The State of Our Understanding of the Biogeochemical Processes on Tree Islands in the Greater Everglades

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Why do we care about Tree Islands?

Coupled Human-Ecosystem Interactions
Biodiversity hotspots
Rookery habitat
Wildlife refuge during high water
Breeding and nesting ground for reptiles, amphibians, mammals and birds
Archeological resource
Public aesthetic and recreational value
Integral physiographic component:
  Nutrient sink?
  Driver of oligotrophy?
Wet Head: This area contains many ferns, shrubs, and trees that tolerate varying degrees of flooding.

Dry head of island: This area contains hammock trees and upland plants that cannot tolerate prolonged flooding.

Near Tail: This area contains a mixture of flood-tolerant shrubs, sawgrass, broadleaved plants and ferns.

Sawgrass tail: This region can extend for more than a mile.

Regions of a “Classic” Tree Island
Island shapes may be indicative of groundwater movement.
To evaluate groundwater movement, four sets of wells were drilled on and around three islands. Each set has a shallow (15 ft) and deep (30 ft) well, and a port for sampling water quality.
Arctic tadpole shaped islands (bog islands):

1) *Sphagnum* becomes established downstream of obstructions in zones of sluggish water flow.

2) Presence of a *Sphagnum* mat acidifies the sluggish water zone and the mat advances outward.

3) Further advance is blocked by higher alkalinity and flux of cations along the main drainage paths. 

From Wetzel, 2002
Bioavailable P across 3AS4 at two depths indicate a general trend of decreasing nutrients downstream of the tree island head (Newman, unpub).
Plots of total phosphorus concentration (ug/g dry wt.) vs depth for sediments (Orem et al. 2002)
<table>
<thead>
<tr>
<th>Soil Depth (cm)</th>
<th>Marsh</th>
<th>Head</th>
<th>Near Tail</th>
<th>Far Tail</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (S.E.)</td>
<td>Median</td>
<td>Range</td>
<td>Mean (S.E.)</td>
</tr>
<tr>
<td>0–10</td>
<td>6 (1)</td>
<td>5</td>
<td>2–12</td>
<td>421 (93)</td>
</tr>
<tr>
<td>10–20</td>
<td>3 (0)</td>
<td>3</td>
<td>2–3</td>
<td>699 (131)</td>
</tr>
<tr>
<td>20–30</td>
<td>2 (0)</td>
<td>2</td>
<td>1–3</td>
<td>775 (257)</td>
</tr>
</tbody>
</table>

† Square meter over a depth of 10 cm.
Relationship between the ratios of total soil phosphorus (g m\(^{-2}\) in the upper 10 cm) on the head to the surrounding marsh and the maximum elevation of the tree island heads (r\(^2\)=0.81; p=0.0005) for 12 tree islands in the Everglades.
Focused Nutrient Redistribution: Maintaining Everglades oligotrophy?
All values grams Total Phosphorus m$^{-2}$ yr$^{-1}$

TP Accumulation Rate in Marsh
- 0.01
  (Orem et al. 2002)

TP Accumulation Rate on Tree Island Head
- 1.05
  (Orem et al. 2002)

Dry Fallout
- 0.062
  (Redfield 2002)

Wet Fallout
- 0.033
  (Davis 1994)

Less than 10% of annual TP input to tree island heads is from wet & dry fallout
Locations and names of the Willow Tree Islands.

Mean Nitrogen Content

Mean Phosphorus Content
### Tree Island Head vs Marsh (Wilcoxon p-values)

