Fire Project Update:

Mass and nutrient loss of cattail communities in WCA 2A in response to prescribed fires

Quarterly Communications Meeting on the Long-Term Plan for Achieving Water Quality Goals for Everglades Protection Area Tributary Basins

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Management objective
Assess whether multiple surface fires accelerate the recovery of the nutrient-enriched areas now dominated by cattails in WCA 2A

Research objectives
• Determine ecological effects of multiple surface fires on critical wetland ecosystem structure, function, and processes in nutrient-enriched areas

• Examine natural recovery pattern in WCA 2A
Conceptual model for Fire Project

1. Release and Return
2. Surface Water
3. Soil
4. Vegetation

1. Ash
2. Water Flow
3. Decomposition
4. Periphyton
5. Soil P
6. Sediment
7. Competition for Nutrients
8. Species other than cattail
Objectives

• Quantify mass and nutrient loss and return

• Examine factors that affect mass and nutrient loss and return

• Assess ash chemistry and its impacts on water quality
**Fire Project Design**

<table>
<thead>
<tr>
<th>Date</th>
<th>Type</th>
<th>Water Depth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2006</td>
<td>Prescribed</td>
<td>10</td>
</tr>
<tr>
<td>July 2008</td>
<td>Prescribed</td>
<td>43</td>
</tr>
<tr>
<td>February 2006</td>
<td>Wildfire</td>
<td>19</td>
</tr>
<tr>
<td>August 2008</td>
<td>Prescribed</td>
<td>32</td>
</tr>
</tbody>
</table>

**Highly P-enriched (1000 - 1200 mg/kg)**

**Moderately P-enriched (600 - 1000 mg/kg)**

**Reference (< 600 mg/kg)**
Fire Implementation
Average Biomass and Nutrient Loss
Average Biomass and Nutrient Loss

- Mass: 40 g/m²
- Carbon: 30 g/m²
- Nitrogen: 20 g/m²
- Phosphorus: 10 g/m²

Loss (%): 10 to 20
Biomass & Nutrient Loss at Different Habitat & Burns

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Fire #</th>
<th>Mass</th>
<th>Carbon</th>
<th>Nitrogen</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly-enriched</td>
<td>1</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>44</td>
<td>43</td>
<td>58</td>
<td>49</td>
</tr>
<tr>
<td>Moderately-enriched</td>
<td>1</td>
<td>49</td>
<td>62</td>
<td>63</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>28</td>
<td>25</td>
<td>28</td>
<td>30</td>
</tr>
</tbody>
</table>
Highly-enriched plot post-fire, 2006

Combusted mass
- 62% of total mass
  - 78% of dead litter layer
  - 24% of live leaves

Nutrients released m^-2
- 585 g C
- 0.7 g P
- 11 g N
Highly-enriched plot post-fire, 2008

Combusted mass
• 44% total mass
  • 63% of dead litter layer
  • 10% of live leaves

Nutrients released m⁻²
• 379 g C
• 0.6 g P
• 10 g N
Combusted mass
- 49% total mass
  - 59 % of dead litter layer
  - 19 % of live leaves

Nutrients released m⁻²
- 424 g C
- 0.1 g P
- 10 g N
Moderately-enriched plot post-fire 2008

Combusted mass
• 28% total mass
  • 33% of dead litter layer
  • 17% of live leaves

Nutrients released m$^{-2}$
• 195 g C
• 0.2 g P
• 3 g N
Mass Loss and Pre-Fire Mass

\[ y = 0.02X + 4.02 \]
\[ r^2 = 0.28 \]
\[ p = 0.05 \]
Mass Loss and Water Depth

\[ y = -0.854x + 63.59 \]

\[ r^2 = 0.27 \]

\[ p = 0.056 \]
Mass Loss and Temperature

- Cattail
- Sawgrass

Regression line
95% Confidence interval
- Highly enriched 1st Fire
- Moderately enriched 1st Fire
- Highly enriched 2nd Fire
- Moderately enriched 2nd Fire
Mass Loss and Species

Cattail

Sawgrass
Total C (351 g/m²) (40%)

Total N (7.3 g/m²) (47%)

Particulate P (0.36 g/m²) (40%)

