWS) and the US Geological Survey (USGS), our research team at MIT has developed a participatory modeling approach which allows managers to begin to grapple with key first and second order effects of climate change. Our study area was a 30 county region encompassing Southern and Central Florida. The project employed two methodological approaches: 1) stakeholder-based participatory landscape planning and 2) scenario-based simulation modeling. Through extensive consultation with over one hundred FWS managers, USGS scientists, county land use planners and conservation and water managers, eight scenarios were derived. The scenarios generated were nested within global IPCC scenarios, but included additional information and assumptions relevant to conservation planning in Florida. The scenarios were then used as inputs to spatial simulation models which simulated sea level rise and spatial shifts in human land use and settlement patterns. The resulting "alternative futures" represent a range of plausible future land use and land cover configurations in 2020, 2040 and 2060. This set of spatially-articulate potential future land use maps allows us to explore the interaction between global climate change, human population settlement preferences, and state and local policies. In particular, we can begin to judge the effectiveness of current conservation strategies against a landscape in which people - as well as species - are likely to relocate in response to climate change.

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Stuff Happens: Robustness and Flexibility as Tools for CERP Adaptive Management

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Adaptive Management (AM) can help address scientific/technical uncertainties by incorporating robustness and flexibility into the Comprehensive Everglades Restoration Plan (CERP) planning and implementation, and by learning through monitoring and assessment. One of the CERP AM principles is to incorporate flexibility and robustness into project and program planning, design, construction, and operations to address uncertainty. The National Research Council's Committee on Independent Scientific Review of Everglades Restoration Progress in their First Biennial Review of CERP Progress (2006) supported the use of robustness, which was described as the ability of key design parameters, including engineering, operations, and hydrologic responses, to operate effectively in the face of variability and uncertainty of future events. The draft CERP Adaptive Management Integration Guide Version 3.2 (March 2010) stated that the development of robust alternatives improves the likelihood of restoration success by ensuring good performance across a broad range of future conditions. Flexible alternatives ensure the capacity to change in response to future conditions to optimize restoration performance and improve the chance of success of achieving ecosystem goals. The concept of using robustness and flexibility in water resources planning, engineering, and management has been around since at least the 1970's and has some roots in the concept of ecological resilience introduced by Buzz Holling.[2] Reasons why we should use robustness and flexibility along with some of the limitations and impediments of their use as tools for AM will be described based on the author's many years experience in Water Management and RECOVER with the U.S. Army Corps of Engineers.

The UNESCO Working Group/ASCE Task Committee on Sustainability argued the best way to enhance sustainability is to maintain reversibility and robustness. They defined reversibility as keeping design and management options open or available for future generations and robustness as the ability to adapt to varying and often unforeseen conditions in the future with little additional costs. Robust, or flexible, systems may not be the most cost effective for the forecasted future condition, but rather are designed to be near cost effective for a wide range of possible future conditions.[3] IWR Director James Hanchey argued that a robust water resources system is able to absorb the inevitable range of uncertainties associated with the planning and design of a water resources project. These uncertainties include the typically cascading or cumulative uncertainties of model selection, parameters, and data and what is sometimes called strategic uncertainty – i.e., the forecasts of future conditions, needs, and project outputs.[4]

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Vegetation Ecology of Ghost Islands in the Everglades

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Tree islands in Water Conservation Area 2A (WCA 2A) have been significantly degraded due to water management practices initiated early to mid 20th century. Many of the islands have disappeared completely from the landscape and are now known as “ghost” islands. In this study, we surveyed the vegetation of eight “ghost” islands, one “live” island, and a “transitional” island in WCA 2A. Five points were sampled along each transect, three on the island and two in the surrounding marsh; three transects (head, middle and neartail) were measured on each island.

Canopy height, % canopy cover, and herbaceous vegetation height differed across transects within the islands. Canopy cover and height was highest at the head, and decreased towards the neartail. Lowered canopy heights at the middle and neartails of the ghost islands was due to presence of *Cladium jamaicense* (sawgrass) and the limited number of woody species at these sites. Most of the ghost islands had limited, if any, woody vegetation at the mid and neartail transects. The most common species on all islands was sawgrass. Vegetation on the “ghost” islands was fairly depauperate, with only a few species (*Salix caroliniana, Myrica cerifera, Schinus terebinthifolius*) dominating the head of the islands and sawgrass on the middle and neartail transects. Live tree islands (n = 72) in WCA 3A had about 50% canopy cover (Ewe, 2009) but the tree islands (ghost, live and transition) in WCA 2A only had ~10% canopy cover.

Structurally, the middle and neartails of many of the ghost islands appear to have been influenced by hydrology while vegetation at the head appears to be more resilient to these changes. This is evident by the loss of structure in the neartail and the sparser and smaller woody areas observed in the 2008 imagery relative to the 1940 photography in some of the northern islands. However, structural integrity on the head of the tree islands within the WCA 2A landscape has persisted, indicating an ability of the vegetation on the head to adapt and sustain despite changes in hydrology over the last half century.

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Response of Wading Birds to Fire in the Central Everglades

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Fire has long been used as a management tool in uplands to alter habitat and encourage habitat use. Although wetlands are also sometimes burned for similar reasons, it is unclear whether and how wetland animals might benefit from the effects of burning. Anecdotal evidence and recent work in cattail-infested areas suggests that long-legged wading birds (i.e., herons, egrets, ibises, storks, spoonbills, order Ciconiiformes) are generally attracted to recently burned areas. The goal of this study was to determine whether burned areas in the central ridge and slough habitat of the Everglades are preferred locations for foraging by wading birds. We flew weekly aerial surveys over pre-determined burn units before and after fires to determine locations of foraging wading birds. Aerial surveys covered 100 percent of the burn and an additional similarly sized, adjacent unburned area. Birds were identified, counted, and categorized based on the habitat in which they were standing (i.e., burnt ridges, slough with adjacent burn, slough, sawgrass, airboat track). We also conducted foraging observations of wading birds to determine whether foraging success differed between burned and unburned areas. Preliminary results suggest that wading birds are found in greater numbers in burned areas than in other available habitats immediately after a burn, a result which diminishes with time since burn.

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Online Everglades Library (OEL)

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An online Everglades scientific resource library is essential as an information center for widely scattered Everglades-related science efforts and as a resource for the community dealing with multifaceted problems of the Florida Everglades. The independent *EvergladesHUB.com* website is well positioned to develop and provide an excellent digital platform for a new information system focused on collecting and offering scientific research literature. A working pilot example is already currently provided on this website presenting citations of scientific journal articles published during the last 5 years. They have been conveniently divided into 7 most relevant science fields:

Agriculture, Biology & Zoology, Hydrology, Modeling, Water-Nutrients, Water-Toxicants, and Wetlands. The new Online Everglades Library *(OEL)* is offering the **Science** literature database as an initial priority because of the immediate demand. The literature database domains will gradually be expanded for other key areas such as **Law**, **Business**, **Social Sciences**, **Governmen**t, **Media releases**, (etc.).

This facility will substantially differ from existing *Everglades Digital Library* (FIU), *SOFIA* (USGS) and *NPS* information systems that contain only a very limited selection of literature resources. Restricted by different regulations and lack of resources, these could hardly serve as an information resource for all of Everglades-related interests and they remain on the distant fringe of the current information flux and demand where vast amounts of information are required to flow instantaneously, digitally, and online, accessible to all.

The expansion of the *OEL* pilot project into a comprehensive database to cover at least 40 years of published scientific literature is considered. Apart from offering titles and abstracts of published articles, *EvergladesHUB.com* website will also offer open access to full texts wherever possible. As full access to subscription-based literature publications offered by commercial databases is invariably expensive and often cumbersome, all the various Everglades stakeholders would benefit from the availability of a carefully pre-selected relevant literature resource base at their fingertips - online. In future, this free online facility will also offer a section with consolidated technical and scientific reports available in the public domain that have been broadly scattered and difficult to locate. In addition, the user-friendly *OEL* will feature high-speed search capabilities and will be continuously maintained and updated.

This presentation will familiarize the audience with the concept of the proposed new *OEL*, its features and operation.

