USDA Northeast Climate Hub
U.S. DEPARTMENT OF AGRICULTURE

What can forest managers do to increase carbon storage and mitigate climate change?

Research from: Dugan, A.J., Lichstein, J.W., Steele, A., Metsaranta J., Bick, S., Hollinger, D.Y. "Opportunities for Forest Sector Emissions Reductions: A state-level analysis". Ecological Applications. ***doi:10.1002/eap.2327***

- **The carbon sink in Vermont forests is declining**
- **Alternative management action scenarios were analyzed**
- **Models showed that most of the scenarios would reduce net emissions**
- **Scenarios determined to be feasible included increased longer-lived wood products, increased bioenergy, increased residues, reduced deforestation, extended rotations and combinations of these.**
- **This info may be used as part of a process to evaluate trade-offs and risk assessments, in order to weigh the cost and benefits of actions**

The results from a new study in Vermont show how forests can play a significant role in fighting climate change.

Forests take up carbon dioxide (CO_2) from the atmosphere and store it as forest biomass (carbon sequestration). When wood or wood products burn or decay, the carbon in that material returns to the atmosphere. The removal of CO_2 from the atmosphere by forests on a global scale helps mitigate the impacts of climate change.

Forests cover 76% of Vermont. The Vermont Department of Forests, Parks and Recreation recognizes the value of storing carbon in the forest sector. This is one of the many benefits that forest ecosystems and the durable wood products derived from them provide. Researchers looked at how forest management scenarios affected climate mitigation in Vermont. Surprisingly, some of the biggest impacts came from wood substituting for other building products or fuels.

Methods: A carbon modeling framework

The study modeled net carbon emissions from all parts of the forest sector. These parts include, (1) the forest ecosystem, including land-use change, (2) harvested wood products (HWP), and (3) substitution effects. Substitution comes from using renewable wood-based products and fuels in place of more emission-intensive materials and fossil fuel-based energy. Net emissions across the forest ecosystem, wood products sector, and atmosphere were estimated by summing the differences between gains and losses. Gains included forest growth, afforestation and reforestation, as well as long term storage of carbon in wood products. Losses came from disturbance events, decay and decomposition, deforestation, or retiring wood products. This method of carbon accounting makes it possible to isolate the effects of individual factors (i.e., management or disturbances) on the outcomes.

Researchers first estimated baseline historical emissions and carbon trends from 1995 through 2050. The carbon accounting approach used tracks carbon stocks and estimates annual changes. Actual historical data were used up to the present to form the baseline. Then those historical baseline conditions were continued into the future to derive the business as usual (BAU) management scenario.

Researchers then chose 11 management options and looked at their effect from 2020 to 2050. They compared results from each option to the baseline (current BAU management) case. Negative emissions mean that a management option results in more carbon storage than under the base case. This first effort focused on the climate benefits of a management change and did not take other critical factors into account.

Photo: Nichols Pond in Woodbury, Vermont by Emily Stephens

Results: Decline in carbon may be changed by adjusting management

The new carbon Vermont forests may store is likely to decline as forests age and land clearing for other uses continues. However, many management strategies have positive climate benefits and may increase carbon storage. Results varied widely among the eleven scenarios.

The scenarios that were most effective in reducing net emissions include: a) using more harvested wood in long-lived products, b) combining longer harvest rotations with using more harvest residues for bioenergy and increasing forest productivity, and c) shifting commodities from pulpwood to bioenergy. Six of the most effective scenarios are described in Table 1. See the paper by **Dugan et al.** for more details on all the scenarios.

TABLE 1 *Net mitigation potential for each of the top scenarios across all forests in Vermont for all forest sector components combined. A negative value indicates a reduction in greenhouse gas (GHG) emissions relative to the baseline. The ecosystem and HWP models include emissions from all GHGs, which were converted to carbon dioxide equivalents (CO_2e) using global warming potentials.*

