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Forests and Carbon

Jay O'Laughlin and Ron Mahoney

Forests affect climate and climate affects forests with carbon linking the two. Forests contain three-fourths of the earth's plant biomass, about half of which is carbon. Consequently, forests play a key role in the global carbon cycle by capturing, storing, and cycling carbon.

Forests can be either a carbon "sink" or a source of atmospheric carbon. Trees absorb or "uptake" carbon dioxide (CO2) from the atmosphere during photosynthesis, emitting oxygen while using carbon to build woody stems, branches, roots, and leaves. This carbon is stored in carbon "pools." Trees release CO2 during respiration and after they die through decomposition or when they burn. When carbon uptake in a forest exceeds respiration and other carbon losses, forest carbon pools are increasing and carbon "sequestration" is occurring. Young forests sequester carbon faster than old forests because CO2 uptake greatly exceeds respiration, but old forests store more total carbon than young ones. In very old forests respiration may exceed uptake, and such forests have switched from being sinks to sources of atmospheric carbon.

Carbon sequestration is the capture and storage of atmospheric carbon in other carbon pools, including forest vegetation. From 1990 through 2005, U.S. forests sequestered an annual average of 179 million tons of carbon, enough to offset about 10% of the nation's CO2 emissions. Increased use of wood products and wood energy represent part of the solution to reducing greenhouse gases. When trees are harvested, carbon is extracted from the forest but not necessarily returned directly to the atmosphere. If trees are used to make wood products, a portion of the sequestered carbon is stored in solid form for several or more decades in the wood products carbon pool or even longer in the landfill carbon pool. If wood is used to produce energy, carbon released through combustion offsets or displaces carbon that otherwise would have been released through the burning of fossil fuels.

Positive Impacts of Forest Sector Carbon Sequestration

Trees remove carbon from the air and store it as wood.

- Trees and wood products have long lives.
- Wood can generate energy in biomass or co-generation facilities; indeed, most of the energy used to manufacture wood-based products is from woody biomass.
- Wood products can substitute for some concrete and steel building materials (e.g., above-grade walls in residential construction) to avoid and displace emissions associated with these energy-intensive products.

Forests can be regenerated, so while much of the carbon from a harvested forest remains sequestered in wood products, growing new trees takes more carbon out of the air.

Forest Carbon Strategies

Forests managed for timber can help meet the world's energy needs and limit atmospheric CO2. Strategies include:

1. increasing on-site carbon density (amount of carbon stored per acre);
2. increasing off-site use of wood to substitute for concrete or steel building materials or wood energy to displace fossil fuel energy use and emissions; and
3. increasing or maintaining the forest area by avoiding deforestation and reducing the extent of wildfires.

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Storing more carbon in forests

When carbon becomes a forest management objective several factors and trade-offs need to be considered. Foremost is the trade-off between the rate of carbon uptake and the amount of carbon stored; i.e., the relative contributions of younger and older forests to carbon sequestration. Not harvesting results in more onsite carbon storage than sequential harvest scenarios, regardless of rotation age (see Figure 1 below). However, the fate of harvested carbon should also be accounted for.

Increasing off-site use wood as a substitute for energy-intensive building materials

Forests managed for timber production with a sequence of harvests sequester carbon on-site while trees are growing and move carbon into the off-site pool of wood products and manufacturing residues. The wood products carbon pool more than offsets harvesting and manufacturing emissions, which some groups use to challenge carbon sequestration from timber harvest. Carbon stored in wood products is gradually released as CO_2 if the wood eventually decays or burns. Wood products in landfills may store carbon for a long time, sometimes permanently.

When wood substitutes for more energy-intensive products, carbon emissions are reduced. For example, in residential construction an above-grade wall framed with concrete blocks requires 250% more energy than using kiln-dried lumber for the same purpose. Substituting lumber for cement and steel building products generates substantial benefits from energy displacement and avoided emissions. These benefits may continue almost indefinitely into the future. When wood products substitute efficiently for fossil fuel energy-intensive products, such as concrete, a sequence of sustainable harvests produces greater net carbon benefits than unused old forests (see Figure 2 below).

Increasing or maintaining forest area by avoiding deforestation and reducing wildfires

Much of the international focus on forest carbon stocks has been on preventing deforestation. Although some forest land is lost to urban development in the U.S., deforestation is low compared to many other countries, so other concerns may be more important. Disturbances such as fire, wind, insects, or timber harvest remove large quantities of carbon from forests. Wildfires emitted an annual average of 65 million tons of carbon in 2002-2006 as CO_2, and another 2 million tons per year as particulates. Fine particulate matter is the major pollutant in smoke, and is linked to many adverse human health effects, including premature death for people with respiratory problems.

Wildfire releases carbon into the atmosphere, whereas timber harvest can transfer a substantial amount of this carbon into the wood products pool. The releases of carbon by historic wild fires were largely offset by re-growth over longer time scales. However, the recent trend is a dramatic increase in wildfire extent and intensity (Figure 3). In the U.S. from 1970 to 1999, an annual average of 3 million acres per year burned. In 2000-2004, the annual average doubled to 6 million, and in 2005-2007, increased to 9 million acres per year; meanwhile the number of fires has stayed approximately the same since the mid-1980s. The smoke and carbon emission implications of this trend make wildland fire management urgent.