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Does Water Hyacinth (*Eichhornia crassipes*) Compensate for Simulated Defoliation? Implications for Effective Biocontrol

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Biocontrol agents of water hyacinth (*Eichhornia crassipes*), one of the most ubiquitous invasive aquatic species in the world, were introduced in the waterways of Florida, USA, more than 30 years ago but have not been as successful as expected. The high nutrient, high light, warm year-round temperatures and lack of natural predators provide an optimal growth environment for the plant. The current study was designed to test if a compensatory response by the water hyacinth plants to low levels of biomass removal was one of the reasons for the ineffectiveness of biocontrol agents in the successful control of water hyacinth. The plants were exposed to two levels of nutrient (high and low) and three levels (0%, 10% and 80%) of simulated herbivory treatment. The effect of the nutrient and repeated (i.e., chronic) defoliation treatments was determined after six weeks. Plants with 10% defoliation did not show any significant difference from control plants in biomass allocation or relative growth rate (RGR) in either nutrient concentration, while 80% defoliation caused a significant decrease in the final RGR under high and low nutrient treatments. High nutrient treatment resulted in higher RGR and allocation to asexual reproduction resulting in higher biomass accumulation compared to the low nutrient treatment, which had higher root growth and allocation to sexual reproduction. Results from this study indicate that water hyacinth can fully compensate for low levels of continuous defoliation regardless of the nutrient concentration, which has implications and important considerations for biocontrol strategies.

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Trophic Focusing of Nutrients on Tree Islands in the Florida Everglades

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The Florida Everglades is a patterned wetland consisting of thousands of relatively phosphorus-rich tree islands in a matrix of oligotrophic sawgrass ridges and deeper-water sloughs, which rely on scale-dependent feedback for pattern maintenance. The primary objective of our study was to determine if the apparent redistribution of nutrients from marshes to tree islands in the Florida Everglades is primarily driven by trophic focusing of animal inputs. We examined soil and foliar nutrients, including, TP, $\delta^{15}N$ and TN across Everglades slough to tree island gradients. Foliar N:P values among the nine species studied ranged from 11 to 19 and supported the hypothesis that vegetation on tree islands were largely N-limited while plants located on tree island tails and surrounding sloughs were largely P-limited. Also consistent with previous studies, we found no significant variability between soil TN and landscape location. In contrast, soil and foliar $\delta^{15}N$ and TP were highest on island heads and decreased in tree island tails and were typically the lowest in the adjacent sloughs. Levels of enrichment varied greatly among islands, though average $\delta^{15}N$ levels were at or above 2, nearly a magnitude higher than ambient atmospheric levels of $\delta^{15}N$. Soil $\delta^{15}N$ and TP levels were positively correlated suggesting a common source. Foliar N:P and foliar $\delta^{15}N$ were negatively correlated, suggesting greater uptake of $\delta^{15}N$ by N-limited plants. The results of our study support the hypothesis that a significant source of P on Everglades tree islands is a result of trophic focusing of animal derived nutrients.

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Interactions between Periphyton and Macrophytes in the Southern Everglades Wet Prairies, USA

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Periphyton and plant communities coexist in Everglades marshes, yet not much is known about the form of interactions among them. Both communities are influenced by hydrology, yet plant- and periphyton-based hydrologic inference models, used to guide Everglades restoration, have not considered the potential mediating effect of their interaction. This is particularly true in the marl prairie, where hydrology is the primary driver of plant and periphyton community change. In order to characterize the interactions between periphyton biomass and plants in different hydrologic settings, we carried out a removal experiment at three sites with contrasting hyderoiperiods in the southern Everglades wet prairies. Four permanent 50 m long transacts were at each of the sites in May 2003. Twelve 0.25 m^2 large pairs of sparsely vegetated plots were chosen for the periphyton-removal plots with matched control and treatment plots, and the other twelve pairs of densely vegetated plots were designated as plant-removal plots, with matched control and treatment plots. After initial assessment of environmental conditions, periphyton biomass, and plant biomass and structure at each site, plots have been harvested on bi-monthly basis between May 2004 and April 2006.

Muhlenbergia filipes was affected negatively by periphyton removal, while *Rhynchospora tracyi* biomass increased at the deepest site and declined at medium-depth site during dry periods. Additionally, *Panicum tenerum* and *Solidago stricta* biomass benefitted from periphyton removal at shallower sites during dry periods, while biomass of *Schizachyrium scoparium* var. *rhizomatum* and *Sisyrinchium angustifolium* significantly declined, especially during wet period in 2005. Removal of macrophytes benefited periphyton biomass. We hypothesize that the enhanced growth of periphyton was most likely due to the opening of new areas for algal colonization after plant removal and higher availability of sedimentary nutrients, which are normally sequestered faster by macrophytes. Additionally, we hypothesize that because periphyton mats are a source of nutrients and moist to plant roots, their removal had a negative effect on biomass of plants that heavily rely on moisture for seed germination and are sensitive to nutrient fluctuations, but the removal was beneficial to the young shoots of plants that have delicate structure in the early stages of their growth and are prone to smothering by thick periphyton mats. Conclusions for modeling?

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Response of Diatom Communities to the 20th Century Changes in Water Quality Conditions in Biscayne Bay

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The ecology of Biscayne Bay has been greatly affected by intensive urban development in South Florida. Construction of flood-protection structures and expansion of agricultural areas along the Bay's coast resulted in changes of quantity and quality of water that is being delivered into the Bay. These changes have been superimposed on long-term climate-driven changes and sea level rise. Due to the planned Biscayne Bay restoration, which aims to increase freshwater flow into the Bay, it is imperative to determine the impact that these changes may have on the Bay's biota and establish the pre-impact environmental conditions in order to aid selection of appropriate restoration targets.

In order to accomplish these goals we developed diatom-based quantitative salinity and nutrient prediction models, and applied them to fossil records preserved in sediment cores collected at three locations in central and south Biscayne Bay. Additionally, we evaluated compositional changes in diatom distribution with depth/time in the cores. Even though reconstructions did not reveal significant trends in salinity and nutrient concentration, diatom communities responded to changing water quality conditions with increased rates of community restructuring. Species turnover rates significantly increased at Featherbed Bank (central Bay) since around the early 1940's, and communities at No Name Bank (central-north Bay) and in Card Sound (south Bay) experienced similar changes in the 1950's-1960's and around the 1980's. These findings imply that the magnitude of species turnover rates significantly increased since surface and ground freshwater flow into Biscayne Bay was altered as a result of the extensive modifications of hydrological conditions on mainland. Diatom assemblages in Biscayne Bay are very sensitive to even small changes in salinity and water quality conditions, and they respond to those changes quickly by changing their community structure. Therefore, diatoms are excellent ecological indicators because they can provide early warning signs of deteriorating environmental conditions faster than instrumental surveillance of water quality, which is imperative in restoration efforts. Our study also showed that diatoms can resist water quality alterations to some point, but their communities change almost completely when ecological thresholds are reached or surpassed. Complete restructuring of diatom communities in the past was most likely due to the combined effects of anthropogenic and stronger than usual natural factors such as hurricanes or unusually strong teleconnection patterns. These factors affect the amount of rain in South Florida, and the quantity and quality of water that is being released from the drainage canals into Biscayne Bay. Results of this study should be used as a warning that even small changes in water quality can cause significant changes in Biscayne Bay fauna and flora.

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Designing and Testing Modeled Hydrological Performance Measures

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A performance measure (PM) may be alternatively termed a figure-of-merit, or objective function. Modeled PMs may be applied as design constraints or as objectives to be maximized or minimized, and are often applied in support of selecting a preferred alternative. Performance Measures quantitatively clarify project objectives, benefits, and impacts.

Here, alternative PMs for adequacy of meeting ecologically beneficial high stage conditions in the Arthur R. Marshall Loxahatchee National Wildlife Refuge are examined. We analyzed two alternative PMs using three modeling approaches: The first PM, designated PM 1a, is based on the number of days during each annual high-water period that stage exceeds 5.18 m (17 feet) NGVD 29. A second measure, designated PM 1b, annually aggregates a daily index that varies in a piecewise linear fashion from zero at and below 5.00 m (16.4 feet), to one at and above 5.30 m (17.4 feet). These PMs were tested using the Simple Refuge Screening Model (SRSM), a model applying the commercial MIKE-FLOOD model, and the South Florida Water Management Model (SFWMM). The three models performed similarly in predicting historical values of the PMs, and it is concluded that the simpler model, the SRSM, is likely the most efficient model choice for many modeling studies utilizing these PMs. We conclude that:

- Traditional model calibration statistics do not necessarily correspond to the model's capability to simulate historical PMs.
- Reliability of a model in projecting PMs is reduced for PMs that are dependent on very rare events over the simulation period.
- Reliability of a model in projecting PMs is reduced for PMs that are based on a single trigger level or discontinuity.
- Criteria for acceptability of model calibration in applications projecting PMs for alternatives may necessarily be less stringent than traditional model calibration evaluation.

