Freshwater Subaqueous Soil Survey Investigations and Applications

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Thank you

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RI-AES
• In the second edition of Soil Taxonomy the definition of soil was changed to accommodate subaqueous soils.

• This was done as resource scientists began to recognize the importance of these shallow-water soil resources for their habitats, structure, and associated ecosystem functions.
Why Map Freshwater Subaqueous Soils?

• There is a growing need for a tool to manage shallow aquatic systems and resources at an ecosystem scale
• Environments need to be managed in order to ensure long-term sustainability
• Growing difficulties in managing elevated nutrient levels (N & P) and the trophic state of lakes
• Abundance of issues related to sediment accumulation including contaminants such as metals, herbicides, and pesticides
• Explosion in the population of invasive species
Technical Soil Services

- Sedimentation rates and volume of sediment for pond restoration
- Engineering calculations for water volume in ponds
- Geotechnical data for engineering docks, etc
- Contaminant levels
- Floodplain restoration
- Cultural resources needs
- Bathymetry
- River data for dam removal and fish ladders
- Carbon accounting
Project Objectives

• Characterization the most common freshwater soil types
• Calculate carbon pools
• Understand the distribution of phosphorus
• Develop relationships between soils and invasive species distribution
• Estimate sedimentation rates
Project Goals

Develop recommendations for additional taxa in Soil Taxonomy for freshwater SAS

Develop additional methods, procedures, or standards for mapping freshwater SAS

Develop soil-landscape relationships for freshwater SAS

Answer the question: Are impounded freshwater SAS and different than natural lake SAS?
Bathymetry

Data collected with a Garmin fathometer (fish-finder; about $500)

Essentially drive back and forth across the water body in a cross-hatched pattern; X, Y, Z points are collected every 10 seconds

Data set to NAVD88

No worry about lake level variations or tidal corrections

Use software to create maps
Delineate soil-landscape units

- Lake Bed
- Shoreline
- Cove
- Deep Water
- Shoal
Run GPR transects

Can also use underwater video along transect to look for surface stones or surface patterns indicative of different soils, and/or support GPR images
GPR in towed raft
GPR on ice
Ground-truth GPR

Investigate soils

Build soil-landscape models

Understand map unit composition and purity
Subaqueous Soil Suborders
(Keys to Soil Taxonomy, 2010)

• **Wassents:** subaqueous Entisols. Defined as Entisols that have a positive water potential at the soil surface for more than 21 hours of each day. These soils are the first suborder to classify out under Entisols. The formative element Wass is derived from the German (Swiss) word “wasser” for water.

• **Wassists:** subaqueous Histosols. Defined as Histosols that have a positive water potential at the soil surface for more than 21 hours of each day. These soils are the second suborder to classify out under Histosols after Folists.
Wassent Great Groups

- **Frasiwassents:** Wassents that have, in all horizons within 100 cm of the mineral soil surface, an electrical conductivity of <0.2 dS/m in a 5/1 by volume mixture of water and soil.

- **Psammowassents:** Wassents that have less than 35 percent (by volume) rock fragments and a texture of loamy fine sand or coarser in all layers within the particle-size control section.

- **Sulfiwassents:** Wassents that have a horizon or horizons with a combined thickness of at least 15 cm within 50 cm of the mineral soil surface that contain sulfidic materials.

- **Hydrowassents:** Wassents that have, in all horizons at a depth between 20 and 50 cm below the mineral soil surface, both an $n$ value of more than 0.7 and 8 percent or more clay in the fine earth fraction.

- **Fluviwassents:** Wassents that have either 0.2 percent or more organic carbon of Holocene age at a depth of 125 cm below the mineral soil surface; or an irregular decrease in content of organic carbon from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

- **Haplowassents:** Other Wassents.
Frasiwassent Subgroups

- **Psammentic:** identify with bucket auger
- **Thapto-histic:** organic layers buried by recent sediment
- **Fluventic:** typically found where stream enters system
- **Aeric:** typically found near-shore
- **Typic:** others.
Wassist Great Groups

- **Frasiwassists**: Wassists that have, in all horizons within 100 cm of the mineral soil surface, an electrical conductivity of <0.2 dS/m in a 5/1 by volume mixture of water and soil.

