Linking water sources and foliar nutrients in tree islands, Shark River Slough, Everglades National Park (ENP)

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Introduction

Tree Islands are biodiversity and nutrient hotspots in the Everglades.

Only areas above water in the wet season, habitat for terrestrial life; 2 % of park area;
~70% of islands in northern and central Everglades have disappeared/degraded due to flooding and /or drought.

Tree islands are completely dependant on hydrology (hydroperiod and water

Everglades Restoration Plan(CERP)
⇩
Tree Island Restoration ⇨ How floods and droughts affect plant species and communities
⇩
Water sources and nutrient requirements of different species

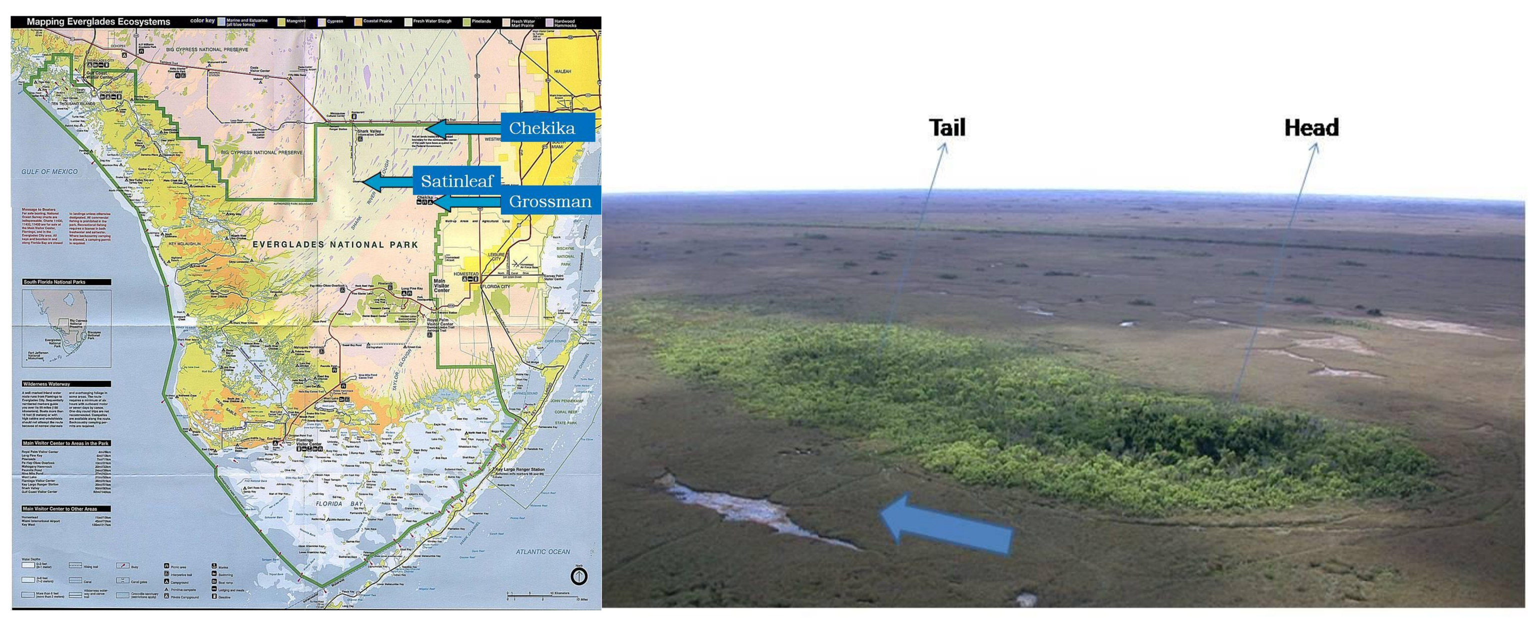


Fig 1: Tree islands in the Shark River Slough, ENP. Study sites shown. Photo shows Chekika tree island with head and tail zones, along with direction of water flow (NE-SW)

In the Southern Everglades (Shark Valley, ENP)…

tree islands have two DISTINCT, clearly demarcated plant communities – upland and lowland.