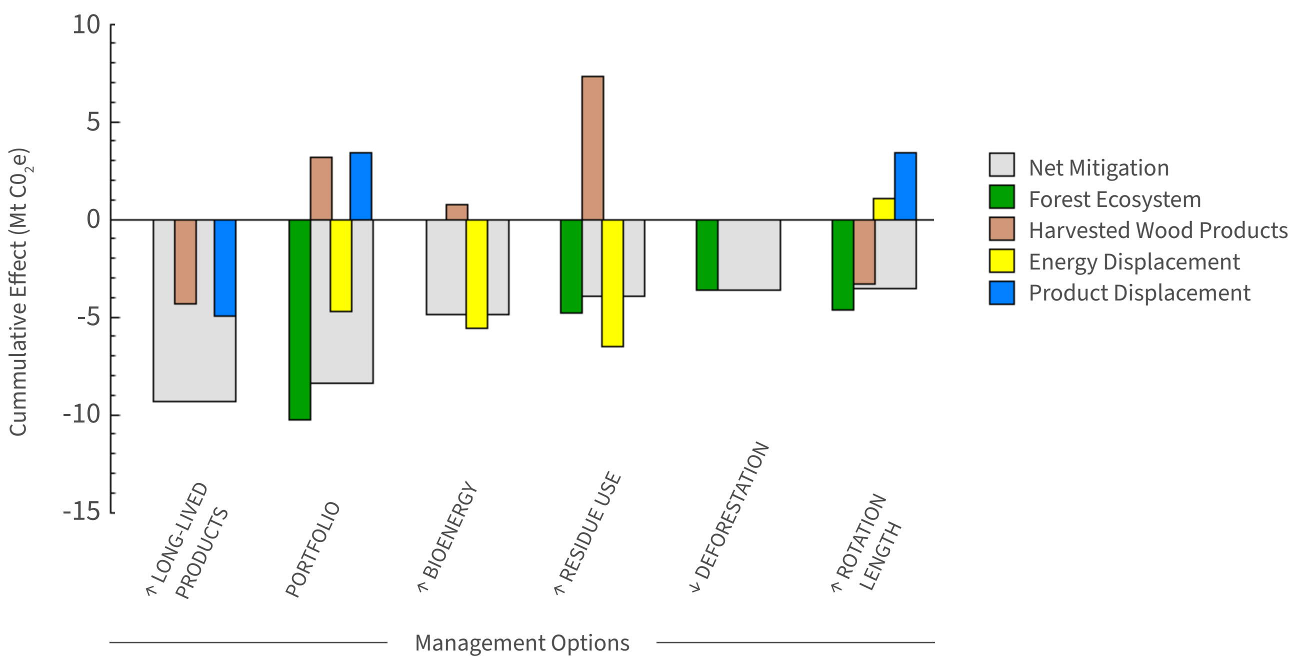
NET MITIGATION (CO_2e) IN 2050 COMPARED TO BASELINE *Negative values show reduction in GHG emissions*	**SCENARIO NAME**	**DESCRIPTION**	**DIFFERENCE FROM THE BASELINE** *Business as usual management*
-14%	Increase longer-lived products	Increase proportion of harvested wood for long-lived products (sawlogs) and decrease proportion of wood used for pulp and paper, delaying retirement of wood products	HWP proportions change: Longer-lived Products +10% Pulp and paper – 10%
-12.6%	Portfolio	Combine extend rotation, residues, and productivity scenarios	Harvested removals: - 10% Minimum harvest age: reduced Residues recovered (%) increased by: +9% for partial harvest +17% for shelterwood +20% for clearcut Volume curves: +15% Additional residues used for bioenergy
-7.3%	Increase Bioenergy	Increase the proportion of harvested wood for bioenergy at the cost of pulp and paper	HWP proportions change: Bioenergy + 10% Pulp and paper -10%
-6%	Increase Residues	Increase harvest residues collected by increasing proportion of whole tree methods. Additional residues are used for bioenergy.	Residues (tops, stumps, branches) recovered (%) increased by: +9% for partial harvest +17% for shelterwood +20% for clearcut Additional residues used for bioenergy
-5.5%	Reduce Deforestation	Reduce the annual area deforested to zero for public lands and by half for private lands.	Deforestation rate reduced by: -16 ha/yr National Forest -104 ha/yrOther Public -50% (-373 ha/yr) Private
-5.3%	Extend Rotation	Extend the length of time between harvests, reduce harvest removals.	Harvested removals: - 10% Minimum harvest age increased to 90 years

An important finding is that different management options can help reduce CO_2 loss in different ways (Figure 1). Some options such as “reduce deforestation” work because more carbon is stored in the trees and soil of the forest. Others, such as using more long-lived products, store carbon in the wood product itself for a longer period. Substitution or “Product displacement” is also important for long-lived wood products. This additional benefit occurs because their use can substitute for and displace concrete and steel construction that has high related emissions. In the same way, using forest residue or other products for fuel can displace fossil fuels. Finally, some of the management options have both positive and negative effects on CO_2 emissions that must be considered.

Preventing forest loss is a relatively low-cost climate mitigation option but increasing bioenergy use at the expense of pulpwood is likely uneconomic. Combining multiple effective options can yield large carbon benefits. This combined approach represented by the “Portfolio” scenario may also be more representative of the multiple outcomes that forest managers strive to achieve.

All results depend on the models, datasets and timeframe used, and their respective uncertainties. Likewise, all scenarios have tradeoffs as well as potential barriers to use. While Vermont’s forests can play a role in climate mitigation, it is important to consider mitigation along with other management objectives and forest benefits.

FIGURE 1 *Cumulative mitigation by component in 2050 for six management options in Vermont in order of highest net mitigation to lowest net mitigation (grey bars) from left to right. Negative values denote a reduction in GHG emissions. Refer to Table 1 for explanations of scenarios.*



Conclusion: Forest management will likely play a significant role in meeting goals to mitigate climate change.

Enhancing forest sector carbon sequestration can come with significant trade-offs. Evaluating the knowledge gaps of costs and benefits and considering impacts to ecosystems and management objectives is critical.

Photo: Vermont’s forests are dominated by middle to older-aged Maple/Beech/Birch established between 1920-1960. By Erin Lane | USDA is an equal opportunity provider, employer, and lender.