Using Soil Attributes to Inform Silvicultural Prescriptions and Carbon Storage Objectives

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Soil – Production Relationships

• Soils are important factors in timber production
  – Drainage, nutrition, structure, parent material

• Growth and quality of individual tree species
  – Softwood v. hardwood sites

• Indices
  – Briggs’ site class

Briggs 1994
Habitat Mapping

• Bill Leak, U.S. Forest Service, 1970s-1980s
  – Habitat: areas within climatic – mineralogical zones which support a distinct successional sequence (i.e., climax forest)
  – Based on drainage, mineral soil characteristics, and parent material
  – Used to determine which species to favor for most production for least effort

Go to “Treesearch” website, enter keywords “habitat mapping” and author “Leak”
Habitat Mapping

- Marinus Westveld, U.S. Forest Service
- 1920s-1930s
  - Spruce types: spruce swamp, spruce flat, spruce-hardwoods, spruce slope, and old-field spruce
- 1950s
  - Site types: climax forest type
  - Based on organic and mineral soil characteristics, topographic position, and ground vegetation
  - Used to determine composition and structure goals for silviculture

Go to “Treesearch” website, enter author “Westveld”
Key Points

• Species respond differently to soil attributes
• Soil variables (drainage, nutrition, parent material) are determinants of potential composition (climax type)
• But current tree species composition is a poor indicator of site type and growth potential
  – Example: stable versus transitional mixedwoods

Photo courtesy of Nathan Wesely
Transitional Mixedwoods

1956

2008

U.S. Forest Service
Managed Forests

• Species composition, quality, and growth are a function of site and disturbance history

To what degree are northern conifer compositional outcomes a function of site versus silviculture?

Photos courtesy of Phil Hofmeyer
Penobscot Experimental Forest

- 3,800 acres
- U.S. Forest Service
- 1950 to present
Silvicultural Treatments
1950 to present

Variants of:
- Shelterwood
- Single-tree selection
- Diameter-limit
- Commercial clearcutting
Soils

- Glacial till and lacustrine deposits
  - Range from well to moderately well drained loams and stony loams, to poorly to very poorly drained silt and silty clay loams
Effect of Silviculture

• Across all sites, commercial clearcutting resulted in lower softwood abundance than any other treatment
• For other treatments, softwood abundance is a function of silviculture and depth to water
  – On wetter sites, proportion of softwoods is similar across treatments
  – On drier sites, proportion of softwoods decreases with increasing intensity of harvest
• Exception:
  – Uniform shelterwood
Site and Silviculture

• Interactions between soils, silviculture, and species silvics
  – Forest composition and production
• Match species objectives to site potential
• Working forest
  – Current composition affected by management
  – Important to consider soils in setting goals
Site Quality & C Dynamics

Research on the PEF
PEF Natural Area
32A - Scantic

70.0 (9.5)  51.7 (19.9)  71.7 (7.5)  90.0 (9.1)
32B - Danforth

64.6 (14.2)  54.2 (10.8)  43.8 (15.8)  37.5 (14.4)
C accumulation

- Cumulative sum of net changes in aboveground live tree and dead wood C stocks over time.
- Rates of C accumulation were fairly similar for stands 32A and 32B despite differences in soil types between stands.
Species composition

- 32A – balsam fir.
- 32B – eastern hemlock.
### C in the forest

About half of the C stocks are in belowground C pools.

<table>
<thead>
<tr>
<th>Aggregated C pools</th>
<th>Stand</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>32A</td>
<td>32B</td>
</tr>
<tr>
<td>Aboveground (Mg ha(^{-1}))</td>
<td>100.1 (14.1)</td>
<td>146.5 (20.2)</td>
</tr>
<tr>
<td></td>
<td>87.6-122.6</td>
<td>128.7-168.7</td>
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<tr>
<td>Belowground (Mg ha(^{-1}))</td>
<td>96.3 (7.6)</td>
<td>100.4 (6.6)</td>
</tr>
<tr>
<td></td>
<td>86.8-105.7</td>
<td>96.2-110.3</td>
</tr>
<tr>
<td>Total ecosystem (Mg ha(^{-1}))</td>
<td>196.3 (9.6)</td>
<td>247.0 (17.7)</td>
</tr>
<tr>
<td></td>
<td>185.6-209.4</td>
<td>226.8-267.3</td>
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</tbody>
</table>
Site quality and C stocks

The percentage of coarse fragments in the mineral soil was negatively correlated with many C stocks and explained much of the variation in C stocks between stands within treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Selection</th>
<th>Clearcut</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stand</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>Coarse fragments (%)</td>
<td>28.2 (10.9)</td>
<td>42.8 (19.8)</td>
</tr>
<tr>
<td>Aboveground C (Mg ha⁻¹)</td>
<td>78.4 (11.0)</td>
<td>63.3 (11.7)</td>
</tr>
<tr>
<td>Total ecosystem C (Mg ha⁻¹)</td>
<td>188.5 (24.1)</td>
<td>153.1 (34.1)</td>
</tr>
<tr>
<td>(Mg ha⁻¹)</td>
<td>155.4-218.0</td>
<td>132.5-213.4</td>
</tr>
</tbody>
</table>
New soil research to inform silviculture

Joshua Puhlick, Marie-Cecile Gruselle, and Ivan Fernandez