Influences of Salinity Intrusion on Belowground Decomposition: Implications for Surface Elevation Change

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# Experimental Design

## Salinity Gradient

<table>
<thead>
<tr>
<th>Depth</th>
<th>Upper</th>
<th>Middle</th>
<th>Lower</th>
<th>Marsh</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td><img src="image1" alt="River 1 Upper Depth" /></td>
<td><img src="image2" alt="River 1 Middle Depth" /></td>
<td><img src="image3" alt="River 1 Lower Depth" /></td>
<td><img src="image4" alt="River 1 Marsh Depth" /></td>
</tr>
<tr>
<td>25</td>
<td><img src="image5" alt="River 1 Upper Depth" /></td>
<td><img src="image6" alt="River 1 Middle Depth" /></td>
<td><img src="image7" alt="River 1 Lower Depth" /></td>
<td><img src="image8" alt="River 1 Marsh Depth" /></td>
</tr>
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<td>50</td>
<td><img src="image9" alt="River 1 Upper Depth" /></td>
<td><img src="image10" alt="River 1 Middle Depth" /></td>
<td><img src="image11" alt="River 1 Lower Depth" /></td>
<td><img src="image12" alt="River 1 Marsh Depth" /></td>
</tr>
</tbody>
</table>

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<thead>
<tr>
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<th>Middle</th>
<th>Lower</th>
<th>Marsh</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td><img src="image13" alt="River 2 Upper Depth" /></td>
<td><img src="image14" alt="River 2 Middle Depth" /></td>
<td><img src="image15" alt="River 2 Lower Depth" /></td>
<td><img src="image16" alt="River 2 Marsh Depth" /></td>
</tr>
<tr>
<td>25</td>
<td><img src="image17" alt="River 2 Upper Depth" /></td>
<td><img src="image18" alt="River 2 Middle Depth" /></td>
<td><img src="image19" alt="River 2 Lower Depth" /></td>
<td><img src="image20" alt="River 2 Marsh Depth" /></td>
</tr>
<tr>
<td>50</td>
<td><img src="image21" alt="River 2 Upper Depth" /></td>
<td><img src="image22" alt="River 2 Middle Depth" /></td>
<td><img src="image23" alt="River 2 Lower Depth" /></td>
<td><img src="image24" alt="River 2 Marsh Depth" /></td>
</tr>
</tbody>
</table>

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![Salinity Gradient Diagram](image25)
Methods

Roots and Rhizomes
• Litterbags
• Labile and refractory materials
• Long-term = 1 year
• Single exponential decay model: \( Y = ae^{-kt} \)

Cellulose
• Cotton Strips
• Labile material only
• Short-term ~ 14 days
• %Tensile strength lost
Physico-chemical Drivers of Decomposition

- Temperature
- Sea-level Rise
- River Flow
- Soil Redox
- Salinity
- Sedimentation
- Surface Elevation
- Organic Matter Composition
- Subsidence
- Decomposition
- Plant Growth
- Biomass Accumulation
Physico-chemical Drivers of Decomposition

**Temperature**
- 10 cm depth
- April 2011-October 2011

**Redox**
- 10 cm, 25 cm, 50 cm depth
- October 2010, 2011

**Salinity**
- October 2010-2011, 60 cm well depth

**Organic Matter Composition**
- Root and Rhizomes, initial material
- Lignin, Cellulose, Total Carbon, Total Nitrogen
Depth Effect
Roots and Rhizomes

P = 0.7609
Depth Effect
Cellulose

P < 0.0001
Hydrology

Waccamaw Upper

Waccamaw Middle

Waccamaw Lower

Waccamaw Marsh
Site (Salinity) Effect
Root and Rhizome Decomposition

P < 0.0001
Site (Salinity) Effect
Root and Rhizome Decomposition

P = 0.0203

\[ \text{Upper} \quad \text{Middle} \quad \text{Lower} \quad \text{Marsh} \]

% Mass Remaining

Landscape Salinity Gradient
Physico-chemical Characteristics

Redox

Salinity

Soil Temperature

- P < 0.0001
- P = 0.0663
- P = 0.0856
Root and Rhizome Decomposition

<table>
<thead>
<tr>
<th>Pearson Product-Moment Correlations</th>
<th>Redox Potential (mV)</th>
<th>Temperature (°C)</th>
<th>Porewater Salinity (ppt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Mass Remaining</td>
<td>r = -0.18041</td>
<td>r = 0.47682</td>
<td>r = 0.38309</td>
</tr>
<tr>
<td></td>
<td>P = 0.5037</td>
<td>P = 0.2322</td>
<td>P = 0.1430</td>
</tr>
</tbody>
</table>

