Using Ecological Site Concepts to Assess Restoration Success: A Case Study on MLRA 98 Mucky Depressions

August, 2018
Skye Wills, National Resource Soil Scientist
Greg Schmidt, Ecological Site Specialist
Matt Bromley, MLRA office leader
Study Design: Sample According to DSP Guidance
DSP Guidance

Dynamic Soil Properties – properties that change with land use, management and disturbance. Soil survey focuses on properties that change on the human time scale (~decades).

Guidance: for this project – Soil Change Guide, current Ch. 9

Both rely on space-for-time substitution (based on ecological site concepts) and multi-scale replication
Ecological Site - frames inference space and comparisons
Reference condition sets benchmark conditions (soil properties and vegetation)
AM - Actively Managed Agricultural Land

RR - Recently Restored Wetlands < 5 years

ER - Established Restoration > 5 years
1 project (ecological site defines the entire relevant area)

- **4 conditions**
  - Reference
  - Recent Restoration
  - Established Restoration
  - Agriculture

- **Replicate locations across each condition**
  - 3 – 5 locations in each

- **Plot assessment of species composition and cover**

- **Replicate pedons at each location**
  - One center pedon
  - Four satellite pedons
  - Vegetation data collected within plot formed by pedons
Results
Water
CNRatio
Calcium
Potassium
Magnesium
Phosphorus
Nitrogen
Carbon
Nitrate
Sulfur
pHCaCl₂
EC
Db
fiberR
FiberU
Enzyme
Total Phosphorus Content in Upper 50 cm

Maximum Sulfur Content in Upper 100 cm
Carbon to Nitrogen Ratio and Nitrate in upper 50 cm by Treatment/Site
Bulk Density in Upper 50 cm by Treatment/Site
Relationships Among Sites Based on Abiotic Properties
Classification Tree of Abiotic Properties by Treatment

- AM: 0.76 (28%)
- ER: 1.00 (13%)
- RR: 0.62 (13%)
- RF: 0.88 (27%)

**AM**

- AM: 0.34 (73%)
  - AM: 0.25 (100%)
  - Nitrate >= 2.1
    - Yes: AM
    - No: ER
  - ER: 0.44 (45%)
    - Magnesium < 21
      - Yes: ER
      - No: RR
    - RR: 0.64 (18%)
    - RR: 0.64 (18%)
  - RF: 0.88 (27%)
Conclusions
• Dynamic Soil Properties were significantly different by condition

• The RR sites were more similar (successful) than ER sites at restoring DSPs to reference conditions
  • despite being more recently restored, the newer techniques gave better results
  • neither treatment was as wet as the reference.

• The abundance of invasive *Phalaris arundinacea* (reed canary grass) in the restored sites was not related to treatment, but was associated with changed DSPs

• Decades of tree development are required before restored sites resemble reference vegetation.
Next Steps
Complete State and Transition Model

Update guidance to incorporate complex systems in sampling scheme
<table>
<thead>
<tr>
<th><strong>Michigan Natural Features Inventory</strong></th>
<th><strong>Group</strong></th>
<th><strong>Alliance</strong></th>
<th><strong>Association</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Hardwood Swamp</td>
<td>Central Hardwood Flatwoods &amp; Swamp Forest</td>
<td>Red Maple - Ash - Swamp White Oak Swamp Forest</td>
<td>Acer (rubrum, saccharinum) - Fraxinus spp. - Ulmus americana Swamp Forest</td>
</tr>
<tr>
<td>Rich Tamarack Swamp</td>
<td>Laurentian-Acadian-Appalachian Alkaline Swamp</td>
<td>Black Ash - Red Maple Swamp Forest</td>
<td>Larix laricina - Acer rubrum / (Rhamnus alnifolia, Vaccinium corymbosum) Swamp Forest</td>
</tr>
<tr>
<td>Rich Conifer Swamp</td>
<td>Laurentian-Acadian-Appalachian Alkaline Swamp</td>
<td>Northern White-cedar - Red Maple Swamp Forest</td>
<td>Larix laricina - Thuja occidentalis Swamp Forest</td>
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<tr>
<td>Hardwood-Conifer Swamp</td>
<td>Laurentian-Acadian-Appalachian Alkaline Swamp</td>
<td>Northern White-cedar - Red Maple Swamp Forest</td>
<td>Thuja occidentalis - Fraxinus nigra Swamp Forest</td>
</tr>
<tr>
<td>Prairie Fen</td>
<td>Midwest Prairie Alkaline Fen</td>
<td>Midwest Prairie Fen</td>
<td>Cornus amomum - Salix spp. - Toxicodendron vernix - Rhamnus lanceolata Fen</td>
</tr>
<tr>
<td>Prairie Fen</td>
<td>Midwest Prairie Alkaline Fen</td>
<td>Midwest Prairie Fen</td>
<td>Dasiphora fruticosa ssp. floribunda / Carex sterilis - Andropogon gerardii - Arnoglossum plantagineum Fen</td>
</tr>
<tr>
<td>Southern Wet Meadow</td>
<td>North-Central &amp; Northeastern Seep</td>
<td>Northern Calcareous Seep</td>
<td>Symphlocarpus foetidus - Mixed Forbs Seep</td>
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<tr>
<td>Inundated Shrub Swamp</td>
<td>Eastern North American Shrub Swamp</td>
<td>Buttonbush - Swamp-loosestrife Shrub Swamp</td>
<td>Cephalanthus occidentalis / Carex spp. Northern Shrub Swamp</td>
</tr>
<tr>
<td>Southern Shrub-carr</td>
<td>Eastern North American Shrub Swamp</td>
<td>Red-osier Dogwood - Willow Shrub Swamp</td>
<td>Cornus sericea - Salix spp. - (Rosa palustris) Shrub Swamp</td>
</tr>
<tr>
<td>Southern Wet Meadow</td>
<td>Midwest Wet Prairie &amp; Wet Meadow</td>
<td>Midwest Sedge - Bluejoint Wet Meadow</td>
<td>Carex stricta - Carex spp. Wet Meadow</td>
</tr>
<tr>
<td>Emergent Marsh</td>
<td>Eastern Ruderal Wet Meadow &amp; Marsh</td>
<td>Ruderal Non-tidal Common Reed Marsh</td>
<td>Phragmites australis ssp. australis Eastern Ruderal Marsh</td>
</tr>
<tr>
<td>none</td>
<td>Eastern Ruderal Wet Meadow &amp; Marsh</td>
<td>Eastern Ruderal Reed Canarygrass Marsh</td>
<td>Phalaris arundinacea Eastern Ruderal Marsh</td>
</tr>
</tbody>
</table>