CLIMATE CHANGE RESOURCE CENTER

Carbon Benefits of Wood-Based Products and Energy

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Issues

Management activities can have a substantial effect on greenhouse gas mitigation that extends beyond the carbon contained within forest ecosystems. Harvested wood goes into diverse forest products that continue to store carbon for the duration of their useful life (1, 2). Forest management activities can also supply wood directly for energy, and waste materials from wood products manufacturing and processing can be recovered to produce power.

Carbon Storage in Harvested Wood Products

A substantial amount of carbon is stored in wood products. Differences in the type of wood product, its production, its use, and its disposal have substantial influences on the amount and duration of carbon storage. Where the goals of forest management include carbon benefits, product use and disposal is an important consideration. Standard methods are available for estimating the carbon that is sequestered in harvested wood products (3), and life-cycle assessment approaches can be used for more in-depth analysis of carbon gains and emissions (4-6).

In 2015, more than 2,600 million metric tons of carbon was stored in harvested wood products in the United States, which is equivalent to approximately 3 percent of the amount of carbon stored in U.S. forest lands (7). Carbon stored in these wood products is further divided into two different pools: carbon that is stored in products currently in use and carbon that is stored in landfills (7, 2). Nearly 60 percent of the carbon in wood products is currently stored in products in use (7). This category includes items such as paper, pallets, and the lumber used to construct buildings, each of which has a different decay rate. The remaining 40 percent of wood product carbon, from any source, is stored in landfills. Because materials in landfills are periodically covered, oxygen is not able to enter and facilitate decay; as a result, the total amount of carbon released from wood products in landfills is substantially reduced (2). Further, of the carbon that is released, a greater proportion of it is in the form of methane due to anaerobic conditions (2).

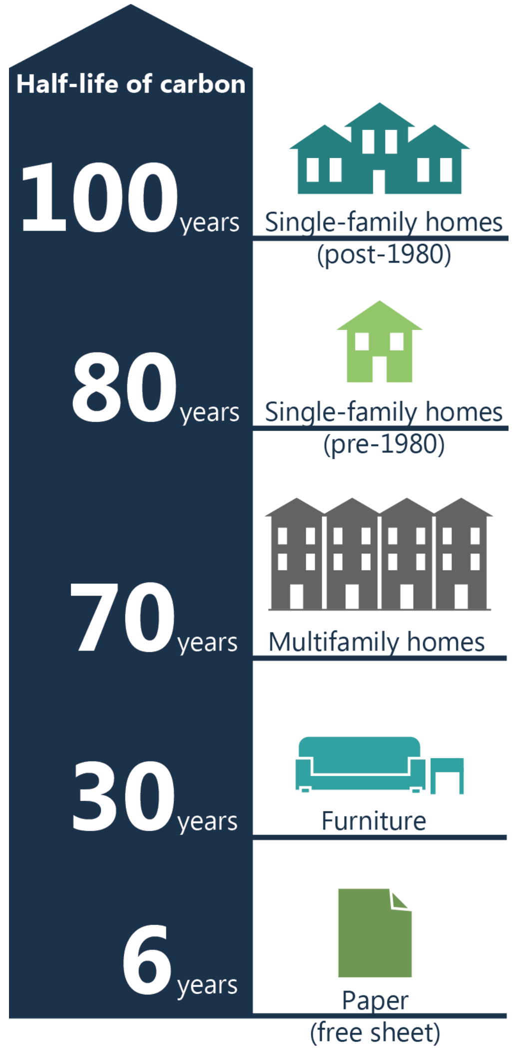

Figure (right): Carbon stocks within different ecosystems in the eastern and western U.S., or alternately averaged across the entire U.S. Data from Skog and Nicholson (2).

There are some ways that forest management can help to increase carbon storage in the harvested wood products pools. Emphasizing “durable” or “long-lived” wood products, such as lumber used for building construction can help to increase the overall lifespan of the product in use, as well as shift the mix of products toward those that decay less in landfills (2). Wood products can also be used as substitutes for other materials that require greater fossil fuel inputs to produce, such as steel or concrete (8, 9). For example, one study that compared the life-cycle emissions needed to build a single-family home using primarily wood, steel, or concrete construction materials found that the wood house had the least embodied energy, particularly compared to steel construction (10, 11). Although forest management can influence the species and size of trees available for wood products, larger-scale policies and markets will largely drive the demand for particular products.

