Examining the effects of sea-level rise on Everglades coastal marshes using coupled mesocosm and in-situ field manipulations:

Design and Implementation

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“...research advances and science that are needed ...such as understanding peat collapse, saltwater intrusion,...”

“...Ongoing experimental studies in Everglades National Park and in controlled mesocosms...show the combined influence of salt addition and hydroperiod affect plant production, net ecosystem exchange, and porewater chemistry – all influencing the carbon balance and, ultimately, the peat soil stability...”
OBJECTIVES

• Provide an introduction to on-going studies to understand the mechanisms leading to peat collapse in southern Everglades marshes
• Describe the experimental design of both the field and mesocosm studies
• Summarize the response variables
• Present results indicating the experimental designs were successful in achieving the desired outcome
Mesocosm Facility

- Located at the Florida Bay Interagency Science Center in Key Largo
- Built in 1997 by the SFWMD, refurbished in 2011
- 12 rectangular concrete tanks holding 250 gallons
Mesocosm Facility (cont)

- 4 head tanks holding 2100 gallons
  - 2 for freshwater collected from the C111 canal
  - 2 for saltwater collected from Sunset Cove in Florida Bay
- 6 mixing tanks, 100 gallons each, holding water of different salinities
- Water is delivered continuously (press) via submersible pump (5-35 ml min$^{-1}$)
Mesocosm Facility (cont)

- Peat soil or peat soil plus plant (sawgrass) monoliths (n=24) were collected intact and placed in 5 gallon perforated buckets to allow water exchange.
- Monoliths were placed in one of the 6 concrete tanks randomly assigned to a treatment depending on the experimental design.
<table>
<thead>
<tr>
<th>Site</th>
<th>Core</th>
<th>Salinity (psu)</th>
<th>Inundation (cm)</th>
<th>+ P</th>
<th>Duration</th>
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</thead>
<tbody>
<tr>
<td>BW</td>
<td>Soil Only</td>
<td>Ambient (15) vs Elevated (30)</td>
<td>Ambient vs Elevated (+8)</td>
<td>No</td>
<td>10 Weeks</td>
</tr>
<tr>
<td>FW</td>
<td>Soil+Plant</td>
<td>Ambient (0) vs Elevated (10)</td>
<td>Ambient</td>
<td>Yes</td>
<td>24 Months</td>
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<tr>
<td>FW</td>
<td>Soil+Plant</td>
<td>Ambient (0) Recovery</td>
<td>Ambient</td>
<td>No</td>
<td>17 months</td>
</tr>
<tr>
<td>BW</td>
<td>Soil Only</td>
<td>Ambient (10) vs Elevated (20)</td>
<td>Ambient vs Elevated (+4)</td>
<td>No</td>
<td>3 Months</td>
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<tr>
<td>BW</td>
<td>Soil+Plant</td>
<td>Ambient (10) vs Elevated (20)</td>
<td>Ambient vs Elevated (+4)</td>
<td>No</td>
<td>17 Months</td>
</tr>
<tr>
<td>BW</td>
<td>Soil+Plant</td>
<td>Ambient (10) vs Elevated (20)</td>
<td>Ambient vs Drought (-10 to -20)</td>
<td>No</td>
<td>12 Months</td>
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<tr>
<td>FW</td>
<td>Soil+Plant</td>
<td>Ambient (0) vs Elevated (5 &amp; 10)</td>
<td>Ambient</td>
<td>No</td>
<td>On-going</td>
</tr>
</tbody>
</table>
Response Variables may Include

**Surface water, Pore water**
- In-situ
  - salt, temperature, pH, redox
- Analytical
  - NO₃, NO₂, NH₄, SRP, DOC, TDP, SO₄, HS

**Soil (0-5, 5-15, 15-25 cm)**
- Bulk density, % moisture, % organic matter, TN, TC, TP
- Microbial extracellular enzyme activity

**Soil and plants**
- Above and below ground biomass, CNP
- Annual Net Primary Production
- Root biomass and production
- Periphyton metabolism, CNP, and diatom species composition
- Gas flux (CO₂, CH₄)
  - Gross Ecosystem Production, Net Ecosystem Production, Ecosystem Respiration
- Elevation change/SET’s
Soil + Plants Results

