Determination of nutrient limitation on trees growing in LILA tree islands

Suresh C. Subedi and Michael S. Ross
Florida International University, Miami, FL, USA

Introduction

Tree islands are important centers of biodiversity in the Florida Everglades and considered key indicators of the health of the Everglades ecosystem. They are often initiated on slightly elevated bedrock and surrounded by fresh water marshes. In some cases, they develop further through a slow sedimentation process over a long period of time, which allows them to grow in size and height, and to accumulate nutrients. It is believed that a tree island takes on a tear-drop shape owing to the flow of water, and as a result, the nutrients released at the head are re-distributed, eventually establishing a nutrient gradient from the head to the tail of the island. Thus, the accumulation of soil nutrients in tree island heads can result in a more than 100 times greater phosphorus concentration than found in surrounding marshes (Ross et al. 2006). 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 species. It is important to understand the nutrient dynamics and biomass production in the tree islands in order to preserve the tree islands in Everglades.
Fertilization experiments have proved successful in determining the growth-limiting nutrient in various ecosystems including wetlands (Feller 1995, McKee 2002). When stands of natural vegetation are fertilized, treatment effects on biomass production are commonly observed (Van Duren and Pegtel 2000). Typically, biomass production is enhanced by the addition of a limiting nutrient, while the addition of non-limiting nutrients has little or no effect on biomass (Verhoeven et al. 1996). On the other hand, the availability of nutrients appears to change between marsh and uplands in tree islands and a distinct nutrient gradient exists. The highest phosphorus concentrations are reported on the head as compared to the surrounding marsh (Wetzel et al., 2005, Ross et al. 2006). In similar fashion, differences in hydroperiod between the elevated center of tree island and their lower fringes may lead to parallel patterns in nutrient accumulation and availability, i.e., relative N-limitation at upslope and P-limitation at downslope.

Fig. Tree islands in Everglades

Objectives and Hypotheses

The objectives of our study were two folds. First, we compared tree height growth when conditions limiting optimal growth for the plant species are improved by application of nitrogen and phosphorus fertilization. Second, we compared the nature of nutrient limitation in a tree species growing on 2 types of common tree islands (limestone and peat islands) in Everglades.

Methods and Materials:

This study was carried out at the Loxahatchee Impoundment Landscape Assessment (LILA) site. LILA features artificially created islands in a controlled hydrologic framework. LILA consists of four cells or macrocosms (M1-4), approximately 8 ha each. In each cell, two tree islands were constructed in 2002-03, one with a limestone core covered with peat and other wholly of peat. M2 and M3 macrocosms provideed the setting for the experiment. Eighteen trees of each species, *Annona glabra* and *Chrysobalanus icaco*, were selected within each island, total of 36 trees per island, 72 trees per microcosm, and 144 trees overall. Each tree received one of three nutrient treatments: Nitrogen (N), Phosphorus (P), or no nutrient enrichment (control). A total of 108 trees were fertilized with one of the two nutrient enrichments (excluding the 36 control trees) monthly for a 8 month period. The N enrichment was added in the form of urea (45-0-0) and P in the form of orthophosphate, H_2PO_4, (0-45-0). Monthly nutrient enrichments were applied as a solution of dry pellet fertilizer dissolved in 250 ml water per tree. From July 2009 to June 2010, the cumulative amount of N and P applied were twice the amount of the two nutrients that one individual normally incorporates into live tissue during an annual cycle (about 60 g of each). In order to apply nutrient enrichments, two 30 cm deep holes were cored into the substrate within a canopy shadow of each tree and a 1.3 m long PVC pipe (0.75 inch diameter) with holes at the base was installed in each hole. To assess the effect of nutrient enrichment on tree growth height was measured before fertilization (July 2009) and after 11 months (June, 2010) for all sample trees. Relative elevation (elevation minus mean annual water level surrounding marsh) was calculated for each tree, and regressed against tree height. ANOVA was used to test effects of species, substrate, and fertilization treatment on tree growth.

Fig: PVC pipes installed around trees for nutrient delivery: A. glabra (left) C. icaco (right)

Results:

The positive response of P- treatment on tree growth was found for *A. glabra*, in both types of islands (2 peats and 2 limestones), which was found significantly higher growth response than those of control and nitrogen treated plants. *A. glabra* also showed significantly higher growth rate on limestone islands than peat islands. C. icaco did not show a significant response with nutrient treatments in both types of islands. The nutrient treatment effect on tree growth was found vary with relative elevation (RE) between 2 species. P-treated *A. glabra* trees showed that tree growth decrease significantly as RE increased. *C. icaco* did not show any significant response with nutrient treatment effect.