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Presence of Invasive Cuban Treefrog Reduces Probability of Occurrence of Native Treefrog Species in Southern Florida

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The Cuban treefrog, *Osteopilus septentrionalis*, an introduced species in southern Florida, USA, represents a potential threat to native treefrog species, but the ecological consequences of this invasive species are not fully known. Identifying patterns of co-occurrence of species is important for understanding potential interspecific interactions and the role these interactions may play in influencing spatial patterns of community composition. We developed a new model for estimating patterns of co-occurrence of interacting species in which the occurrence of one species is assumed to depend on the occurrence of another, but the occurrence of the second species is not assumed to depend on the presence of the first species. We assessed whether the occurrence probabilities of native treefrog species differ in the presence and absence of Cuban treefrogs while accounting for differences in occurrence associated with differences in habitat. We found that sites occupied by Cuban treefrogs were 9.0 times less likely to contain green treefrogs and 15.7 times less likely to contain squirrel treefrogs compared to sites without Cuban treefrogs. We found no evidence of an effect of Cuban treefrog presence on the detection of the native species, indicating that their behavior is not altered by the presence of the Cuban treefrog. We also found a significant effect of longitude on the occurrence of Cuban treefrogs which supports our hypothesis that these frogs are invading eastward from the presumed source to the west of our study area. Our model is not able to determine the mechanism by which the native treefrog species are excluded from sites, but other studies indicate that Cuban treefrogs are predators of these species, and they likely also compete for common resources.

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Nested Conceptual Models for Understanding Ecological Impacts of Burmese Pythons in the Florida Everglades

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Invasive species have the potential to impact the communities they invade. For a large predatory species that is a dietary generalist, direct predation can potentially yield the largest impact on native fauna. However, diet is not the only factor important in evaluating potential impacts. Conceptual models can be useful tools in identifying other contributing factors to the decline in native species abundance and in elucidating relationships among those factors. We developed a set of nested conceptual models to better understand potential ecological impacts by Burmese pythons (*Python molurus bivittatus*) in the Florida everglades. The hierarchy includes a primary model of the python population that identifies performance measures for python management and a secondary model that links the python population to impacts on prey. These models identify key drivers and stressors in python population dynamics and python energetics and hypothesize how those factors affect pythons and their prey. These conceptual models not only help to clarify how and why pythons might be impacting native species, but also identify key areas for future research that we are undertaking.

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Using Stable Isotopes and Remote Sensing to Study Nutrient and Water Relations in the Everglades Tree Islands

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The Florida Everglades tree island upland hammock communities are nutrient hotspots. These elevated habitats have a much higher P concentration than the extremely P-limited wetland matrix dominated by sawgrass (*Cladium jamaicense*) freshwater marshes. Here we used stable isotopes and satellite remote sensing analysis to study the eco-physiological processes that lead to this contrast in nutrient distribution. Based on the chemohydrodynamic nutrient accumulation model, we hypothesized that tree islands harvest nutrients by taking up water from the surrounding freshwater marshes, and therefore the tree islands that can harvest more marsh water should have higher P availability than tree islands that harvest less marsh water. We selected tree islands located in the Shark River Slough (perennially flooded) and the adjacent prairies (seasonally flooded) to study their water use patterns and nutrient status. We analyzed hydrogen and oxygen stable isotopes (δ^2H and δ^{18}O) of stem water to determine the water sources that tree island plants take up. The results showed that during the wet season, the tree island upland hammock plants take up rain water trapped in the tree island soil; during the dry season, however, the plants take up the isotopic enriched marsh water from the surrounding marsh matrix. This finding supports our hypothesis and also suggests that the nutrient harvesting process mainly happens during the dry season. We observed that prairie tree islands located in the prairies suffer greater dry season water deficits than tree islands located in the slough by examining shifts in foliar δ^{13}C values from wet to dry season. Further, we found that slough tree islands have higher soil total phosphorus concentration and lower foliar N/P ratio than prairie tree islands. Foliar δ^{15}N values, which often increase with greater P availability, was also found to be higher in slough tree islands than in prairie tree islands. In addition, we utilized five cloud-free SPOT 4 multispectral images (20m spatial resolution) from different times of the seasonal cycle to derive two atmospherically corrected vegetation indices: the normalized difference (NDVI) and the normalized difference water index (NDWI), averaged for each tree island. We found that NDWI, which is reflective to the canopy water content, was positively correlated with the foliar δ^{15}N values of each tree island. Moreover, the correlation is more significant during the dry season than during wet season. These results suggest that prairie tree islands have less water available during the dry season and therefore accumulate less P than slough tree islands during the nutrient accumulation process. Overall, our study adds a temporal and geographical scale to the chemohydrodynamic nutrient harvesting model. We can conclude that dry season is the nutrient harvesting season, and that the hydroperiod of the surrounding marsh matrix is critical in determining the amount of P that the tree islands are able to accumulate.

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Climate-based Distribution Models for the American Crocodile, *Crocodylus acutus*: Illustration of Methodological Challenges and Management Opportunities

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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 21st century. Climate-based species distribution models (climate envelope models) provide one tool that may be used to inform management activities relating to the assessment and adaptation to future climate change. As part of a larger effort to create climate envelope models for 21 species of threatened and endangered vertebrates whose distribution includes the Peninsular Florida Landscape Conservation Cooperative (LCC), we present a prototype model for the American crocodile (*Crocodylus acutus*) that illustrates both limitations and challenges associated with species distribution modeling, as well as how management recommendations can emerge from models of projected future distributions. When modeling the contemporary climate envelope for a species, the often arbitrary selection of a geographic study area can have important implications for the differentiation of “suitable” and “unsuitable” climate space. We compare models bounded by the entire western hemisphere with models bounded by a more realistic climate space determined by observed distributions of other New World crocodilians. We explore projected future distributions of *C. acutus* in the year 2080 under high and low CO_2 emissions scenarios. The high-emissions scenario projects a 70% expansion of suitable climate space for *C. acutus* from approximately 860,000 km^2 at present to 1.46 million km^2 in 2080. The projected future climate envelope for *C. acutus* under a low-emissions scenario suggests a 45% expansion in area to approximately 1.25 million km^2, although the low-emissions scenario predicts a more northerly expansion of suitable climate space in Florida than the high-emissions scenario. Both scenarios predict suitable climate space for *C. acutus* within the Peninsular Florida LCC, but the high emissions scenario also predicts an expansion of suitable climate space into coastal portions of the Gulf Coastal Plain and Ozarks LCC. These data coupled with projections of sea level rise and land use changes provide information that will be useful in assessing the vulnerability of *C. acutus* to climate change and identifying opportunities for future protection for *C. acutus*.

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Decompartmentalization and Sheetflow Enhancement within Water Conservation Area 3

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Often referred to as the "heart of Everglades restoration", the Water Conservation Area (WCA) 3 Decompartmentalization and Sheetflow Enhancement Project (Decomp) aims to restore more natural flow patterns through the removal of levees and canals within the project area. The restoration of these flow patterns is expected to help restore the historic ridge and slough landscape within WCA 3 and in turn, the native flora and fauna. With successful completion of the Decomp project, 70 miles of continuous flow paths will be restored, from the southern border of the Everglades Agricultural Area to Whitewater Bay; more than two thirds of their original length.

The Decomp project will be implemented in 3 phases, each with their own Project Implementation Report (PIR). Decomp is currently in the planning phase of PIR 1. The scope of PIR 1 includes some degree of backfill and levee degradation of the Miami Canal between structures S-8 and S-151. Recent guidance has broadened the scope of Decomp PIR 1 to include a hydration feature along the northern border of WCA 3A with the intent to rehydrate that area. Decomp PIRs 2 and 3 encompass further canal backfill and levee degradation within the project area. A field test (the Decomp Physical Model) has been designed to answer several uncertainties associated with these future PIRs, with field sampling scheduled to begin October 2010.

The Decomp project faces several challenges in planning and implementation. Due to the complex hydrologic interactions between WCA 3 and its surrounding areas, the uncertainty of future CERP and non-CERP projects forces the planning team to consider both near-future (2015) and far-future (2050) project benefits. These uncertainties contribute to project scope changes and potential project delays. Water quality is an overarching Everglades restoration concern that directly affects the water entering WCA 3. Several stakeholders follow the Decomp project closely, each with their unique desired outcomes for the project area (recreational fishermen and environmentalists, for example).

The Decomp project is a prime example of the unique challenges faced in planning and implementing Everglades restoration projects. This poster seeks to highlight the project purpose, status, challenges faced, and path forward.

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Landform Elevation as Evidence of Regular Surface Patterning in Big Cypress National Preserve, Florida

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Understanding the underlying mechanisms that create patterning in landscapes has become increasingly popular among ecologists, especially because of the insights they offer to management and restoration efforts. Aerial and satellite imagery of Big Cypress National Preserve (BCNP) suggest regular surface patterning of depressional landscape features. It is hypothesized that reciprocal feedbacks between biotic and abiotic processes may promote the development of depressions in the landscape whereby the dissolved atmospheric CO_2 causes slow dissolution and deepening of the limestone. The resulting patterning would be evident in a bimodal distribution of landform elevation and community type. Our study had two objectives: 1) evaluate existence of bimodality in the landscape of BCNP by analyzing land surface and underlying limestone elevation and 2) characterize community type at the different elevations. Soil and limestone elevations were measured in two, 1 km^2 study plots comprising representative mosaic landscapes in the Preserve. The underlying limestone elevation was a strong predictor of soil thickness but not surface elevation. Soil surface elevation was not a predictor of soil depth and showed remarkable agreement between sites, suggesting that this mechanism acts across the landscape. Analyses of limestone and soil surface topography revealed significant bimodality in the distributions of soil-elevation and limestone surface measurements, consistent with our predictions. We describe possible reciprocal-feedback mechanisms and suggest future tests to determine the extent to which biotic and abiotic processes and their interactions may produce topographic signatures in the South Florida landscape.