Aboveground Mass (1681 g/m²)
C, N, P & Metals (810 g C/m², 14.0 g N/m², 0.8 g P/m²)

A. Release

All %s in A. are based on pre-mass
Ash Collection Design

H2 Ash/HOBO Design

- Ash Collector
- S.T. Logger (Air)
- S.T. Logger (Air, Soil & Water)
Nutrient Return to the System

Leaf fragments: 1.4%
Ash: 1.4%
### Ash Return to the System

<table>
<thead>
<tr>
<th>Ash return</th>
<th>% pre-fire</th>
<th>% burned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>0.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Ash TN</td>
<td>0.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Ash TC</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Ash TP</td>
<td>4.0</td>
<td>8.9</td>
</tr>
</tbody>
</table>
B. Return

Metals

Ash
(10.6 g/m²)
(1.4%)

TN
(0.06 g/m²)
(0.9%)

TC
(3.4 g/m²)
(1.0%)

TP
(0.03 g/m²)
(8.9%)

NH₄
(0.5 mg/m²)
(0.007%)

NO₃
(0.1 mg/m²)
(0.001%)

PO₄
(0.9 mg/m²)
(0.25%)

All %s in B are based on burned mass or nutrient content
Ash Chemistry with Varying Temperature

- Ash Total Carbon (mg/g residue)
- Ash Total Nitrogen (mg/g residue)
- Ash Total Phosphorus (mg/g residue)

Temperature (°C): 150, 250, 350, 450, 550

- Cattail Live
- Cattail Dead
- Sawgrass Live
- Sawgrass Dead
Surface Water pH Response to Ash Addition

**Graph 1:**
- **x-axis:** Temperature (°C)
- **y-axis:** pH of Plant Residue or Ash

**Graph 2:**
- **x-axis:** Time (06:00 to 22:00)
- **y-axis:** Surface Water pH
- Legend:
  - ● Highly enriched 1st Fire
  - ○ Highly enriched 2nd Fire
  - ▲ Moderately enriched 2nd Fire
Ash Deposition and Water Depth on SWTP

\[ y = \text{ash TP}(g/m^2)/\text{water depth (m)} \times 1000 \]

- **H2 2006 fire Predicted**
- **H2 2008 fire Predicted**
- **M2 2008 fire Predicted**
- **H2 2006 fire Actual**
- **H2 2008 fire Actual**
- **M2 2008 fire Actual**

**Axes:**
- **Y-axis**: Surface Water Total Phosphorus (\( \mu g/L \))
- **X-axis**: Water Depth (cm)
Air

Total C (351 g/m²) (40%)

Total N (7.3 g/m²) (47%)

Particulate P (0.36 g/m²) (40%)

Aboveground Mass (1681 g/m²)
C, N, P & Metals
(810 g C/m², 14.0 g N/m², 0.8 g P/m²)

A. Release

B. Return

Metals

Ash (10.6 g/m²) (0.6%)

TN (0.06 g/m²) (0.5%)

TC (3.4 g/m²) (0.4%)

TP (0.03 g/m²) (4.0%)

Water

NH₄ (0.5 mg/m²) (0.004%)

NO₃ (0.1 mg/m²) (0.001%)

PO₄ (0.9 mg/m²) (0.1%)

Soil

All percentages are based on pre-fire mass or nutrient content
Major Conclusions

• Prescribed fires were an effective way to quickly remove nutrients, as approximately 1% of N and C and < 8% of P of burned nutrients was returned as ash.

• Pre-fire mass and water depth at the time of fire were the main factors determining mass and nutrient loss.

• Water depth and fire temperature both directly (release) and indirectly (ash effect on water quality) affected ecosystem nutrient concentration.
Management Implications

• Two years were required for fuel loads to return for repeated fire but more time may be required for additional fires.

• As more N was released and less returned in ash than P, repeated fires can lead to a more N-limited system, and therefore care must be taken when considering prescribed fires in N-limited systems.
Management Implications

- Water depth is a key management consideration with levels between 10 and 40 cm resulting in successful surface fires.
  - The lower end is good for maximizing nutrient loss
  - The upper end is good for minimizing water quality changes.
- High water levels also reduce fire temperature, creating ash with lower pH, TP and soluble P concentrations.
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Project Publications


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Thank You