- **Sulfiwassists**: Wassists that have sulfidic materials within 50 cm of the mineral soil surface.

- **Haplowassists**: Other Wassists.
Frasiwassist Subgroups

– **Sapric Frassiwassists:**
  >130 cm of SOM dominated by sapric SOM

– **Terric Sapric Frasiwassists:**
  <130 cm of SOM dominated by sapric SOM

**Terric** is a proposed change to Soil Taxonomy
Proposed SAS
Inceptisols

- Histic Frasiwassepts
- Umbric Frasiwassepts
Five New Series
(OSDs are available online)

• Burlingame
• Wickford
• Aquapaug
• Shannock
• Tuckertown

Map unit purity was generally >85%
Invasive Species

- Eurasian Watermilfoil
- Water Chestnut
- Curly-Leafed Pondweed
- Variable Leaf Watermilfoil
- Fanwort
• Invasive plants were abundant in some sites and totally absent in others.

• Variable milfoil and fanwort were the predominant species
Logistic regression results concerning the affect of total extractable P (by depth) on the type of vegetation or substrate present. Cells highlighted in dark gray displayed significant results (alpha < 0.05).

<table>
<thead>
<tr>
<th>Variable Tested</th>
<th>Porewater</th>
<th>NaHCO₃</th>
<th>NaOH</th>
<th>Total P</th>
</tr>
</thead>
<tbody>
<tr>
<td>P (0-5 cm) vs. occurrence of N</td>
<td>0.9708</td>
<td>0.3233</td>
<td>0.9903</td>
<td>0.5430</td>
</tr>
<tr>
<td>P (5-10 cm) vs. occurrence of N</td>
<td>0.5021</td>
<td>0.9894</td>
<td>0.9045</td>
<td>0.9198</td>
</tr>
<tr>
<td>P (0-5 cm) vs. occurrence of B</td>
<td>0.0750</td>
<td>0.2944</td>
<td>0.1054</td>
<td>0.1074</td>
</tr>
<tr>
<td>P (5-10 cm) vs. occurrence of B</td>
<td>0.0624</td>
<td>0.0484</td>
<td>0.1245</td>
<td>0.0673</td>
</tr>
<tr>
<td>P (0-5 cm) vs. occurrence of E</td>
<td>0.1095</td>
<td>0.9862</td>
<td>0.8626</td>
<td>0.9529</td>
</tr>
<tr>
<td>P (5-10 cm) vs. occurrence of E</td>
<td>0.0734</td>
<td>0.2726</td>
<td>0.0999</td>
<td>0.0899</td>
</tr>
<tr>
<td>P (0-5 cm) vs. occurrence of M</td>
<td>0.9937</td>
<td>0.9699</td>
<td>0.0355</td>
<td>0.1918</td>
</tr>
<tr>
<td>P (5-10 cm) vs. occurrence of M</td>
<td>0.2027</td>
<td>0.5123</td>
<td>0.8905</td>
<td>0.6642</td>
</tr>
<tr>
<td>P (0-5 cm) vs. occurrence of E and M</td>
<td>0.1029</td>
<td>0.9941</td>
<td>0.1733</td>
<td>0.3995</td>
</tr>
<tr>
<td>P (5-10 cm) vs. occurrence of E and M</td>
<td>0.0119</td>
<td>0.1286</td>
<td>0.0822</td>
<td>0.0485</td>
</tr>
</tbody>
</table>

N = Native species present only (n = 11)
B = Bare ground (n = 9)
E = Exotic species only (Fanwort or Variable Milfoil) (n = 24)
M = Mixture of native species and exotics (n = 6)
E and M = Exotic species present (Fanwort or Variable Milfoil), possibly with native vegetation (n = 30)
Soil Organic Carbon Pools
One-way ANOVA of Carbon Pools (Mg/ha) by Soil Series