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Post-Fire Survival of Pond Cypress following the Deep Fire, Big Cypress National Preserve, Florida

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The Deep Fire burned 27,000 acres of pine uplands, hammocks, and cypress swamps in Big Cypress National Preserve during April and May 2009. Due to the drought conditions at the time, the fire burned into wetland communities that rarely experience fire and ignited smoldering peat fires. This rare event provided the opportunity to assess immediate post-fire mortality of pond cypress (*Taxodium distichium* var. *imbricarium*) in cypress domes affected by the fire. We measured survival and fire-related injury in a sample of 25 domes of varying sizes located throughout the burn. Within each dome, fire injury and severity data were collected to determine whether dome size or distance from the edge of the dome were predictors of mortality or the severity of tree injury from the fire. We also measured fire severity using Composite Burn Index (CBI) for each of the domes at the dome centers and at the dome edges.

Cypress mortality was very low (~0.5%) two months following the fire despite high fire severity values, indicating a high resistance of the species to fire. Also, hypothesized edge and dome size effects on fire severity were not observed. The lack of edge and size effects on fire severity may have been related to the unusually dry conditions when the fire occurred. We also present preliminary results from a survey of delayed mortality among pondcypress, to be collected one year following the Deep Fire in May 2010. Our results indicate a need for greater understanding of the ecological role of fire in wetland ecosystems that rarely burn, but do so severely under the right conditions.

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Hydrologic Controls on Ecosystem Carbon Exchange in Ridge-Slough Landscape

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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. The loss of pattern can be partially 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), which has interrupted the feedbacks that previously maintained elevation differences between ridges and sloughs. The objective of this study is to determine how local and regional variation in hydrology controls annual ecosystem carbon exchange, and to aid in determining the hydrological conditions under which ridges and sloughs can persist as long-term, stable, peat accreting states. We present the first year (December 2008 through December 2009) of bi-monthly ecosystem respiration measurements taken at 64 locations (32 ridge-slough pairs) along a gradient of hydrologic conditions in Water Conservation Area (WCA) 3A, as well as preliminary data on net ecosystem exchange. A multivariate model was used to predict respiration based on hydrologic attributes (inundation probability, median water depth) and other environmental covariates (water temperature, pH, and community type). Extrapolating this model to the recent hydrologic conditions at each of the locations allows preliminary investigation into our central hypothesis that the ridge and slough landscape patches represent alternative configurations for achieving the regional rate of peat accretion.

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Space-Based High-Resolution, Multi-Temporal Monitoring of Wetland Water Levels: Case Study of WCA1 in the Everglades, Southern Florida

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Interferometric Synthetic Aperture Radar (InSAR) techniques can successfully detect phase variations related to the water level changes in wetlands and produce spatially detailed high-resolution maps of water level changes. Despite the vast details, the usefulness of the wetland InSAR observations are rather limited, because hydrologists and water resources managers need information on absolute water level values and not on relative water level changes. We present an InSAR technique called Small Temporal Baseline Subset (STBAS) for monitoring absolute water levels time series using radar interferograms acquired successively over wetlands. The method uses stage (water level) observation for calibrating the relative InSAR observations and tying them to the stage's vertical datum. We tested the STBAS technique with two-year long Radarsat-1 data acquired during 2006-2007 over the Water Conservation Area 1 (WCA1) in the Everglades wetlands, south Florida (USA). The InSAR derived water level data were calibrated using 13 stage stations located in the study area to generate 28 successive high spatial resolution maps (50 meter pixel resolution) of absolute water levels. We evaluate the quality of the STBAS technique using a root mean square error (RMSE) criterion of the difference between InSAR observations and stage measurements. The average RMSE is 6.6 cm, which provides an estimation of the STBAS technique to monitor absolute water levels. About two thirds of the uncertainty are attributed to the accuracy of the InSAR technique to detect relative water levels. The other third reflects uncertainties derived from tying the relative levels to the stage stations' datum.

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CERP Climate Change Study - Modeling the Effects of Sea Level Rise in South Florida

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The modeling work plan for the CERP Climate Change Study is based on the premise of interagency cooperation and consensus in the modeling approach. This entails that a common suite of modeling tools be developed and utilized by the participating agencies (USACE, USGS, SFWMD) during the study. It will also involve a phased approach with initial efforts aimed at development of density-dependent groundwater models along the coastal areas of the study area. Initially these models will be used primarily to assess the effects (i.e., salinity intrusion and increased flooding potential) of varying levels of predicted sea level rise on the groundwater and surface water systems near the coastal areas. Subsequently, these density-dependent groundwater models will be further enhanced and converted to integrated surface water groundwater (ISGW) models with the addition of surface water components such as canals, water control structures and operations in order to better represent the overall hydrologic system response to climate change. This improved representation of the physical system will also allow for the modeling of potential adaptation strategies, either as structural, non-structural or operational measures, in response to the effects of sea level rise. Surface water bodies including rivers, estuaries, and some lakes may be affected by the sea level rise, either directly because they are within the spatial extent of the physical rise or indirectly because their inherent hydro-dynamics have been affected by changes in the volume and water quality of inflows and outflows resulting from the sea level rise. For example, estuaries will be directly inundated with increased depths of saline water and indirectly affected by reductions of freshwater discharges from coastal rivers and water control structures. Therefore, it is anticipated that hydrodynamic modeling of estuaries and bays will be needed with upland boundary conditions provided by the before mentioned integrated surface water groundwater models.

Both event scale and multi-year continuous scale simulations will be performed utilizing different modeling tools designed to capitalize on their strengths. Continuous longer term simulations are particularly suited for evaluating the effect of climate change on salinity intrusion, water supply, well-field vulnerabilities, ecosystem health and vegetation change while event scale simulations are more useful in evaluating system response and performance under short-term phenomenon such as intense rainfall flood events and accompanying rapid operational changes.

Only USACE certified modeling software will be employed and most modeling products will undergo three types of review: 1) Interagency Modeling Center (IMC); 2) Agency Technical Review (ATR) and 3) Independent External Peer Review (IEPR). All models will be constructed in reference to the National American Vertical Datum, 1988 (NAVD88) as mandated by USACE and CERP guidance.

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Shifts in Snail Kite Nesting and Implications for Central Florida Lake Management

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The Everglade Snail Kite (*Rhostrhamus sociabilis plumbeus*) is a critically endangered raptor that feeds primarily on freshwater apple snails (*Pomacea* spp.) from Florida's larger wetlands. For reasons not entirely understood, the majority of nesting activity over the last 5 - 10 years has shifted to several lakes in central Florida, instead of the historically significant breeding areas of the Everglades. This shift was accompanied by smaller percentages of the population actively breeding, and estimates that nearly 75% of the population was lost in the last 10 years (< 600 remain). Further, the largest concentration of nesting attempts left in the state are apparently supported by a newly introduced exotic apple snail (*Pomacea insularum*) which is primarily foraged from dense populations of the invasive exotic weed, Hydrilla (*Hydrilla verticillata*). These events have challenged the status quo of various agencies involved with managing aquatic habitat and wildlife resources in central Florida, and have sparked new coordination and joint efforts in the conservation of this species. The Florida Fish and Wildlife Conservation Commission has created a new position to coordinate these efforts, and are implementing a proactive approach to improving nesting and foraging habitat, minimizing nest failures and fledgling mortality, and promoting public awareness of one of our state's imperiled treasures.

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Everglades Science in Support of Restoration – Synthesis of Everglades Restoration and Ecosystem Services (SERES)

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The restoration of the Everglades requires resource managers to make complex decisions within a framework of societal, ecological, and institutional interests. Scientific information is an important input into this decision-making process, but that information is traditionally presented in scientific journals or agency publications. The synthesis of scientific information across multiple disciplines and into natural resource decision making is left to managers and policy makers. There is a strong need for the "co-production" of knowledge and synthesis by managers and scientists. Managers need to be involved in articulation of scientific, synthesis, and restoration questions and scientists need to be involved in the interpretation of scientific knowledge and synthesis for use in policy. It is by such a co-production process, through the common development of products and solutions, that credible and salient restoration decisions can be made.

