Linking soils, hydrology, forest structure & productivity in Everglades tree islands
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Tree Island restoration

Setting the objective

Achieving the objective

Extent
1. Density
2. Size/shape
3. Distribution

Condition
1. Stocking
2. Diversity
3. Productivity
Stocking - many Everglades tree islands are under-stocked
Diversity - many Everglades TI’s hold fewer tree species than their size would allow

Species-area scatterplot for 130 south Florida tropical hardwood hammocks
Considering the entire range of Everglades TI’s, deep water usually implies low tree production.

![Graph showing litterfall and mean water level](image)

**Litterfall (kg/ha/yr x 10^3)** in hammock, bayhead, and bayhead swamp in three Shark Slough TI’s, 2001-2003

**Mean water level (cm)** in hammock, bayhead, and bayhead swamp in three Shark Slough TI’s, 2001-2003
What controls production in tropical hammocks? Hydrology? Nutrients? Other soil factors?
Soil & site characteristics in 4 physiographic regions, Part I

Caliche formed mid-way in profile, Sour Orange Hammock, NESS

**Box plots showing:***
- Island Height (cm)
- Soil Depth (cm)
- Water depth (cm)
- pH
- TP (µg/g dm)

**Significance levels:**
- $p = <0.001$
- $p = <0.001$
- $p = <0.001$

**Legend:**
- a
- b
- c
- ab
- bc
### Clay mineral %’s in several nearby Everglades soil series

Sodek et al. 1990

<table>
<thead>
<tr>
<th>Soil Name</th>
<th>Hydroxyl-interlayered vermiculite</th>
<th>Kaolinite</th>
<th>Quartz</th>
<th>Calcite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perrine Marl</td>
<td>-</td>
<td>-</td>
<td>40</td>
<td>60-100</td>
</tr>
<tr>
<td>Pennsuco Marl</td>
<td>48</td>
<td>5-10</td>
<td>15-26</td>
<td>27-74</td>
</tr>
<tr>
<td>Krome</td>
<td>58</td>
<td>35</td>
<td>7</td>
<td>na</td>
</tr>
</tbody>
</table>
Reducing the dimensionality of the soil:site data

Table 2: Factor loadings of first three factors of Principal Component Analysis, applied to 2 physiographic and 7 edaphic variables measured at 69 Everglades hardwood hammocks. Most important variables on each factor are printed in bold face.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>“Alkaline, high P”</td>
<td>“Non-carbonate minerals”</td>
<td>“Well-drained”</td>
</tr>
<tr>
<td></td>
<td>42.0</td>
<td>26.6</td>
<td>16.6</td>
</tr>
<tr>
<td>Eigenvalue (% of total)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Island Height</td>
<td>0.61</td>
<td>0.27</td>
<td>0.70</td>
</tr>
<tr>
<td>Water depth</td>
<td>-0.46</td>
<td>-0.38</td>
<td>-0.76</td>
</tr>
<tr>
<td>Soil depth</td>
<td>0.18</td>
<td>-0.63</td>
<td>-0.14</td>
</tr>
<tr>
<td>Total N</td>
<td>-0.91</td>
<td>0.27</td>
<td>0.08</td>
</tr>
<tr>
<td>Total P</td>
<td>0.73</td>
<td>0.48</td>
<td>-0.32</td>
</tr>
<tr>
<td>pH</td>
<td>0.79</td>
<td>-0.22</td>
<td>-0.23</td>
</tr>
<tr>
<td>IOC</td>
<td>0.33</td>
<td>-0.89</td>
<td>0.23</td>
</tr>
<tr>
<td>TOC</td>
<td>-0.94</td>
<td>0.20</td>
<td>0.17</td>
</tr>
<tr>
<td>NCM</td>
<td>0.42</td>
<td>0.78</td>
<td>-0.40</td>
</tr>
</tbody>
</table>
1. Estimating production directly is costly and has been done on only a small subset of sites.

2. Potential structural surrogates are basal area, biomass, and canopy height.

3. Structural variables that are relatively insensitive to (a) initial density and (b) the legacy of past disturbances provide the best surrogates for potential growth rates.

4. Height growth is generally less sensitive to crowding than diameter growth (or measures dependent on it such as basal area or biomass). For this reason, foresters have long used the height of dominant trees to index site productivity.

5. Moreover, in fast-growing, hurricane-prone south Florida forests, it appears that canopy height approaches an asymptote after disturbance more rapidly than do basal area or biomass.
Result: a strong positive association between canopy height and PCA Factor 2 (Non-carbon Minerals). Other PCA Factors and other structural surrogates showed no significant relationship.

Table 4: Stepwise regression models for prediction of three metrics of Everglades tropical hardwood forest structure from three composite PCA factors

<table>
<thead>
<tr>
<th>Regression model</th>
<th>R²</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal area, Biomass: No significant independent variables</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Canopy height = 7.24 + (1.55*Factor 2)</td>
<td>0.706</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>
Conclusion

1. The abundance and impact of Non-carbon Minerals (Factor 2) in Everglades tree islands is an intriguing result. Once more is learned about the nature of these materials, we may find that they improve the soil’s capacity to supply the water or nutrient(s) that limit forest growth.

2. Lack of depth-to-water effect is surprising, may result from narrow range in data.

3. Phosphorus (Factor 1) is limiting in the Everglades marsh, but is present in such large amounts in tropical hammocks that stand growth is unaffected by it.