Upland (head)	Lowland (tail and sides)
Almost never floods	Hydroperiod 1-9 months
Flood-INTOLERANT Neotropical hardwoods	Flood-tolerant species of temperate origin
Unsaturated soil layer – litter and marl	Saturated soil – peat

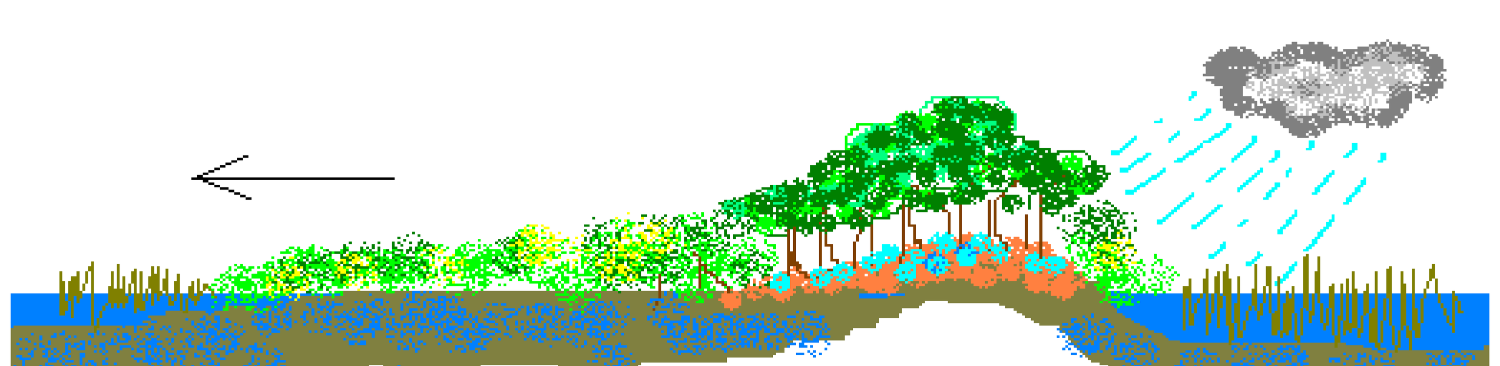


Fig 2: Profile of a tree island in wet season. Two water sources available to tree island plants:
1. lowland plants can use P-poor regional surfacewater/groundwater pool
2. upland plants can have access to rainwater entrapped in litter-derived soil that is P-rich

Hypotheses

1. Upland plants have access to rainwater entrapped in litter (P rich) while lowland plants are restricted to the regional pool (P poor).

2. Leaf nutrient concentrations are associated with water sources used by different plant communities on the tree islands

The Study (Nov 2006 – Nov 2007)

1. 3 tree islands - Chekika, Satinleaf and Grossman Hammock
2. Plant stems (water) and leaves (nutrients) sampled every 2 months (species in adjacent table), along with soil(upland and lowland) and surface water
3. 20 plants in upland, 30 in lowland, 50 plants/tree island
4. Stable isotope ($\delta^{18}O$, δD, $\delta^{13}C$ and $\delta^{15}N$) analysis, Foliar nutrient analysis (N,P)

Results

1. Sourcewaters – In the wet season, upland plants use entrapped rainwater while lowland plants use regional water. In the dry season upland plants increase their uptake of regional water (Fig 3, 4, 5)