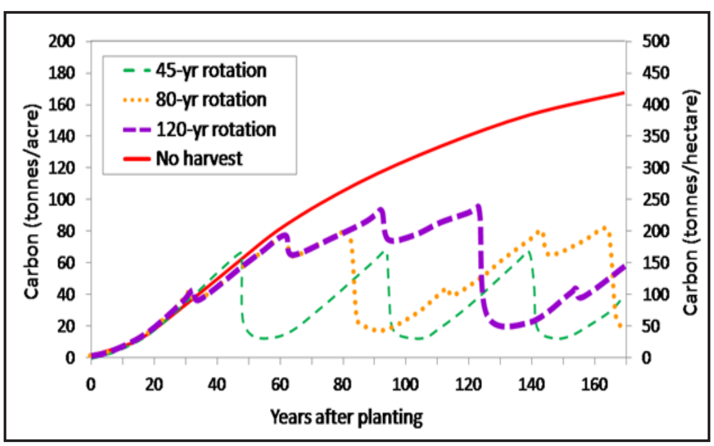

Figure 1. *Carbon storage in the forest pool for 45-, 80-, 120-year rotations or harvest cycles and no harvest option that should be considered a potential maximum for carbon storage in the forest pool.*

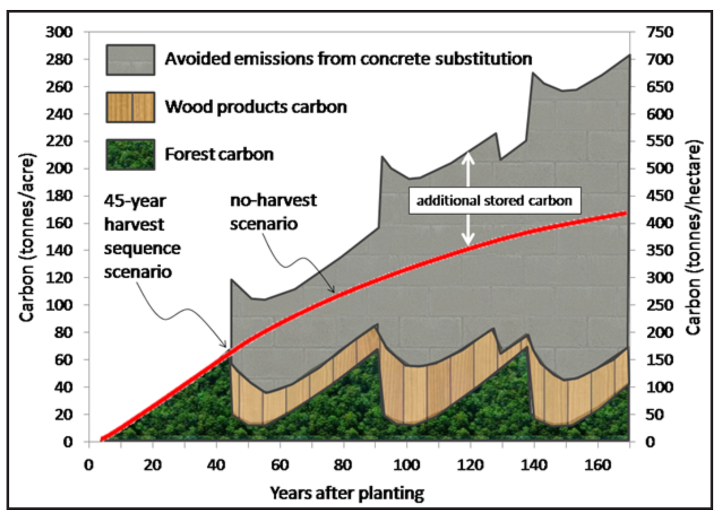

Figure 2. *Carbon storage over time in the no-harvest scenario compared to a sequence of 45-year rotation harvests, illustrating additional carbon storage from making and using wood products that substitute for concrete walls in residential housing construction.*

What to do?

Concerns about carbon management have created a new vector of interest directed at forest management. Issues about the potential contribution of forests to carbon sequestration discussed below include when to cut trees and wildland fire management.

Harvest or preservation?

Does a forest harvested periodically for wood products sequester more carbon than an old-growth forest? Yes and no. The answer depends on three factors:

1. considering only the growth of trees, not harvesting will always sequester more carbon, regardless of the harvesting rotation age;
2. not harvesting remains the better choice even after adding off-site conversion of harvested timber into long-lived wood products; but
3. harvesting is the better choice if wood products substitute for concrete or steel building materials to avoid emissions by displacing fossil fuel use (Figure 2), but only in forests with above-average productivity and only if the product substitution is efficient.

Research also shows that when wood products and fossil fuel-intensive product substitution are considered, the shorter the forest rotation age, the more favorable the carbon balance becomes over time. To sum up, for productive forests the reply is yes, harvested forests do sequester more carbon than preserved old forests, but only with efficient use of wood products that substitute for fossil fuel-intensive products such as concrete or steel, and/or using wood products manufacturing residues to displace fossil fuel energy use. For forests with below-average productivity and/or inefficient use of wood products to displace fossil fuels, the reply is no.

Wildland Fire Management

A century of fire suppression in the interior northwest has created fuel conditions that lead to very large, intense, and destructive wildfires. In Idaho, emissions of CO2 from wildfires during 2006 were 1.6 times greater than annual fossil fuel-burning emissions from vehicles, industry and other sources in the state. Reducing fuels can reduce wildfire emissions. As a first step in increasing carbon sequestration in the forest sector, the federal government should examine how it can modify management practices on its extensive lands to emphasize carbon sequestration consistent with other management objectives such as habitat protection, erosion control, and timber production. The most promising action is to reduce the risk of stand-replacing wildfires. Others include use of wood products in "green" building certification programs, and in carbon credit offset programs designed to reduce CO2 emissions.

Conclusion

Although increasing the growth rates or carbon storage of existing forests, the use of wood products and tree planting provide carbon benefits, larger benefits may come from avoiding deforestation and reducing wildfires. Forest management cannot fully solve the problem of carbon accumulation in the atmosphere, but it can contribute significantly to the solution. Over the course of the next 50 years, reforestation, afforestation (planting previously unforested areas), and reduced deforestation globally could provide a cumulative additional sequestration of 28 billion tons of carbon. This is similar to the effect of doubling the fuel economy of cars. Increased carbon storage, in combination with a host of emission reduction measures, can help reduce, and even end, the ongoing rise of carbon concentration in the atmosphere. Consider, however, that although existing forests annually sequester enough carbon to offset 10% of the nation's annual CO2 emissions, attempting to attain a similar amount of offset by afforestation would require new forest plantations covering an area the size of the state of Texas. Although there are many ways to improve our planet's carbon balance, some strategies such as wildfire reduction are more effective that others and most have additional benefits such as reducing demand for oil or improving air quality.

Authors Note: *The following article is based on University of Idaho Policy Analysis Group (PAG) Issue Brief No. 11. Author Dr. Jay O'Laughlin is a University of Idaho (UI) Professor Emeritus, former PAG Director, and member of the Idaho Carbon Sequestration Advisory Committee. Dr. Ron Mahoney is an UI Professor Emeritus and former Extension Forester. Sources for the scientific claims and data for the figures can be found in the PAG Issue Brief document at http://www.cnrhome.uidaho.edu/default.aspx?pid=106665*