- Wickford
- Tuckertown
- Burlingame
- Shannock
- Aquapaug
<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Soil Classification</th>
<th>n</th>
<th>Mean SOC (Mg/ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessively Drained Uplands</td>
<td>Typic Udipsamments</td>
<td>20</td>
<td>110</td>
</tr>
<tr>
<td>Well Drained Uplands</td>
<td>Typic Udipsamments</td>
<td>29</td>
<td>136</td>
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<tr>
<td>Poorly Drained Palustrine Wetlands</td>
<td>Aeric Endoaquepts</td>
<td>20</td>
<td>187</td>
</tr>
<tr>
<td>Very Poorly Drained Palustrine Wetlands</td>
<td>Typic Haplosapripts</td>
<td>30</td>
<td>586</td>
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<tr>
<td>Poorly and Very Poorly Drained Riparian Wetlands</td>
<td>Aeric Endoaquepts</td>
<td>29</td>
<td>246</td>
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<tr>
<td>Estuarine Subaqueous</td>
<td>Fluventic Psammowassents</td>
<td>9</td>
<td>47</td>
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<tr>
<td>Estuarine Subaqueous</td>
<td>Sulfic Psammowassents</td>
<td>5</td>
<td>57</td>
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<tr>
<td>Estuarine Subaqueous</td>
<td>Typic Fluviwassents</td>
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<td>109</td>
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<tr>
<td>Estuarine Subaqueous</td>
<td>Haplic Sulfiwassents</td>
<td>10</td>
<td>123</td>
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<tr>
<td>Estuarine Subaqueous</td>
<td>Typic Sulfiwassents</td>
<td>5</td>
<td>141</td>
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<tr>
<td>Freshwater Subaqueous</td>
<td>Sapric (Terric) Frasiwassists</td>
<td>8</td>
<td>434</td>
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<tr>
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<td>Aeric Frasiwassists</td>
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<tr>
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<td>Typic Humaquepts</td>
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<td>206</td>
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<tr>
<td>Freshwater Subaqueous</td>
<td>Psammentic Frasiwassents</td>
<td>5</td>
<td>56</td>
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</table>
## SOC Sequestration Rates

<table>
<thead>
<tr>
<th>Waterbody</th>
<th>Sampling ID</th>
<th>Depth to As above background</th>
<th>Depth to Pb above background</th>
<th>Depth used for Sequestration Rate</th>
<th>Sequestration Rate (Mg/ha/yr C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belleville Pond</td>
<td>9018</td>
<td>22.5</td>
<td>15</td>
<td>22.5</td>
<td>0.25</td>
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<tr>
<td>Belleville Pond</td>
<td>9021</td>
<td>35</td>
<td>25</td>
<td>35</td>
<td>0.38</td>
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<tr>
<td>Bellville Pond</td>
<td>9022</td>
<td>20</td>
<td>30</td>
<td>30</td>
<td>0.33</td>
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<tr>
<td>S&amp;S Reservoir</td>
<td>7003</td>
<td>N/A</td>
<td>30</td>
<td>30</td>
<td>0.33</td>
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<tr>
<td>S&amp;S Reservoir</td>
<td>7005</td>
<td>10</td>
<td>30</td>
<td>30</td>
<td>0.33</td>
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<tr>
<td>S&amp;S Reservoir</td>
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<td>N/A</td>
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<tr>
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<td>9014</td>
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<td>35</td>
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<td>Watchaug Pond</td>
<td>9026</td>
<td>7.5</td>
<td>surface</td>
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<td>Watchaug Pond</td>
<td>9029</td>
<td>N/A</td>
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<td>25</td>
<td>0.27</td>
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<tr>
<td>Watchaug Pond</td>
<td>9032</td>
<td>N/A</td>
<td>5</td>
<td>5</td>
<td>0.05</td>
</tr>
</tbody>
</table>

On average soils in a forest system in our region sequesters 0.5 to 0.85 Mg/ha/yr.
Project Goals

Develop recommendations for additional taxa in Soil Taxonomy for freshwater SAS

Develop additional methods, procedures, or standards for mapping freshwater SAS

Develop soil-landscape relationships for freshwater SAS

Answer the question: Are impounded freshwater SAS and different than natural lake SAS?