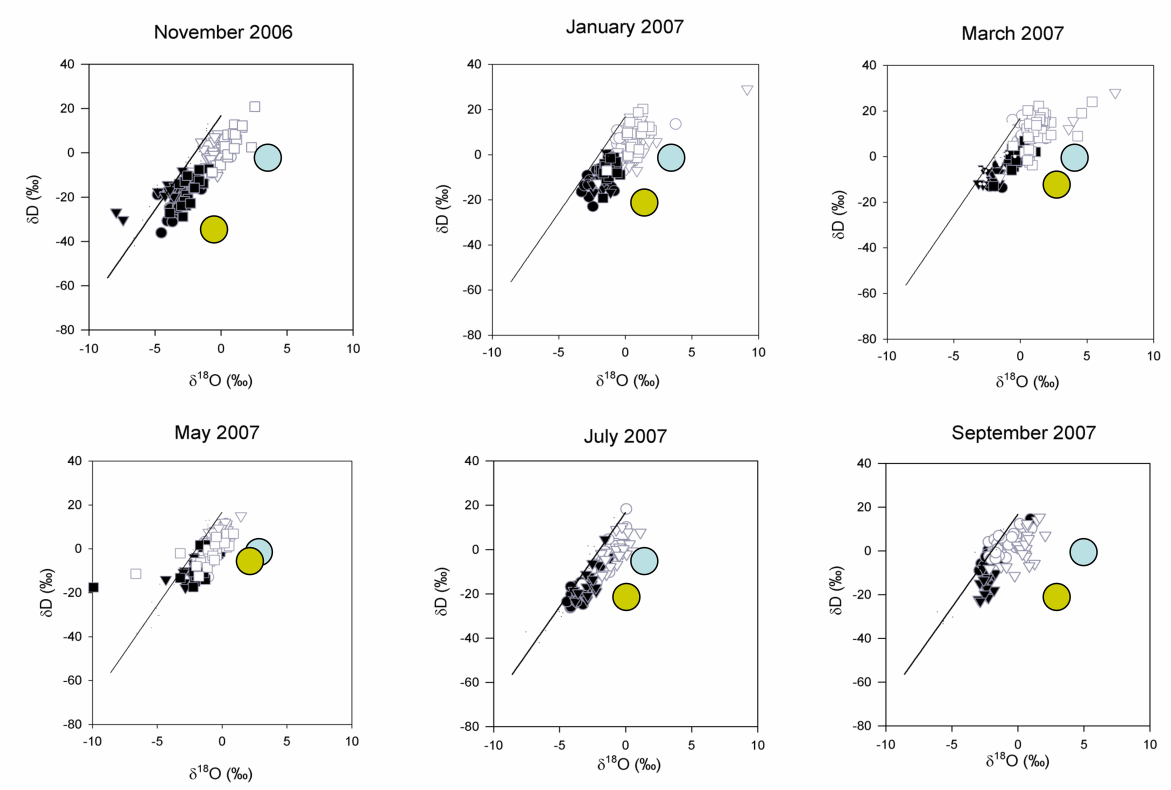


Figure 3: Plots of δD vs. $\delta^{18}O$ of plant stemwater in upland (shaded symbols, ●) and lowland (open symbols, ○) communities for Chekika (circles), Satinleaf (squares) and Grossman Hammock (triangles). Upland and lowland plant stemwaters have distinct compositions in November (end wet season). As the dry season proceeds, upland plants start getting closer to the lowland plant isotopic composition in course of the dry season until May 2007 when they are the closest to lowland plants, indicating sharing the same water sources. Also shown is the Everglades local meteoric water line ($\delta D = 8.5\ \delta^{18}O + 17$ ‰, $r^2 = 0.93$, $P < 0.01$), indicating that lowland stemwaters are from evaporatively enriched sources (values to the right of the line).

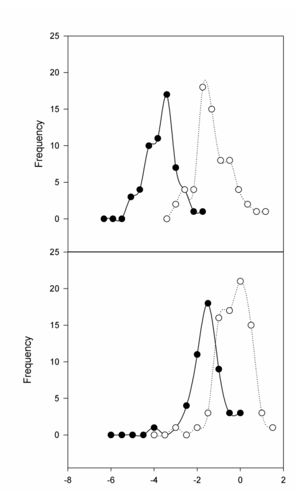


Figure 4: Frequency classes (vertical axis) for $\delta^{18}O$ values of upland (•) and lowland (o) stemwaters at the end of the wet season (November, top plot) and dry season (May, bottom plot) respectively.

