The Impact of Fire on Soil and Plant Nutrients in Calcareous Subtropical Wetlands


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Fire Biogeochemistry

- Consumes fuel (organic matter)
- Nutrient loss (N volatilization)
- Nutrient inputs (Ash deposition)
- Vegetation shifts

Brennan et al. (2009)
Burning Questions

- Seasonally dry systems?
  - Soil temperature?

- Effect of fire on wetland biogeochemistry?
  - Nutrient inputs (P), losses (C, N)
  - Productivity, species shifts (longer term)

- P-limited, calcareous systems?
Study Site

- Prairie wetland (wet grassland)
- Short hydroperiod
- Marl, calcareous, P-limited
- “Fire-adapted”
Restoration

- Former agricultural use
- High P soils scraped to bedrock
- Succession toward P limitation
- Vegetation management
Experimental Burn – HID, Everglades National Park

- ENP Research Centers
- Nike Missile Base
- Restored former agricultural field
- Reference short hydroperiod marl prairie

Location:
- Miami
Field study design:

- Two adjacent 30x30m plots burn & control
- High and low elevation sites in Reference and Restored areas
Thermocouples dataloggers, Pyrometers
Biomass Harvesting, nutrient budgets
• Short-duration fires (5 min)
• Reference fires hotter than Restored areas
• High elevation fires hotter than low elevation
• Soil temps elevated ~10°C
Ash Deposition

<table>
<thead>
<tr>
<th></th>
<th>Reference</th>
<th>Restored</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Above-Ground TP</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live Biomass</td>
<td>13.7</td>
<td>15.8</td>
</tr>
<tr>
<td>Dead Biomass</td>
<td>8.22</td>
<td>17.0</td>
</tr>
<tr>
<td>Litter</td>
<td>3.04</td>
<td>29.1</td>
</tr>
<tr>
<td>Periphyton</td>
<td>30.2</td>
<td>18.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>55.3</td>
<td>81</td>
</tr>
<tr>
<td><strong>Post-Fire (2day)</strong></td>
<td>58.9</td>
<td>46</td>
</tr>
</tbody>
</table>

**Pre-Fire**

**Post-Fire (2day)**

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**mg m\(^{-2}\)**

~22 mg P m\(^{-2}\)

~48 mg P m\(^{-2}\)
Nutrient limitation

Months after fire

Macrophyte TN:TP

- Restored High
- Restored Low
- Reference High
- Reference Low
Combustion Residues

Char, Charcoal, Biochar

200°C  300°C  400°C  550°C

Ash
Residue Characterization

- Low temperatures enhance P availability
- High temperatures (forming ash) reduce P availability

Hogue and Inglett (2012)
Ash mineralogy

• Calcite, Quartz dominate
• Presence of apatite Ca-PO$_4$
• High temp → oxides → stable P

XRD analysis after salt and partial carbonate removal
(W.H. Harris)
Conclusions/implications

• Merging soil biogeochemistry and fire ecology disciplines
  – Fire experiments are difficult!

• Differences in fire intensity are important
  – Woody vs. herbaceous, elevation
  – Nutrient transformer, residue quantity
Conclusions/implications

• Fire residues determine biogeochemical response
  – Char residues enhance P
  – High temps favor ash, increase stable P minerals

• Hotter fires promote restoration maintenance of P limitation
  – Fuel load, frequency
Thank you!

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  — L. Serra, J. Taylor

- US NPS, ENP Fire Team:
  - J. Adams, M. Vadiya, J. Weer, T. Woody

- Field Assistance:
  - D. Irick, A. Brestel, A. Cheesman, A. Baker

- Wetland Biogeochemistry Laboratory
  - Y. Wang, G. Wilson,
Fire characteristics

- May 4\textsuperscript{th} 2010
- \textbf{Ignition}: drip torch, aerial ignition
- Heading fire
- \textbf{Rate of spread}: 15-30 chains hr\textsuperscript{-1}
  \[ (1 \text{ chain}=66 \text{ ft}) \]

Fire pictures taken by T. Osborne