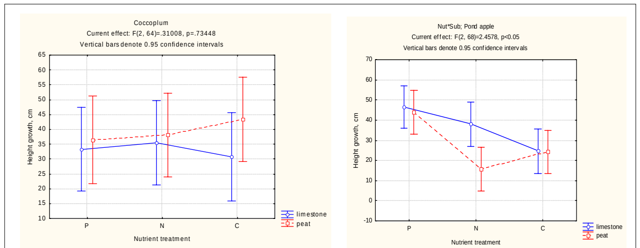
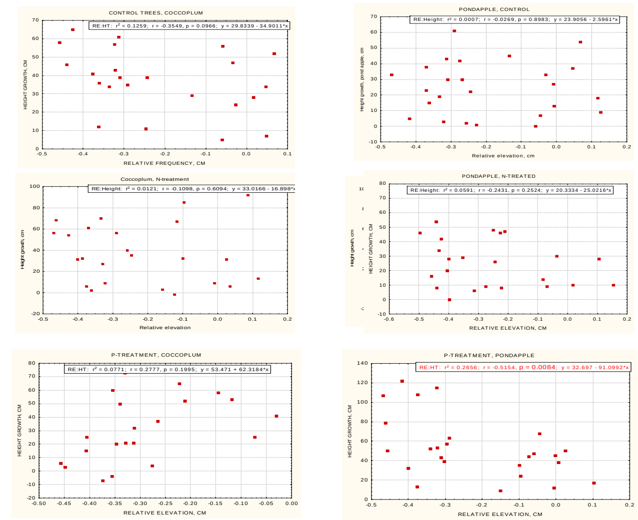


Fig: Mean height growth comparison among 3 treatments: phosphorous (P), Nitrogen (N) and Control (C). C. icaco (Left); A. glabra (R).



Figs: Scatterplot showing relationship between tree height growth and relative elevation (RE) for N, P and C trees

Conclusion:

- *P-treated A. glabra* height growth response was found significantly higher than N and C trees in both types of tree islands, therefore LILA tree islands are probably P-limited systems.

- A. glabra showed negative growth response with increase in relative elevation only with P-treatment. This supports the hypothesis that the fringes of the tree islands are P-limited.

- On the other hand, the variation on species response with N-treatment seems to be affected by the substratum because the growth rate of N-treated A. glabra was found significantly higher in limestone islands than that of peat island. It means two types of islands in LILA have differences in tree growth response driven by their substrates.

- But *C. icaco* which is the other species in this experiment did not show any significant growth response with any nutrient treatment in both types of islands.

- Plant-growth response is one of the techniques in this study to determine the nutrient limitation along with soil and leaf N:P ratio and resorption efficiency. Since, we have already collected leaf and soil samples of each sample trees, other techniques would probably make clear on nutrient availability on LILA tree islands.

Literature Cited

Feller, I.C. 1995. Effects of Nutrient Enrichment on Growth and Herbivory of Dwarf Red Mangrove (Rhizophora Mangle**).** *Ecological Monographs*, Vol. 65, No. 4., pp. 477-505.
McKee, K. L.; Ilka C. Feller; Marianne Popp; Wolfgang Wanek, 2002. Mangrove Isotopic (# 15 N and # 13 C) Fractionation across a Nitrogen vs. Phosphorus Limitation Gradient *Ecology*, Vol. 83, No. 4., pp. 1065-1075.
Misch, W.J & Gosselink, J.G. 2007. Wetlands. John Wiley & Sons, Inc. 4th Edition. 582 pp.
Ross, M.S., S. Mitchell-Bruker, J.P. Sah, S. Stothoff, P.L. Ruiz, D.L. Reed, K Jayachandran and C.L. Coultas. 2006. Interaction of hydrology and nutrient limitation in the Ridge and Slough landscape of the southern Everglades. *Hydrobiologia* 569: 37-59.
Scinto, L.J. Price R. and Ross, M. 2009. Loaxahatchee Impoundment Landscape Assessment (LILA): Tree Island Experiments and Management. Annual report submitted to South Florida Water Management District (SFWMD)
Van Duren, I.C. and D.M. Pegtel, 2000. Nutrient limitations in wet, drained and rewetted fen meadows: evaluation of methods and results. *Plant and Soil* 220: 35–47.