Surface Water Salinity (psu)
- Ambient Salinity
- Elevated Salinity

Surface Water SO4 (mg/l)
- Ambient Salinity
- Elevated Salinity

Pore Water Salinity (psu)
- Ambient Salinity
- Elevated Salinity

Pore Water SO4 (mg/l)
- Ambient Salinity
- Elevated Salinity
Two marsh sites in Everglades National Park started in October 2014
- Fresh water (FW) and brackish water (BW)

- 12 circular chambers per site (1.4 m diameter) installed along an 80 m elevated boardwalk
- 6 controls (ambient salinity) and 6 treatments (elevated salinity) at each site
Field Experiments (cont)

- Chambers have rotating collars allowing water exchange with the surrounding marsh or isolated when closed during salinity dosing.
Monthly dosing (pulse) of the controls is accomplished by adding on-site water when available or C-111 water when dry.

Monthly dosing (pulse) of the treatments is accomplished using a brine solution of on-site or C-111 water and Instant Ocean salt.

Brine is prepared based on site surface water depth and salinity.

Target salinities are twice that of site salinity (FW=10, BW=20 psu).
Field Results

Brackish Water Pore Water Salinity (psu mean ±sd)
- Control Salinity
- Elevated Salinity

Fresh Water Pore Water Salinity (psu mean ±sd)
- Control Salinity
- Elevated Salinity

Brackish Water Pore Water SO4 (mg/l mean ±sd)
- Control Salinity
- Elevated Salinity

Fresh Water Pore Water SO4 (mg/l mean ±sd)
- Control Salinity
- Elevated Salinity
Biogeochemical effects of simulated sea level rise on carbon loss in an Everglades mangrove peat soil

Lisa G. Chambers, Stephen E. Davis, Tiffany Trinh, and Alan Downing

Phosphorus alleviation of salinity stress: effects of saltwater intrusion on an Everglades freshwater peat marsh

Benjamin J. Wilson, Shelby Servais, Sean P. Charles, Viviana Mazzei, Evelyn E. Gaiser, John S. Kominoski, Jennifer H. Richards, and Tiffany G. Troxler

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APPLICATION

In situ simulation of sea-level rise impacts on coastal wetlands using a flow-through mesocosm approach

Joseph Stachelek, Stephen P. Kelly, Fred H. Sklar, Carlos Coronado-Molina, Tiffany Troxler, and Laura Bauman

Declines in Plant Productivity Drive Carbon Loss from Brackish Coastal Wetland Mesocosms Exposed to Saltwater Intrusion

Benjamin J. Wilson, Shelby Servais, Sean P. Charles, Stephen E. Davis, Evelyn E. Gaiser, John S. Kominoski, Jennifer H. Richards, and Tiffany G. Troxler

Saltwater intrusion and soil carbon loss: Testing effects of salinity and phosphorus loading on microbial functions in experimental freshwater wetlands

Shelby Servais, John S. Kominoski, Sean P. Charles, Evelyn E. Gaiser, Viviana Mazzei, Tiffany G. Troxler, and Benjamin J. Wilson

Functional and Compositional Responses of Periphyton Mats to Simulated Saltwater Intrusion in the Southern Everglades

Viviana Mazzei, Evelyn E. Gaiser, John S. Kominoski, Benjamin J. Wilson, Shelby Servais, Laura Bauman, Stephen E. Davis, Steve Kelly, Fred H. Sklar, David T. Rudnick, Joseph Stachelek, and Tiffany G. Troxler
Dong Yoon Lee
Lasting Salt and Phosphorus Effects Limit the Capacity of Restored Freshwater Wetlands to Recover Carbon Losses

The salt and phosphorus memory can extend the time required for marsh-peat wetland restoration

Tiffany Troxler
Response of Marsh Ecosystems to Coastal Change in the Southeastern Florida Everglades

BW Site Net Ecosystem Exchange and water level
Talks in this Session

Michael Savarese
Landscape Effects of Peat Collapse: Examples from the Ten Thousand Islands NWR and Everglades NP

Map of Cape Sable illustrating area of observed marsh collapse associated with degraded coastal freshwater peats with image of collapsing marsh (center).

Lukas Lamb-Wotton
An Emerging Tool to Assess Peat Loss and Wetland Vulnerability in the Florida Everglades

Recent results of our current Sea Grant work mapping coastal vulnerability as a function of modeled salinity, soil depth and vegetation cover. Red is highly vulnerable.
QUESTIONS?

Stephen P. Kelly
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