In this presentation we describe such a co-production effort to synthesize Everglades science in support of restoration. The effort is supported by a two year grant to the Everglades Foundation from the Department of Interior. The objectives of the project are to:

- Synthesize existing freshwater Everglades science relevant to management questions
- Perform options analyses on a range of restoration scenarios and
- Produce integrative products that are understandable and that inform decision making

A core team of scientists and natural resource managers have co-produced a set of key science management questions about Everglades restoration. Hydrologic restoration of the Everglades ecosystem was established as the main question to be addressed and then related to five focal areas: exotic species, water quality, microtopography, food web dynamics, and landscape pattern. The effect of climate change as an external driver of Everglades restoration scenarios was also identified as a management concern. A synthesis of current scientific information about each key management question will be used to analyze a set of restoration scenarios. These analyses will highlight ecosystem services and trade-offs of each scenario. Although the core team has primary responsibility for the project effort it will regularly seek input and review from the extended core team of resource managers and the greater Everglades science community using this model of co-production. A discussion session immediately following this presentation will provide an opportunity to explore ideas with the extended Everglades restoration community.

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Knowledge Gaps in Tree Island Ecology

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Prior to 1997, vegetation research in the Everglades focused on herbaceous marsh and slough plants. Islands of woody vegetation had been noted, but virtually ignored by ecologists despite numbering in the thousands. However, the sheer presence of tree islands on the landscape and a growing awareness of their decline focused attention on their function in the Everglades ecosystem. Conceptual models describing nutrient movement on tree islands and island expansion were developed. Once it was discovered that tree islands were nutrient hot spots on the landscape the original individual tree island models were expanded to encompass landscape level biogeochemical processes and were tied to mechanisms of landscape patterning. Tree islands, and their function in the Everglades ecosystem, are now at the forefront of the Everglades restoration process and it is accepted that full restoration of the Everglades cannot occur without the restoration of tree islands.

Several areas of study are needed to continue our understanding of tree islands and develop restoration strategies that can be applied with confidence. One important area of study as a measure of ecosystem change is the strength of resource gradients–nutrient, hydrologic, topographic–on the landscape. If it is assumed that tree islands form the endpoint of the slough—ridge—tree island landscape pattern, then a pattern of decreasing strength in resource gradients is expected. Tree islands in the process of decline, ghost tree islands, are expected to have weaker resource gradients than fully functional islands. Therefore, the study of ghost tree islands for a greater understanding of healthy tree island function and for strategies of tree island restoration is clearly necessary.

Other information gaps include the island and landscape level importance of the aerial nutrient capture by trees. Aerial nutrient inputs are not known and may affect the underlying mechanism and significance of tree island pattern in the Everglades. Finally, the difficulty and expense of tree island research has limited studies to individual islands. There is a need to understand ecosystem processes and interactions within a cluster of tree islands. This knowledge is needed to determine if the tree islands are functioning collectively in ways that are not apparent on a single island.

Knowledge of tree island ecology has increased greatly over the last decade, although there are still significant gaps in our understanding. As tree island research continues to fill those gaps with a goal towards restoration, it is important to recognize that a complete understanding of tree island ecology is not possible. The uncertainty of this lack of knowledge should not prevent restoration efforts using the best existing information, while constantly incorporating new findings as they become available.

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Corridors of Invasiveness Plant Monitoring, NPS Early Detection Protocol for Invasive Exotic Plants

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Invasive plants are one of the most serious threats to maintaining ecosystem integrity in South Florida. Detecting new species with the potential to become invasive while they are still in small controllable populations is an important cost-effective resource management action that can be taken to deal with invasive plants. The monitoring goal of the South Florida Caribbean Inventory and Monitoring Network's (SFCN) Corridors of Invasiveness program is to detect newly emerging invasive plant species. Corridors of invasiveness are areas that allow or facilitate the introduction of exotic species due to intentional or non-intentional human activities. For our purposes corridors of invasiveness include paved and unpaved roads, trails, trail heads, ORV trails, boat ramps, campgrounds, and canals. For this program, new invasive plant species are restricted to plant species that are not listed in the park unit currently.

In 2009, the SFCN Corridors of Invasiveness program surveyed 76 mi in Everglades National Park, 28 mi in Big Cypress National Preserve, and 11 mi in Biscayne National Park. A total of 46 exotic species were encountered during the pilot study. Of these 46 species, 15 were new to the parks. Everglades National Park had the most new species at 8, followed by Big Cypress National Preserve with 5, and Biscayne National Park with 2 new exotic plant species. In EVER, the new species include *Washingtonia robusta, Bougainvillea spectabilis, Auracaria heterophylla, Mangifera indica, Stenotaphrum secundatum, Panicum repens, Senna pendula,* and *Emilia sonchifolia*. In BICY, the new species include *Stachytarpheta urticifolia, Ludwigia peruviana, Panicum repens, Lantana camara*, and *Sphagneticola trilobata*. In BISC, the new species include the trees *Ficus religiosa* and *Syzygium cumini*. In both cases these trees were small in stature and consisted of only one individual for each species. All location and amount of infestation information has been forwarded to the appropriate park personnel in each park unit.

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Long-Term Spatial and Temporal Heterogeneity within Everglades Marl Prairies: A Late Holocene Perspective

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Marl prairie habitats in the Florida Everglades provide critical refuges for rare and endemic species, including the endangered Cape Sable Seaside Sparrow (CSSS). Strategies to stabilize and maintain their habitats have become an important component of Everglades restoration planning. Marl accumulation requires the shortest hydroperiods (3-7 months) of Everglades wetlands. Landscape models have suggested that hydroperiods in modern marl prairies may have been long enough to support peat accumulation during historic time. Our prior paleoecological research on marl prairies documented a shift from peat to marl accumulation at some sites that was nearly synchronous with the onset of 20th century water-management practices. We will present new results from a more extensive study on marl-prairie vegetation, hydroperiod, and fire regime patterns of the last few millennia.

We studied sediment cores at thirty-five sites spanning the range of six CSSS sub-populations in Everglades National Park and Big Cypress National Preserve. Most cores recovered peats and organic sediments overlain by marls, but some sites consist of only marl or peat. Based on preliminary results, we found that the timing of initial marl accumulation varies greatly among sites, from as old as ~2700 years ago to ~AD 1900.

Our paleoecological records also indicate changes in vegetation and fire regime indicating drier conditions ~400 to 500 cal yrBP and during the 20th century. The most significant vegetation changes occurred during the 20th century, when short-hydroperiod species (Poaceae, non-*Cladium* Cyperaceae, and Asteraceae) are more abundant and charcoal concentrations are greater at nearly all sites.

The variability in substrate, vegetation, and hydroperiod throughout the marl prairie habitat provokes intriguing questions on long-term use of the habitat by various plant and animal species. Continued analysis of the remaining sites, coupled with sampling of historic CSSS habitats on Cape Sable and mangrove-fringing marshes on the southwest Florida coast should improve our understanding of the unique characteristics of habitats favored by CSSS populations and their migration throughout the greater Everglades ecosystem.

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Salinity History of the Southern Estuaries: Information to Estimate Past Flow Regimes and Set Restoration Targets

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Paleoecologic analyses from over 20 sediment cores collected in Florida Bay, Biscayne Bay, and the southwest coastal system provide information on spatial and temporal salinity patterns spanning the last 150 to 2000 years. These data also supply input to statistical models that estimate historical freshwater flow into the southern estuaries. These analyses illustrate key hydrologic components of the system before significant human alteration and are assisting the Southern Coastal Systems Sub-team of RECOVER (REstoration Coordination & VERification) to set performance measures and targets for restoration of the estuaries.

The paleoecologic analyses are based on extensive observation and analysis of the modern estuarine system conducted over the last 16 years. A molluscan modern analogue salinity dataset has been compiled from 481 individual records collected from more than 100 locations in Biscayne Bay, Florida Bay, and the southwest coastal region between September 1994 through July 2007 (available at http://sofia.usgs.gov/ exchange/flaecohist/). This dataset is the basis for qualitative assessments of molluscan assemblages within cores, which in turn provide an overview of the spatial and temporal changes that have occurred throughout the system. However, this qualitative approach to estimate past salinities does not provide error estimates or confidence limits needed to assess the uncertainty inherent to the method. To address this problem, a weighted averaging metric (the cumulative weighted percent or CWP) is derived for each sample within a core based on the modern analogue dataset. The CWP weights the average salinity value for each species in the modern dataset by the percent abundance of that species within the core sample. The weighted values for all species in the sample are summed and divided by 100 to provide a single average salinity value for each core sample.

