The Carbon Benefits of Climate-Smart Forest Management (I)

Summary of Research from a National Perspective

Last Updated: 8 November 2019

By Ernie Niemi

For each article, I describe its focus and key findings. For some, I add a short discussion to help interpret the findings. Where possible, the discussion includes an estimate the economic value of forest-related carbon stores. This value generally represents the decrease in climate-related damages that would follow from a change in forest management that would increase the amount of carbon stored in forest ecosystems and wood products.

The estimates of economic value come from multiplying the article’s estimate of the increase in carbon stores (usually shown as the metric tons of carbon dioxide-equivalent, or MtCO₂e) times an estimate of the social cost of carbon dioxide (SCCO₂e), i.e., the benefits to society from sequestering one MtCO₂e. I primarily employ estimates of the SCCO₂e from the most recent, comprehensive analysis: Ricke, K., L. Drouet, K. Caldeira, and M. Tavoni. 2018. Country-level social cost of carbon.

This analysis provides two estimates of the SCCO₂e. One, $417, represents the expected benefits from sequestering one MtCO₂e. The other, $800/MtCO₂e shows the potential benefits if climate change proves to be more harmful than was expected at the time the study was completed. The true SCCO₂e likely falls closer to the latter, insofar as 11,000+ scientists just stated that “The climate crisis has arrived and is accelerating faster than most scientists expected…. It is more severe than anticipated, threatening natural ecosystems and the fate of humanity…. ” Moreover, all current estimates of SCCO₂e fail to incorporate all the harms resulting from GHG emissions, including, for example, the full costs of ocean warming and acidification.

Note: these summaries represent my understanding of the major findings of each article. Before incorporating a specific article into your work, I recommend you read the original to ensure that your efforts represent it accurately and comprehensively.

Please, let me know if you:

- Find any errors or ambiguities in the summaries.
- Have any suggestions for making the summaries more useful.
- Know of studies you think I should summarize.
- Have any questions.
## Estimates of Forest Carbon: National Perspective

### N-1. Overview of U.S. forest carbon, 2018

<table>
<thead>
<tr>
<th>Study’s Focus</th>
<th>Present the most recent estimates of carbon stocks and stock changes across the continuum of land with trees in North America.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Findings</td>
<td>Managed forests in the U.S. (except interior Alaska, Hawai’i, and territories) absorbed about 267 Tg of atmospheric C per year from 2000 to 2015 and lost about 113 Tg C through harvest removals, for a net stock increase of 154 Tg C per year. The 2014 net uptake estimate from forestland remaining forestland was 742 Tg CO$_2$e per year, which offset about 11% of gross U.S. GHG emissions that year. Historical land clearing yields a legacy of carbon uptake in the Northeast; regrowth from contemporary harvesting dominates carbon uptake in the Southeast; and disturbances and environmental stresses (e.g., droughts, insects, and pathogens) raise carbon releases in the West. The amount of carbon in harvested wood products grew by 25–36 Tg C per year from 1990 to 2005. These products are not themselves a carbon sink, but a transfer in use of carbon previously stored in trees. Currently, annual afforestation slightly exceeds deforestation, but forest area is projected to level and then decline gradually after 2030. Assuming no policy intervention, annual carbon uptake will decrease to 320 Tg CO$_2$e per year in 2050 as a result of forest aging, forest disturbance, and land-use change. Severe warming of forest soils can accelerate loss of soil carbon emitted as CO$_2$.</td>
</tr>
</tbody>
</table>

### Discussion

### N-2. Carbon impacts from business-as-usual management of U.S. forests, 2017

<table>
<thead>
<tr>
<th>Study’s Focus</th>
<th>Calculate annual economic benefits for the nation from business-as-usual management of forests in the conterminous U.S., through 2050.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Findings</td>
<td>U.S. forests, on average, are expected to grow older and sequester more carbon (live tree above ground and below ground, deadwood, litter, and soil) in future years. This removal of CO$_2$ from the atmosphere will generate benefits by reducing the extent and intensity of the expected negative effects of climate change. A 2015 estimate of the social cost of carbon dioxide (SCCO$_2$e) indicates the stream of annual benefits is expected to be equivalent to a single, present value of about $700 per acre. If climate change proves to be more harmful than expected in 2015, the benefits from this forest-based carbon sequestration could be about $2,000 per acre. Applying the most recent estimate of the SCCO$_2$e, by Ricke, et al (2018), raises the expected benefit about tenfold, to about $7,000 per acre. This research also raises the estimate for the benefit, if climate change proves to be more severe than expected, to about $14,000. This information suggests that, on average, converting U.S. land from another use to forest would generate carbon-related benefits of at least $7,000 per acre, with a significant likelihood that the benefit would exceed $14,000 per acre.</td>
</tr>
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| Discussion    | Applying the most recent estimate of the SCCO$_2$e, by Ricke, et al (2018), raises the expected benefit about tenfold, to about $7,000 per acre. This research also raises the estimate for the benefit, if climate change proves to be more severe than expected, to about $14,000. This information suggests that, on average, converting U.S. land from another use to forest would generate carbon-related benefits of at least $7,000 per acre, with a significant likelihood that the benefit would exceed $14,000 per acre. |

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### N-3. Carbon impacts from afforestation and reforestation of U.S. forests, 2017

**Study’s Focus**
Calculate annual economic benefits for the nation from afforestation on about 12 million acres of private lands in the eastern U.S. and reforestation on about 9 million acres of public lands in western states, through 2050.