% Mass Remaining vs. Salinity (ppt)

- r = 0.38309
- P = 0.1430
Root and Rhizome Decomposition

Landscape Salinity Gradient

% Mass Remaining

P=0.0203

Upper: A
Middle: A
Lower: A
Marsh: B

> 3ppt
### Root & Rhizome Chemical Composition

<table>
<thead>
<tr>
<th>Site</th>
<th>Lignin</th>
<th>Cellulose</th>
<th>Carbon : Nitrogen</th>
<th>Lignin : Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper</td>
<td>35.1 (3.9) a</td>
<td>20.3 (0.9) bc</td>
<td>44.5 (1.2) bc</td>
<td>35.8 (1.5) b</td>
</tr>
<tr>
<td>Middle</td>
<td>34.9 (0.6) a</td>
<td>22.4 (0.9) ab</td>
<td>48.7 (3.8) b</td>
<td>38.6 (2.9) a</td>
</tr>
<tr>
<td>Lower</td>
<td>26.5 (6.0) b</td>
<td>18.0 (1.7) c</td>
<td>41.1 (0.9) c</td>
<td>29.0 (3.4) d</td>
</tr>
<tr>
<td>Marsh</td>
<td>22.3 (1.3) b</td>
<td>24.2 (0.5) a</td>
<td>61.6 (2.9) a</td>
<td>32.0 (3.1) c</td>
</tr>
</tbody>
</table>

Different letters indicate significant differences between site/salinity treatments
Results
Cellulose

Landscape Salinity Gradient

CSTL day$^{-1}$

Upper | Middle | Lower | Marsh

P < 0.0001
Possible Mechanisms
Stimulated Decomposition of Labile Material

• Sulfate Introduction
  – Stimulated respiration
  – C- mineralization: Weston et al., 2011; Weston et al., 2006

• Nitrogen Availability
  – Salinity-induced plant mortality or stress with subsequent nutrient pulse, or lower Nitrogen uptake and increased Nitrogen availability.
Mineralization of Soil N

Pearson Product-Moment Correlations (n=120)

<table>
<thead>
<tr>
<th></th>
<th>Total sulfur</th>
<th>Conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>N mineralization flux</td>
<td>r = -0.088</td>
<td>r = -0.076</td>
</tr>
<tr>
<td>(µmol m⁻² d⁻¹)</td>
<td>P = 0.338</td>
<td>P = 0.412</td>
</tr>
<tr>
<td>N turnover</td>
<td>r = 0.017</td>
<td>r = 0.055</td>
</tr>
<tr>
<td>(d⁻¹)</td>
<td>P = 0.852</td>
<td>P = 0.551</td>
</tr>
</tbody>
</table>

Noe et al., *in review*
Cellulose Decomposition

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<th>Temperature (°C)</th>
<th>Porewater Salinity (ppt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSTL day⁻¹</td>
<td>r = -0.03203</td>
<td>r = 0.39566</td>
<td>r = 0.08374</td>
</tr>
<tr>
<td></td>
<td>P = 0.9063</td>
<td>P = 0.3319</td>
<td>P = 0.7578</td>
</tr>
</tbody>
</table>

\[ r = 0.08374 \]
\[ P = 0.7578 \]
Indirect Effects

Salinity → Plant Growth/Mortality → Nutrients → Decomposition

- Salinity
+ Plant Growth/Mortality
+ Nutrients
+ Decomposition
Refractory vs. Labile

Refractory + Labile

- Upper: A
- Middle: A
- Lower: A
- Marsh: B

Labile

- Upper: C
- Middle: B
- Lower: A
- Marsh: B

% Mass Remaining vs. CSTL day⁻¹

Landscape Salinity Gradient: Upper Middle Lower Marsh

Filter: Refractory + Labile

Symbol: > 3ppt N

Bar charts showing the comparison of refractory and labile components across different salinity gradients.
Implications

Primary Production

Wetland Elevation

Decomposition
Implications: Surface Elevation Change

SLR 0.3 - 0.4 cm y⁻¹

P < 0.001

Landscape Salinity Gradient
Conclusions

• Decomposition of refractory organic matter is limited when salinity exceeds 3ppt.
• There is not effect of salinity on decomposition of refractory material between 0-3ppt
• Decomposition of labile organic matter is stimulated in the degraded forest. Stimulation may be due to nutrient pulse/increased nutrient availability resulting from salinity-induced plant mortality or stress.
• Decomposition of labile organic matter is limited in the marsh, either from adverse impacts of salinity on microbial activity or lack of nutrient availability.
• Marsh elevation is increasing and likely due to a combination of decreased organic matter decomposition and increased primary production.