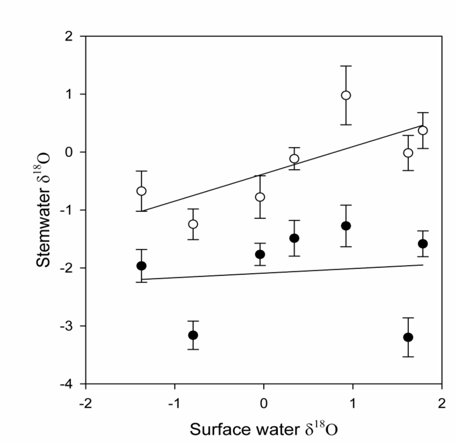


Figure 5: Correlation of lowland stemwater $\delta^{18}O$ (o) and upland stemwater $\delta^{18}O$ (•) with surface water $\delta^{18}O$ sampled over the year on 3 islands. The correlation between lowland stemwaters and surface water ($r = 0.74$) was stronger than that between upland stemwaters and surface water ($r = 0.11$).

2. Nutrients – Upland plants have higher foliar P at the community level than lowland plants (Fig 6)

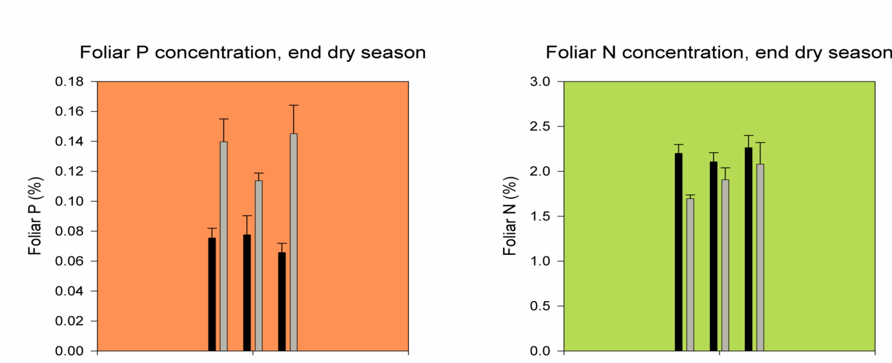


Figure 6: Left - Foliar P(%) in lowland (solid) and upland (hatched lines) plant communities. Uplands have significantly higher foliar P values than lowland plants (n = 20 and 30 respectively per site).
Right – foliar N (%). Pattern between uplands and lowlands is the reverse, with lowland plants showing higher foliar N levels in general.

Results (continued)

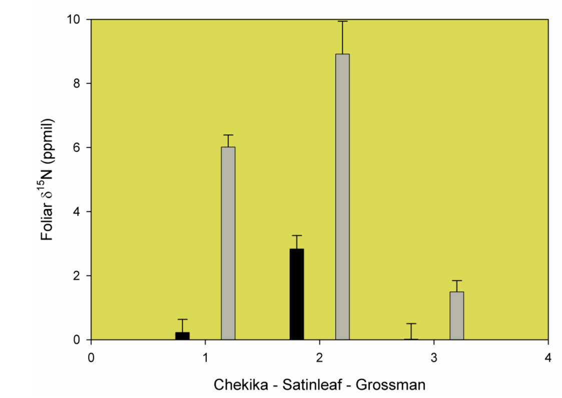


Figure 7: Foliar $\delta^{15}N$ values in lowland and upland plant communities. Upland plants have higher $\delta^{15}N$ values than lowland plants at the community level.

Higher foliar P → Higher $\delta^{15}N$ (Fig 7) in upland plants due to greater N uptake accompanying greater P availability, → decreased discrimination against ^{15}N