<table>
<thead>
<tr>
<th>Environment</th>
<th>TP</th>
<th>TN</th>
<th>N:P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree Island</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-75 Colony</td>
<td>0.0277</td>
<td>0.0177</td>
<td>0.0192</td>
</tr>
<tr>
<td>I-75 Control</td>
<td>0.0003</td>
<td>0.0138</td>
<td>0.0007</td>
</tr>
<tr>
<td>Alley North Colony</td>
<td>0.0394</td>
<td>0.482</td>
<td>0.0246</td>
</tr>
<tr>
<td>Alley North Control</td>
<td>0.0004</td>
<td>0.009</td>
<td>0.0089</td>
</tr>
<tr>
<td>Big Melaleuca Colony</td>
<td>0.0044</td>
<td>0.0019</td>
<td>0.0032</td>
</tr>
<tr>
<td>Big Melaleuca Control</td>
<td>0.01</td>
<td>0.0013</td>
<td>0.0519</td>
</tr>
</tbody>
</table>

### Colony vs Control (Kruskal-Wallis p-values)

<table>
<thead>
<tr>
<th>Environment</th>
<th>TP</th>
<th>TN</th>
<th>N:P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>0.0722</td>
<td>0.0773</td>
<td>0.0281</td>
</tr>
<tr>
<td>Marsh</td>
<td>0.7803</td>
<td>0.6385</td>
<td>0.8789</td>
</tr>
</tbody>
</table>
Daily sap flow velocities for two tree species during the 2008 dry season indicate a day-time influence on shallow and deep groundwater elevations on the 3AS3 Tree Island.
Significantly higher concentrations of Total Phosphorus in the green leaves and litter from Pond Apple and Cocoplum were found on the head of the 3AS3 Tree Island.

<table>
<thead>
<tr>
<th></th>
<th>TP</th>
<th>TP</th>
<th>TN</th>
<th>TN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/g</td>
<td>mg/g</td>
<td>mg/g</td>
<td>mg/g</td>
</tr>
<tr>
<td></td>
<td>Head</td>
<td>Near Tail</td>
<td>Head</td>
<td>Near Tail</td>
</tr>
<tr>
<td><strong>Green Leaves</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pond Apple</strong></td>
<td>1.21</td>
<td>1.11</td>
<td>21.7</td>
<td>22.2</td>
</tr>
<tr>
<td><strong>Cocoplum</strong></td>
<td>1.27</td>
<td>0.43</td>
<td>15.0</td>
<td>11.8</td>
</tr>
<tr>
<td><strong>Litter</strong></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pond Apple</strong></td>
<td>1.05</td>
<td>0.65</td>
<td>14.0</td>
<td>14.2</td>
</tr>
<tr>
<td><strong>Cocoplum</strong></td>
<td>1.29</td>
<td>0.15</td>
<td>6.2</td>
<td>5.9</td>
</tr>
</tbody>
</table>
Generalized Geological Cross Section Through 3AS3 with TP Groundwater Quality (n=4)

Head

North

GW1 Cluster
7 ppb
GW2 Cluster
32 ppb
(NE Corner)

Tail

GW3 Cluster
9 ppb
GW4 Cluster
23 ppb

South

GW1 Cluster
52 ppb
GW2 Cluster
71 ppb

GW3 Cluster
74 ppb
GW4 Cluster
96 ppb

0.58 feet/day to 103.6 feet/day
1.5 feet/day to 16.08 feet/day

For more on diurnal drawdown impacts see Pam Sullivan in the LNWR Session, Wed. at 11:40.
**WET HEAD**: Early Wet Season -- Precipitation events slow infiltration rates as water table rises above soil surface. Infiltration increases as water drains below soil surface (Troxler et al. unpub).

Each of the 12 sets of pizometers has 2 wells (30 cm and 100 cm).

1. *Humans were present earlier and more intensively than previously thought.*

2. *This could be re-precipitated calcium carbonate that is biologically mediated through ET.*

3. *It may be phosphorus source or sink.*

C. Archaeological test pit exposing mineralized layer and unconsolidated sediments below.

D. Carbonate layer with surface sediments removed.
A Landscape Hypothesis with implications for Restoration: *Flow and focused nutrient redistribution facilitate the ridge & slough landscape pattern and the sustainability of tree islands.*
The State of Our Understanding of the Biogeochemical Processes on Tree Islands in the Greater Everglades?

*Much better than it was 10 years ago, and still fascinating!*