**Findings**
Carbon sequestration resulting from these actions would yield economic benefits totaling about $6,300 per acre. This number represents their core assumption, that changes in climate would cause economic damages corresponding to 2015 expectations for the social cost of carbon dioxide (SCCO₂e). If the negative effects of climate change prove to be more severe, the benefits from the forest-based carbon sequestration that would follow afforestation and reforestation would be as high as $19,000 per acre.

**Discussion**
Applying the most recent estimate of the SCCO₂e, by Ricke, et al (2018), raises the expected benefit about tenfold, to about $63,000 per acre. This research also raises the estimate for the benefit, if climate change proves to be more severe than expected, to about $120,000 per acre. This information suggests that, on average, planting trees (afforestation or restoration) in the conterminous U.S. would yield carbon-related benefits of about $63,300 per acre, with a significant likelihood that the benefits would exceed $120,000 per acre.

### N-4. Cost of forest-based carbon sequestration, 2005

**Study’s Focus**
Synthesize the literature to analyze the true opportunity costs of using land for forest-based carbon sequestration.

**Findings**
The sequestration of 270 million metric tons (MMt) of CO₂e/yr can be accomplished at a cost of $7.50–$22.50 per ton. The cost rises to $9–$27 for the sequestration of 450 MM CO₂e/yr.

**Discussion**
Even if adjusted upward for inflation since 2005, these costs fall far short of the economic benefits from carbon sequestration. The most recent estimates of the SCCO₂e, by Ricke, et al (2018) are $417/Mt CO₂e for the expected value of the benefits, and $800/Mt CO₂e if climate change proves to be more damaging than expected.

### N-5. Carbon-credit payments and harvest-rotation age: a meta analysis, 2018

**Study’s Focus**
Review studies from around the world to ascertain the extent to which higher carbon-credit payments induce landowners to extend the harvest-rotation age.

**Findings**
On average, an increase of 1% in the carbon payment can induce landowners to increase rotation age 0.16%.

**Discussion**

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### N-6. Carbon impacts from extending the harvest-rotation age for forests in different regions of the U.S., 2009

#### Study's Focus
For 46 different forest types in the conterminous U.S., estimate the amount of additional forest carbon (live tree, standing and down deadwood, understory, forest floor, and wood products) that would be sequestered by extending the harvest-rotation age by 5 years or 100 years.

#### Findings
All regions show an increase in carbon sequestration with longer rotations. The westside of the Pacific Northwest would generate the greatest level of carbon per hectare. The highest sequestration, aggregated over an entire ecosystem, occurs in the PNW West, South Central, and Northeast regions.

#### Discussion
For six forest ecosystems, researchers compared the additional carbon that would be sequestered and the amount of timber that would be forgone from a 100-year extension of the rotation age. These findings, multiplied by $417/MtCO_2$, the most recent estimate of the SCCO\textsubscript{2}e by Ricke, et al (2018), suggest the timber prices that would be needed for the lost value of the logs to exceed the value of the carbon benefits:

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>per m(^{3})</th>
<th>per thousand board feet*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacific Northwest Douglas-fir</td>
<td>$1,300</td>
<td>$3,000</td>
</tr>
<tr>
<td>Southeast Loblolly-Shortleaf Pine</td>
<td>$900</td>
<td>$2,100</td>
</tr>
<tr>
<td>Northeast Maple-Beech-Birch</td>
<td>$1,600</td>
<td>$3,700</td>
</tr>
<tr>
<td>Pacific Southwest Fir-Spruce-Mtn. Hemlock</td>
<td>$4,100</td>
<td>$9,700</td>
</tr>
<tr>
<td>N Lake States Aspen Birch</td>
<td>$2,700</td>
<td>$6,400</td>
</tr>
<tr>
<td>Rocky Mt. South Ponderosa Pine</td>
<td>$4,000</td>
<td>$9,500</td>
</tr>
</tbody>
</table>

The timber prices would have to be roughly twice as great to exceed the climate-related benefits if climate change proves to cause damages higher than general expectations. This information strongly suggests that extending the harvest-rotation age for plantations across the U.S. would generate carbon-related benefits that likely would exceed the value of the forgone timber production.

*Assumes 1 m\(^{3}\) = 424 board feet.

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### N-7. Achieving forestry goals for deep carbonization, 2018

<table>
<thead>
<tr>
<th>Study’s Focus</th>
<th>Compile relevant literature to describe the costs of the climate-smart forestry practices necessary to contribute to an 80% reduction in economy-wide GHG emissions by 2050, and the spatial distribution of these practices across the conterminous U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Findings</td>
<td>Carbon sequestration through land management (forestry and agriculture) declined nearly 10% from 1990, to 745.4 million metric tons (MMt) CO(_2)e in 2016. Forest sequestration declined from 789.7 to 745.5 MMt CO(_2)e. Land management can sequester an additional 150–800 MMt CO(_2)e per year for a carbon price of $10–$50/tCO(_2)e. Opportunities for forest sequestration—avoiding conversion of forests to other uses, expansion of forests onto lands currently under different uses, and improved management of private and public forests—exist across the conterminous U.S.:</td>
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</tbody>
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