Before using the CWP method to interpret past salinity patterns from cores, the method was validated by testing modern assemblages collected near water monitoring stations in Florida Bay. Comparison of the station salinity data averaged over time periods ranging from one day to three years with CWP salinity estimates returned correlation coefficients of $r=0.88$ to 0.96 for the 24 to 36 month time periods. These values suggest that the CWP provides an accurate estimate of historical salinity averaged over a two to three year time frame in the cores. The CWP has been used to interpret paleosalinity for four cores and linear regression equations using the CWP salinity have estimated historical stage and flow in the Everglades (see Marshall, this volume). This historical perspective provides information that allows the RECOVER teams to set realistic and sustainable goals for restoration and it provides insight into the potential response of the South Florida ecosystem to various future scenarios of global change.

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Mangrove Restoration in Selected Areas of Pine Island Sound after Hurricane Charlie

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Pine Island Sound is located between Charlotte Harbor and Gasparilla Sound to the north; Caloosahatchee River and San Carlos Bay to the south; Pine Island to the east; and the barrier islands that separate the Sound from the Gulf of Mexico (North Captiva and Captiva Islands, Sanibel Island, and Cayo Costa) to the west. The Sound supports extensive seagrass and mangrove habitats that historically fringed many of the small barrier islands found throughout the preserve. Hurricane Charlie passed directly over the northern tip of Captiva Island directly to the northwest of Pine Island Sound. Hurricane damage to mangrove islands found within the Sound ranged from moderate to severe and in some cases catastrophic.

Mangrove restoration was initiated on five Keys (Darling, Rat, Cat, Little Wood and Wood Keys) within Pine Island Sound to augment natural repropagation in areas where seed sources had been depleted. Thousands of *Rhizophora mangle* (red mangrove) propagules and seedlings were planted between 2006 and 2009 along the fringe of the islands and approximately 5-10 meters inland. Additionally, *Avicennia germinans* (black mangrove) and *Laguncularia racemosa* (white mangrove) propagules were scattered on the interior portions of the islands.

All islands in Pine Island Sound still bear the visible impacts of Hurricane Charlie as the remains of large standing and toppled dead trees dominate the landscape. All of the Keys that were replanted showed encouraging signs of regrowth. Red mangrove saplings that were monitored on Darling Key increased their stature by an average of 19%, whereas Rat Key had a growth rate of 9% annually. Branch number per sapling increased at a rate of 48% and 28.9% and prop root growth increased at a rate of 31% and 30% on Darling and Rat Keys respectively. Natural propagation is now evident on all five Keys, which is a positive indication that the restoration effort on these Keys has been successful and further planting is not necessary, as natural recovery will hopefully continue without further anthropogenic interference.

Most attempts at mangrove restoration fail or do not meet stated goals. However, restoration may be appropriate when the area can no longer self-correct or renew itself. The availability of viable seeds was extremely limited on the islands selected for planting in Pine Island Sound, due to the large-scale destruction of adult mangroves. This restoration project was deemed largely successful as Darling, Rat, Cat and the Wood Keys have reached a state of self sufficiency barring the occurrence of future devastation. The restoration has given nature the assistance necessary to initiate recolonization that will hopefully result in a mature forest within 15 to 30 years.

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The Picayune Strand State Forest;Restoration Project: How We Got Here from There From Wetland Ecosystem to Failed Residential Development and Back

David Addison and ***Kathy Worley***
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The origin of what is now the Picayune Strand State Forest began in the mid-1960s when real estate developers purchased vast tracts of land in Collier County. The Rosen brothers, two hair oil salesmen (we're not making this up) from Baltimore purchased 45,731 ha of the western portion of the Big Cypress in Collier County during the 1950s and 60s. With no laws in place to protect wetland destruction, beginning in the mid-1960s a system of 275 km of drainage canals and a grid of 1,298 km of mostly limestone roads were constructed. Dubbed Golden Gates Estates (GGE) .61-2.0 ha parcels were aggressively marketed throughout the U.S. and abroad. The portion of GGE that was located north I-75 eventually became populated with homes. Known as southern Golden Gate Estates (SGGE), the 1,497 ha south of I-75 remained essentially undeveloped. The 88 km of canals and 483 km of roads in SGGE severely impacted the hydrology of the mostly cypress wetlands within this area (historically known as Picayune Strand). The drainage also had negative hydrological effects on adjacent conservation lands such as the Fakahatchee Strand State Preserve. With in SGGE some 22,000 lots were sold to over 17,000 individual landowners. Summer rains flooded the roads while dry season fires ravaged the over-drained wetlands during the spring dry season. In short, SGGE was a text book example of the biological and sociological impacts of uncontrolled ditching and draining of wetlands on a landscape scale.

Interestingly, even before this enormous drainage project was completed, environmental concerns were being raised. These concerns turned out to be correct as the multitude of problems caused by this development scheme played out over the years. The beginning of the process that eventually brought us to where we are today began in 1985 when the Florida Department Environmental Protection added SGGE to the Conservation and Recreation Lands Program's acquisition list. The acquisition of this land turned out to be a task of monumental proportions.

This presentation presents an overview of how through the past 25 years of effort the hydrologic restoration of the Picayune Strand became a reality. There were countless individuals involved, and their collective efforts, both large and small, have resulted in a one-of-a-kind restoration project that, to those who have seen it come together through all the ups and downs, is the most improbable of positive outcomes.

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Decomposition Dynamics of *Nymphaea* in Everglades Wetlands

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Nymphaea is common in the natural, oligotrophic areas of Water Conservation 2a in the Florida Everglades, particularly in the deep water sloughs. As such, it likely plays a major role in ecosystem function through primary production and decomposition. The decomposition of its large rhizomes can be rapid and affected by both aerobic and anaerobic processes, as well as availability of nutrients. Our objective was to assess how fluctuating hydrologic conditions and nutrient enrichment influence decomposition of *Nymphaea* rhizomes in soil. Rhizome decomposition proceeded rapidly and led to higher CO_2 and CH_4 production rates compared to soil without rhizomes. Nutrient enriched sites produced significantly higher decomposition rates than oligotrophic sites under both aerobic and anaerobic conditions. Aerobic conditions produced higher CO_2 production rates than anaerobic decomposition. Microbial biomass C, N, and P increased during incubation and corresponded well to decomposition rates. Higher nutrient levels increased microbial biomass which in turn promoted higher rhizome decomposition rates. The presence of mycelia growth on decomposing rhizomes in aerobic soils indicated the potential importance of fungi in decomposition processes in sloughs during drought conditions.

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Extracellular Enzyme Activity in Sulfur-Amended Everglades Soils

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Soil microorganisms play important roles in the decomposition of organic matter and nutrient regeneration. In natural systems, soil microbial activities are related to the efficiency of nutrient cycling. Elemental S is applied in the Everglades Agricultural Area (EAA) to reduce the soil pH and increase the availability of micronutrients and P to crops. Alterations in soil physical-chemical properties by S amendment are likely to change microbial activity and function, which may in turn affect nutrient availability and organic matter turnover rates. The objectives were to investigate the seasonal response of soil microbial activities to sulfur addition. Soils were amended with S at rates up to 448 kg S ha^{-1}. All enzyme activities fluctuated seasonally and were affected by weather patterns and sugarcane growth. Leucine aminopeptidase activity was independent of S application, averaging 63, 87, 63, 60 mg MUF kg^{-1} h^{-1} at 3, 6, 9, and 12 months, respectively, yet it was significantly correlated to soil pH ($r^2 = 0.42$) and dissolved organic C ($r^2 = 0.57$). Phosphatase activity increased with the addition of S, while glucosidase decreased. Phosphatase was not correlated to soil C, N, P, and S chemical parameters. Yet, glucosidase was significantly correlated to extractable P ($r^2 = 0.35$), extractable SO_4 ($r^2 = 0.39$), extractable NH_4 ($r^2 = 0.30$), and soil pH ($r^2 = -0.28$). Overall, sulfur applied to reduce pH had minimal observable effects on enzyme activity, especially compared to strong seasonal effects and sugarcane growth patterns.

