Carbon Stocks in Northern Old Growth Forests

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Key finding: Old growth forest carbon stocks were fairly consistent within forest types across the study stands. The forest floor carbon pool was significantly larger in softwood stands, averaging over 50 mtC/ha.

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http://www.nsrcforest.org
Forest carbon offsets are becoming an increasingly popular climate mitigation option. However, many questions surrounding the role of forests as a carbon sink remain. One of the most critical items to address is the maximum amount of carbon that can be potentially stored in a forest of a given type. How much more carbon can be stored in an old-growth forest compared to an undisturbed second-growth forest, or a sustainably managed working forest? We begin to address that question with a benchmark study that estimates carbon stocks in surface mineral soil (0-20 cm), forest floor, down dead wood, standing dead, and aboveground live biomass pools in hardwood and softwood old-growth forests in Maine, New Hampshire, and Vermont. All hardwood stands were northern hardwoods; softwood stands were either spruce, spruce-hemlock, or hemlock. Twenty-four temporary plots were established (four hardwood and four softwood sites per state) and inventoried using standard methods.

Carbon stock estimates were fairly consistent within forest types across the sites, even though the characteristics of each stand were different. In hardwood forests, carbon in aboveground live biomass ranged from 94 t/ha in New Hampshire to 139 t/ha in Vermont, while estimated total stocks for all pools measured were 214-218 t C/ha. In the softwood stands, carbon in aboveground biomass varied from 111 t/ha in Vermont to 143 t/ha in Maine. Total carbon was significantly higher in softwood stands than in hardwood stands in all states, ranging from 234-292 t/ha. Regardless of site, down dead wood was always a small carbon pool, averaging less than 8% of total stocks. Carbon stored in the upper 20 cm of the mineral soil was fairly consistent, generally averaging between 63-72 t/ha, with no consistent differences between hardwood and softwood stands.
Background and Justification

Recent policy developments such as the Regional Greenhouse Gas Initiative and the Montreal Process Criteria and Indicators of Sustainable Forestry have lead to much discussion about managing for carbon storage as an additional value of forests, but many basic research questions remain unanswered, particularly relating to soils. We do not know what the maximum carbon storage potential is for soils, what determines that threshold, or how much time is needed to reach that maximum. Does forest type affect the amount of carbon stored in the soil? Little information comparing carbon stocks in old-growth and second growth northern forests is available. How much carbon is stored in working forests relative to old growth forests, and how does this affect their roles in the carbon cycle? Does the distribution of carbon among pools differ between old-growth and working forests?

Old-growth forests present a laboratory that is well-suited to answering some of the basic questions about the role of forests in the carbon cycle. By studying carbon stocks in old-growth stands that have experienced little or no natural disturbance, we can establish a benchmark for maximum carbon stocks in northern forests. We can examine the effects of species composition by developing and comparing carbon estimates for both old-growth northern hardwood and spruce-fir stands. Comparing these results to those from mature second growth stands can help us understand the possible impacts of forest management practices on carbon storage, and to develop guidelines for managers.
Methods – Study Sites

- Sites were either documented as never cut, or had not experienced human disturbance for \( \approx 140 \) years.
- Range of average stand diameters and conditions.
- Hardwood sites: Northern hardwoods.
- Softwood sites: spruce-fir, hemlock, hemlock-spruce with fir component.
- Two hardwood and two softwood stands were selected in ME, VT, and NH.
  - Two half-acre temporary plots were sampled in each stand.
Field Methods

- All trees <1” dbh, live and dead, were measured on the sample plot
- Down dead wood measured on transects
- Soil (to 20 cm) and forest floor sampled on systematic grid
Results/Project outcomes

Mean basal area of study stand. Error bars indicate the range of the data, not standard error.

- **Hardwood**
- **Softwood**
## Results/Project Outcomes

Summary of average carbon pool values by forest type

All values given in metric tons C/ha

<table>
<thead>
<tr>
<th></th>
<th>Hardwood</th>
<th>Softwood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aboveground Live</td>
<td>116</td>
<td>125</td>
</tr>
<tr>
<td>Aboveground Dead</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Down Dead Wood</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Forest Floor</td>
<td>15</td>
<td>52</td>
</tr>
<tr>
<td>Mineral Soil (20cm)</td>
<td>63</td>
<td>68</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>214</strong></td>
<td><strong>267</strong></td>
</tr>
</tbody>
</table>
Results/Project Outcomes

Mean carbon stocks by forest type and state. Error bars are standard error of the mean.

(mtC/ha)
Results/Project Outcomes

Summary of main results

• Total C stocks fairly consistent across sites and vegetation type
  • Total stock significantly higher in softwood stands
• Only significant difference between C pools in hardwood and softwood stands was forest floor
  • Can be very large pool in softwood stands, especially where hemlock is present
• Dead wood not a large pool; about ~ 10 mtC/ha
Outreach

• Key findings presented in field tours and forest carbon training sessions

• Non-technical summary publication planned – will be downloadable

• Oral presentation at Ecological Society of America Annual meeting
Implications and applications in the Northern Forest region

• Results for aboveground C agree with existing estimates of aboveground live carbon in northern old-growth forests:
  – N. Hardwoods: 104-140 mtC/ha
  – Softwoods: 119-155 mtC/ha

• Role of dead wood: stocks measured were lower than “conventional wisdom” suggests

• Forest floor C in conifers fairly important pool
Future directions

• Work continues to analyze data from pyrolysis of soil samples
  – Complex chemistry is challenging to interpret
  – Comparing chemical signature of carbon from old growth hardwood and softwood stands
  – Comparing chemical signatures to soil samples from second growth stands

• Role of forest floor C pool in softwood stands
  – Effects of management actions; need for guidelines?
List of products

• Publications:

• Conference presentations:
  – Hoover, C. M. and Magrini, K. A. Planned presentation on carbon chemistry of old-growth forest soils at 2011 SSSA Annual Meeting.

• Other deliverables:
  – Web based fact sheet for non-technical audiences
  – Continued presentation of results on field tours and training workshops