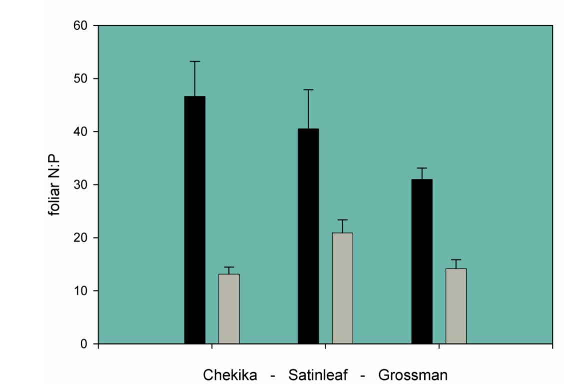
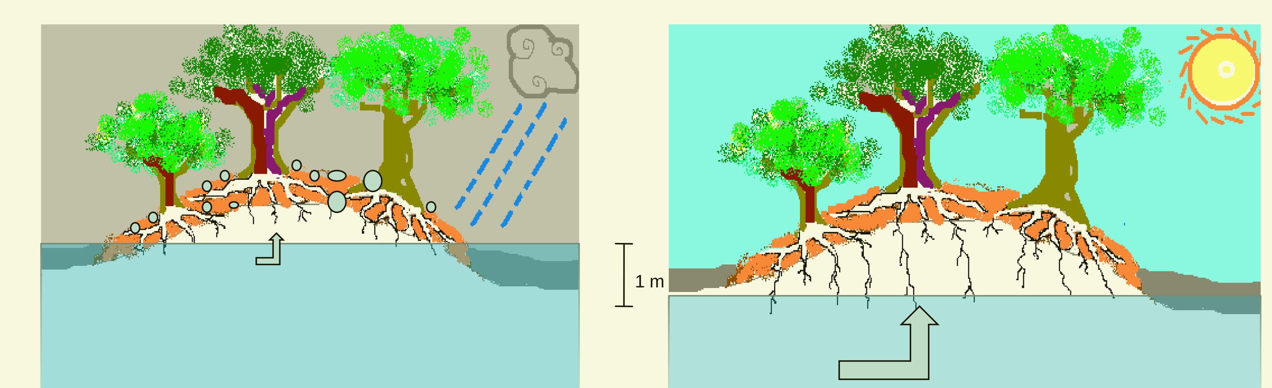


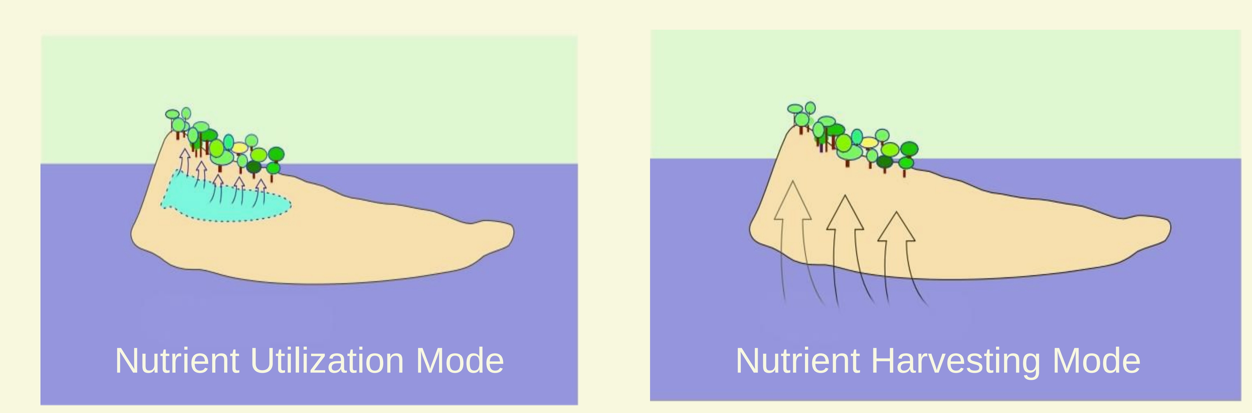
Figure 8: Foliar N:P ratios in lowland and upland communities at the end of the dry season. Lowlands plants have significantly higher N:P ratios than upland plants signifying greater P limitation.

Conclusions and Implications



A: Survival of upland flood-intolerant hammocks
1. Litter layer allows hammock roots to survive while providing water in wet season. Litter layer → Vegetation feedback upon flooded environment.

2. Dry season, roots have to penetrate through existing cracks in limestone bedrock → susceptibility to droughts



B: Uplands are nutrient hot spots on oligotrophic Everglades slough landscape
Support for transpirational pathway of nutrient concentration on island heads in dry season (nutrient harvesting mode)

C: Coupling water sources and foliar nutrients can be effective in identifying nutrient sources and periods of nutrient uptake by plants and communities. This can aid understanding plant community structure, function and restoration of those communities in an ecosystem.

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