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Linking Soil Chemical Properties and Microbial Activity in Everglades Agricultural Area Soils

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Soil physical-chemical properties and microbial activity are key components of ecosystem function. Net results of reciprocal interactions between the two define ecosystem processes. The objectives were to determine whether different land management practices resulted in contrasting soil chemical properties and to evaluate how variances in chemical properties regulate microbial activity. Soil was evaluated from three land uses with distinct land management history: sugarcane, cypress, and uncultivated soil. Cluster analysis (CA) was used to classify soil properties by land use while principal component analysis (PCA) was used to detect dissimilarity of carbon utilization patterns. Discriminant function analysis (DA) was conducted to determine differences in enzyme activities among land uses. Canonical correlation analysis (CCA) was employed to identify and assess linkages between soil chemical properties and microbial activity. Soil samples were perfectly clustered into three groups based on chemical properties. The Na_2CO_3-P ($r^2 = 0.91$), K_2SO_4-NH_4 ($r^2 = 0.87$), and dissolved organic carbon ($r^2 = 0.86$) contributed most to the classification. Two principal components (PCs) were extracted and explained 40% of the variance in carbon utilization efficiency. Principal component 2 clearly separated the uncultivated sites from sugarcane and cypress. Canonical variate 1 (87%) and 2 (79%) separated land uses by overall enzyme activities. The PCA reduced 11 chemical variables to 2 principal components representing 72% of the variance. The Na_2CO_3-P had the highest correlation coefficient ($r^2 = -0.93$) with PC1. Two components were extracted from seven microbial variables to catch 75% of the variance of microbial activities. Canonical correlation between soil chemical properties and microbial activities was strong ($r^2 = 0.89$, $p = 0.005$). Approximately 80% of the variance in microbial activity was explained by soil chemical properties in the first pair of canonical variates. Overall, different land management practices resulted in distinct chemical distributions in soil and consequently altered microbial activities.

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Seasonal Dynamics of Phosphorus in Sulfur-Amended Organic Soils of the Everglades Agricultural Area

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The Everglades Agricultural Area (EAA) in south Florida was drained in the early 1900s for agricultural production. Long-term tillage resulted in incorporation of $CaCO_3$ into the soil profile from underlying bedrock, increasing the pH to approximately 7.0-7.5. In some cases, elemental S is used to reduce soil pH for the purpose of increasing micronutrient and P availability. The objectives were to quantify the seasonal dynamics of P distribution in various fractions as affected by S amendment. Elemental sulfur was introduced in granular form (90% S) at 0, 112, 224, and 448 kg S ha^{-1}. Phosphorus sequential fractionation was employed to determine sizes of different P fractions during the sugarcane growing season. Pools of P fluctuated seasonally and their response to sulfur amendment varied. Organic P was the major form in the soil while the Ca-bound P (Ca-P) dominated the inorganic fraction. Labile P and Fe-Al bound P (Fe-Al-P) had the least contribution to total P and declined during the growing season, corresponding to P uptake patterns by sugarcane. The size of Ca-P fraction was relatively stable but also subject to decrease during the growing season. Humic-fulvic acid P and residual P fluctuated seasonally. Total P stocks declined over time as a result of continuous reduction in inorganic fractions by sugarcane uptake. Application of sulfur at rates up to 400 lb S $acre^{-1}$ had limited effects on altering soil pH. Yet, a small reduction in soil pH did promote P accumulation in both labile P and Fe-Al-P fractions within 2 months of application. None of the Ca-P, humic-fulvic acid P, and residual P responded to any rate of S addition.

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Revision and Assessment of Water-Surface Modeling of the Everglades Depth Estimation Network (EDEN)

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The water-resources products of the Everglades Depth Estimation Network (EDEN) quantify spatial and temporal hydrologic patterns at the landscape scale, and supply critical and easily accessible hydrologic data in support of the Everglades ecosystem restoration. The EDEN water-surface model forms the foundation of the hydrologic dataset and, together with the digital elevation model of ground surface, provides principle investigators and water-resource managers with computations of daily water depths and hydroperiod throughout landscapes in the greater Everglades.

The EDEN water-surface model interpolates water-level data from a network of real-time water-level gaging stations operated by multiple agencies, including the National Park Service, the South Florida Management District, and the U.S. Geological Survey. The hourly water-level readings are compiled and quality-assured, and missing data are estimated. The daily water-level medians are computed and used by the water-surface model to create daily water surfaces on a 400-meter grid. The model utilizes a radial basis function (RBF) algorithm and a combination of real and pseudo canal gages to model the discontinuities of water level across sub-region boundaries of the Everglades.

The objective of the recent and ongoing revisions to the EDEN surface-water model is to incorporate new data from gages, re-parameterize the interpolation program using the newest version of the RBF, and use the recent independent measurements of water levels at benchmark stations to assess the performance of the revised model. Input data for the model was improved by filling missing data gaps, making datum survey corrections to selected gages, and adjusting water-level data for canal gages to better represent observed flow patterns. New protocols for handling gage data under dry or near-dry conditions were incorporated. The revised surface-water model is due to be completed in August 2010 and will be used to update EDEN daily water-level and water-depth surfaces from 2000 to current in September 2010.

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Revisions to the EDEN Ground-Surface Digital Elevation Model and Water Surface Model in the Water Conservation Area 1

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The Everglades Depth Estimation Network (EDEN) is a network of water-level gages used to create daily surfaces of water level and water depth for the greater Everglades. The water-surface model and ground-surface digital elevation model (DEM) were revised for Water Conservation Area 1 (WCA1) after investigators in the field reported EDEN water depths significantly different from their observations.

To better account for heterogeneity, changes were made to the input data filtering, area subdivision, and interpolation processes for the WCA1 portion of the EDEN DEM. As with previous releases, Airborne Height Finder data points falling on "upland" locations in EDEN cells with less than 33% upland area were removed before model development. However, for this revision, "upland" land cover in the WCA1 was defined using 2008 South Florida Water Management District vegetation data rather than USGS National Gap Analysis Program data. The EDEN DEM is actually a mosaic of ground-surface models covering smaller subareas. The entire WCA1 constituted a single model subunit in the previous DEM, but 4 new models (north, central, southeast and southwest) were created within WCA1 during the revision with the loosely defined boundaries of Comprehensive Everglades Restoration Plan landscape units. The resultant DEMs produced encouraging results. Moreover, evaluation of water depths estimated using the revised DEM with field-measured water depths for multiple dates and locations show improved consistency compared to those output using the previous WCA1 DEM.

Adding new canal gaging stations to the EDEN network and using them to develop canal boundary files significantly revised the water-surface model in WCA1. Additionally, a new protocol was implemented to estimate and use water-level data during dry conditions. Daily water-level surfaces created by the revised model were compared with independent measurements of water level at a new network of benchmarks. These results were used to reparameterize the water-surface model and improve the confidence in the EDEN daily surfaces. The revised ground surface DEM and water surface model for WCA1 will be used to update the water-level and water-depth surfaces for the period January 1, 2000 to current and be posted to the EDEN website (www.sofia.usgs.gov/eden) in September 2010.

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Hydrologic Effects on Nutrient Release and Microbial Activity for Different Land Uses in the Everglades Agricultural Area

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Cultivated soils in the Everglades Agricultural Area (EAA) are being converted to wetlands as part of Everglades restoration projects. Elemental S is used in the EAA to decrease pH and to increase nutrient availability to crops. The microbial oxidation of elemental S to sulfate may alter the utilization patterns of electronic acceptors when soils become flooded. The objectives of this study were to determine short-term changes in P dynamics and greenhouse gas production under different hydrologic conditions: drained soil, flooded soil, flooded soil+SO_4. The distribution of P in labile, Fe-Al bound, Ca bound, humic-fulvic acid, and residual pools under drained, flooded, and sulfate-reducing conditions were measured for fields under sugarcane cropping, vegetable cropping, and uncultivated soil. The land uses were differentiated by P storage in different pools as cultivation contributed to higher pH and increased P sequestration in Ca-bound fractions more for sugarcane (50%) and vegetable (49%) than uncultivated soils (17%). Uncultivated soils sequestered more P in organic pools, as storage in residual fractions (70%) was higher than for sugarcane (38%) and vegetable (43%) soils. But the distribution of P in all fractions did not differ in response to flooding. For all three land uses, mineralizable N ranged from 20-30 mg/(kg*d), while inorganic N consumption averaged 10-20 mg/(kg*d) under both flooding treatments since NO_3 was used as an electronic acceptor. Microbial CO_2 production rates under flooded conditions were 50%, 62, and 72% of the aerobic rate for sugarcane, vegetable, and uncultivated soils, respectively. Methane production was minimal in the short-term under flooded conditions due to predominance of denitrification resulting from prior soil oxidation and organic N mineralization, or N fertilization, which contributed to maintenance of high enough levels of NO_3 over the 10 d period to support denitrification. Methane production was minimal in S-amended soils due to stimulation of SO_4 reduction. Short-term responses to flooding showed that CO_2 is the primary endproduct of organic matter decomposition, with pathways of decomposition and P dynamics similar among land uses.

