Spartina alterniflora marsh development on nutrient-rich dredged materials in a large-scale restoration project in mid-Chesapeake Bay: a case of silicon depletion?

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Courtesy U. S. Army Corps of Engineers
Annual Mean Sea Level in Chesapeake and Delaware Bays

- Baltimore -- 3.2 mm/yr
- Lewes -- 3.3 mm/yr
- Solomons -- 3.5 mm/yr
- Cambridge -- 3.6 mm/yr
Pore water concentrations (µmol L$^{-1}$)

Fall 2005 Mean ± SE, n = 18
Changes in pore water NH$_4^+$ and SRP in Dredged Material

- SRP increasing in both surface (<12 cm) and deep (>20 cm)
- NH$_4^+$ decreasing in both surface and deep
Planting  

Lush growth  

Re-colonization  

Die-back
Substrate effect on *S. alterniflora* aboveground biomass production

- Fluctuating biomass on dredged material, more stable biomass on sand
- Initially almost double the biomass on dredged material as on sand
Marsh characteristics associated with high fertility sediments:

- Lodging
- Low root:shoot ratio
- Fungal infection
- Leaf speckling
- Muskrat grazing
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### Poplar Island Biomass 2010

<table>
<thead>
<tr>
<th>Substrate</th>
<th>AG (gdw m⁻²)</th>
<th>BG (gdw m⁻²)</th>
<th>RSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dredged Material</td>
<td>1599</td>
<td>210</td>
<td>0.13</td>
</tr>
<tr>
<td>Sand</td>
<td>974</td>
<td>280</td>
<td>0.29</td>
</tr>
</tbody>
</table>
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*Fusarium* infections on *S. alterniflora* stems (left) and *S. patens* inflorescence (right).
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Reference Marsh  Dredged Material
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**USFWS Muskrat Capture (level of effort)**

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Dredge</td>
<td>50 (0.04)</td>
<td>192</td>
</tr>
<tr>
<td>Sand</td>
<td>4 (0.06)</td>
<td>19</td>
</tr>
</tbody>
</table>

Pers. Com., Chris Guy and Pete McGowan, USFWS
Causes???

- Low root:shoot ratio
- Fungal infection
- Lodging
- Leaf speckling
- Muskrat grazing
Role of silicon in higher plants:

- Essentaility: diatoms, horsetails, scouring rushes
- Enhancement of growth and yield
- Promotion of upright stature and resistance to lodging
- Favorable exposure of leaves to light
- Surface properties
- Resistance to disease organisms
- Resistance to herbivores
- Resistance to salinity stress
- Reduction of drought stress
- Protection against temperature extremes
- Effects on enzyme activities
- Effects on mineral composition

Source: Datnoff et al. 2001, *Silicon in Agriculture*
Silicon in pore water and plant tissue

June 2011, mean ± SE n = 3

Porewater Silicate (μmol L⁻¹)

Plant Tissue Si (mg kg⁻¹)

2010
Silicon amendment pilot study

Sand  Dredge Control  Dredge + Si  Dredge ++ Si
Silicon amendment field trial

May 2012
Elevation monitoring

Installing SETs, Nov. 2008

Feldspar marker horizon
Elevation change 2009-2012
Conclusions

• Restoration using high fertility dredged material has resulted in oscillating productivity of *S. alterniflora* during the first 6 years after planting.

• Elevated pore water NH$_4^+$ concentrations are persistent and SRP concentrations have increased, suggesting that the effects of this nutrient rich substrate will be long-term.

• Soil silicon amendments may help alleviate the problems associated with high fertility in a marsh restoration, as in rice cultivation.

• Implications for natural marshes: there may be a limit to the ability of natural marshes to adjust to increasingly hyper-trophic conditions and keep abreast of sea-level rise.
Acknowledgements: U.S. Army Corps of Engineers, Port of Baltimore and Maryland Environmental Service for providing funding and the photos above.