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Flow Rating Improvement and Uncertainty Analysis for Culverts in a Stormwater Treatment Area

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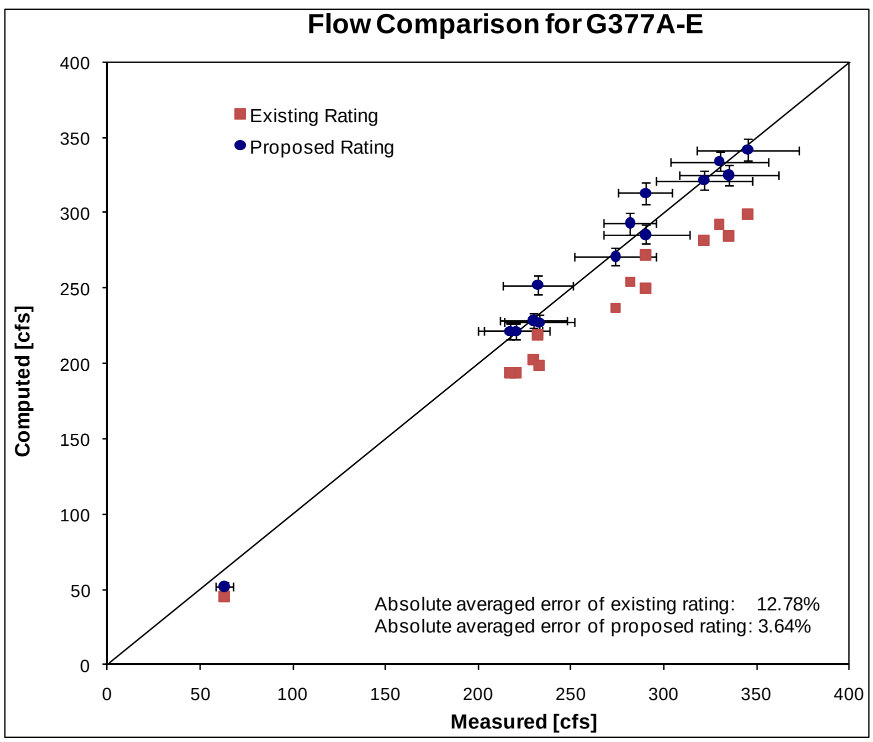
Stormwater Treatment Area 3/4 (STA-3/4) operated by South Florida Water Management District (District) is designed to remove pollutants such as phosphorus and nitrogen from the agricultural water before discharging it into the everglades. Culverts perform the most important function in the STA-3/4. They convey flow in and out of cells to facilitate the water treatment process. By the Everglades Forever Act (1997), pollutant removal rates of the STA-3/4 must be monitored to ensure continuous flow of good quality water to sustain ecosystems downstream. It is therefore important to ensure that each culvert in the STA-3/4 has the best flow rating. A review of computational methods of STA-3/4 structures showed that culverts G377A_C, G377B_C, G377C_C, G377D_C and G377E_C flow ratings underestimate flow through the structures. Since these structures are water quality sampling stations, it is important to redevelop the flow ratings to ensure accurate estimation of phosphorus inflow into Cell 2A.

A total of thirty-seven measurements have been taken at G377B_C and G377D_C since the structures were commissioned in 2005. G377A_C, G377C_C and G377E_C do not have stilling wells installed, therefore no streamgauging data is available for these sites. However, given that G377A-E structures have hydraulic similarity, a rating developed from G377B_C or G377D_C can be applied to the other culverts in the group. In order to estimate the sensitivity of rated discharges to rating parameters and other input factors, an uncertainty analysis was conducted on the proposed rating for G377A-E. Due to limited streamgauging data, Monte Carlo model was used to provide a complete spectrum of various scenarios. The measurements used for the uncertainty analysis are the same as those used in the rating analysis at culverts G377B_C and G377D_C. The following figure illustrates the overall uncertainty related the ratings.



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Three-Dimensional Computational Fluid Dynamics (CFD) Flow Modeling for Culvert in South Florida

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The determination of culvert flow types depends on headwater, tailwater, and gate opening ratio to head differential of considered computed condition. Currently, there are five flow types implemented in the Flow Program for culvert flow computations: full pipe flow, orifice flow, and three open channel flow types. The criteria for the Type 5 orifice flow type are: (a) the headwater is about 1.5 times higher than the gate opening; and (b) tailwater is lower than the crown elevation of the outlet. The Type 5 application for the orifice flow equation has limitations in circular culvert when the ratio of critical water depth and culvert diameter Yc/D is greater than 0.8. The problem identified at circular culvert G328I located southeast of Lake Okeechobee along the inlet cannel of Stormwater Treatment Area 2 in Palm Beach County, was investigated. In G328I culvert, the inlet is beneath the water and much deeper than other culverts in South Florida. Its tailwater is lower than the crown elevation. Typically, Type 5 flow condition is satisfied for the flow calculation in this structure. However, the diameter of the barrel is so small that the flow expansion occurs after the gate and flow can fully occupy the pipe. Flow near the outlet will not be controlled by tailwater stage. When critical water depth inside the pipe is close to the diameter of culvert G328I, the application of Type 5 orifice flow equation gives us unreasonably large discharge.

Due to the flow expansion after the constriction gate and the bottleneck of streamgauging data shortage for flow rating, three-dimensional Computational Fluid Dynamic (CFD) flow analysis has been implemented for this study. More than 25 synthetic flow data has been generated corresponding to different head, tail, and gate opening scenarios. When compared to streamgauging data, the synthetic data gives averaged relative absolute error less than 5%, which is a very good flow prediction. New site-specific parameters were also obtained based on G328I culvert flow rating. The flow rating validated that Yc/D=0.8 is the good limitation of applying of the current orifice equation. Preissmann open-slot concept was used to investigate the limitation of orifice flow equation at circular culvert. After the datasets were successfully validated by available streamgauging data, the synthetic datasets were applied together with field measurement data to test the limitation of the dimensional analysis based flow equations that are not sufficient for the transitional flow condition. The transitional flow can be specified as submerged inlet, free outlet and Yc/D>80% flow condition.

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Monitoring Freshwater Flow to Florida Bay and the Southwestern Coastal Estuaries of Everglades National Park in Support of the Comprehensive Everglades Restoration Plan

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Improving the quantity, quality, timing, and distribution of freshwater flows through Everglades National Park (ENP) is a primary goal of the Comprehensive Everglades Restoration Plan (CERP). Understanding estuary salinity and residence times are important factors for describing a wide range of biological and chemical issues associated with the freshwater marsh/coastal mangrove transitional zone. The U.S. Geological Survey (USGS) has participated in studies since 1995 to quantify the volume of freshwater moving from the Everglades wetlands into the coastal estuaries. The USGS operates an extensive network of monitoring stations at coastal creeks and rivers that discharge freshwater into northeastern Florida Bay and the southwestern coastal estuaries along the Gulf of Mexico. The existing network includes over 30 data-collection platforms, which measure flow volume, salinity, temperature, precipitation, water-level and water-quality data (total phosphorus and total Kjeldahl nitrogen) along transects that represent major flow paths to the coast of ENP. This network has provided valuable data for hydrodynamic model development and calibration, as well as baseline information for CERP and pre-CERP studies. Real-time data (120-days) are now available via the National Information Water System (NWIS) web portal (http://waterdata.usgs.gov/fl/nwis/). Published unit value data can be retrieved from an updated coastal network database located on the South Florida Information Access web portal (http://sofia.usgs.gov/exchange/zucker_woods_patino/hydrology_data.php).

The USGS coastal network in ENP and surrounding estuaries addresses the continuing Everglades restoration because:

1. pre-CERP (baseline) hydrology can be compared to data collected after CERP modifications. For example, flow volume information collected along the southwest coast of Florida will benefit the Tamiami Trail project which began in late 2009; on-going
2. data are used to evaluate hydrologic responses from short- and long-term climatic events, such as tropical storms, hurricanes, and sea level rise;
3. current water quality investigations fill in gaps of knowledge for areas affected by CERP restoration.

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The Semiglades and Beyond: Incorporating Novelty into Restoration

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The process of defining restoration targets is complicated by the social values of people that create them. This is an unavoidable truth, but one that should be acknowledged at every step in the restoration process, including the fact that these values often restrain the creativity needed in restoration today, particularly when considering novel systems. The Everglades is an excellent example of the restoration of a novel system and the difficulties this creates. In such systems, restoration targets often employ vague, value-laden terms such as restoring ecosystem 'health' or 'integrity', and refer to pre-disturbance conditions as the main objective. The Everglades has been so dramatically altered that a pre-disturbance state for many of the vegetation communities and landscapes is impossible. Where to go from there? Acknowledging the novelty of the system is a key initial step. To support this, we provide examples of novelty within the system, and discuss the restoration in terms of social values and how they influence the concept of the ecosystem and restoration. Also, in order to detach old values and ideas from the Everglades ecosystem that could hinder realistic progress, and considering the spatial extent (or "ever") of the Everglades has been reduced by half, we facetiously suggest renaming it "the Semiglades" in an effort to "reboot" ideas for restoration. As
major characteristics of the Everglades will never be restored within a non-geologic time frame, we feel that a readjustment of expectations is necessary and perhaps a new name would facilitate that. We present this in hopes of opening dialogs within restoration projects to expose social/ecosystem biases and include novel landscapes in management and planning.

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