Carbon Implications of Bioenergy

Recent concerns regarding climate change and rising energy costs have dramatically increased interest in the use of renewable and alternative energies, including wood-based energy. While energy consumption from wood sources in the United States is currently greater than it was during much of the 20th century, the contribution of wood to the overall energy portfolio is small. In 2015, nearly 5 percent of U.S. energy consumption was from biomass sources (12), about two-thirds of which is derived from forests (13). The major sources of wood used for energy, including electricity, heat, and transportation fuel, include fuelwood (29 percent of forest biomass consumption), residues and pulping liquors from the forest products industry (60 percent), and wood municipal solid waste (10 percent) (13). Wood sources may account for a greater portion of energy in the future; for example, one study evaluated the potential for the use of biomass feedstocks from forests to increase by 175 percent by 2030, with the majority of the increase coming from additional utilization and production of fuelwood (13).

Forest management can be used to increase the amount of woody biomass that is available for energy use in a few different ways. One option is to increase the removal of logging residues—the woody material generated during forest harvest operations. These materials can include tree tops, branches, and stems that are unsuitable for use in the production of traditional forest products but can be used to generate energy as a replacement to fossil fuels (13). One study identified that additional logging residues could displace as much as 17.6 million tons of carbon emitted from coal-fired power plants, or about 3 percent of total carbon emissions (14). The greatest availability of these residues was in the Southeast and South Central regions of the United States (14). While several studies point to the potential to use logging residues for bioenergy, the availability of these materials is heavily influenced by the financial costs of production relative to the sale price of biomass (13, 15). There are also concerns about the ecological effects of more intensive biomass removal from forests (16-18).

There is also the potential to implement forest management activities for the purpose of generating wood for energy in addition to meeting other management goals. Biomass markets, where they exist, can provide additional opportunities for fuel reduction treatments, noncommercial thinnings, and other silvicultural activities that do not contribute to the traditional forest-products industry. Fuel reduction treatments may reduce the risk of large, high-intensity wildfires, thereby reducing the potential for emissions from wildfire and creating opportunities to substitute renewable forest-based energy for fossil energy (8, 19).

Wood-based bioenergy is often compared favorably to fossil fuels and several renewable energies due to a relatively low amount of fossil fuel inputs and a smaller “carbon footprint” (Malmsheimer et al. 2008). Wood energy is sometimes talked about as being “carbon neutral” based upon the idea that any carbon that is released by the burning or use of wood for energy is recaptured through the sequestration of the forest as it regrows (20). The reality is more complex: The carbon effects associated with bioenergy production need to be evaluated to include the entire life cycle of energy production, as well as the longer term use and growth of the land used to produce the energy, relative to the business-as-usual use of fossil fuels (21-24). While many studies support the idea that woody bioenergy produced from sustainably managed forests can have carbon benefits over the long term, the degree of benefit is heavily influenced by factors that include the initial forest conditions, forest productivity, fossil energy from harvest operations and transportation, and the type of fossil fuel that is replaced by wood (25, 8, 26, 27). A full accounting of the greenhouse gas benefit of forest bioenergy would include comparisons of forest carbon stocks for bioenergy versus a no-bioenergy scenario, as well as a full life-cycle assessment of the emissions used to produce forest bioenergy and for the displaced fossil fuel emissions (21, 15).

How to cite

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Recommended Reading

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Tools

COLE (Carbon OnLine Estimator)
COLE is a versatile and appropriate tool to use for a wide range of carbon estimation needs. COLE draws from Forest Inventory and Analysis (FIA) data to provide basic carbon inventory and growth-and-yield estimates for a particular forest, region, or state.

ecoSmart Landscapes
This tool can help members of the public, cities and other organizations estimate the carbon and energy impacts of trees. The online tools provide quantitative data on carbon dioxide sequestration and building heating/cooling energy savings afforded by individual trees. Results can be used to estimate the greenhouse gas benefits of existing trees, to forecast future benefits, and to facilitate planning and management of carbon offset projects.

First Order Fire Effects Model (FOFEM)
FOFEM is a model that predicts first-order fire effects including tree mortality, fuel consumption, emissions (smoke) production, and soil heating caused by prescribed burning or wildfire.

Forest Inventory Data Online (FIDO) and EVALIDator
FIDO and EVALIDator applications both draw from US Forest Service FIA (Forest Inventory and Analysis) data to produce estimates with associated sampling errors for user selected forest attributes. Carbon estimates can be produced for several carbon pools, including total forest carbon, above and belowground carbon in live trees, standing dead trees, and live seedlings shrubs and bushes; litter; soil; and stumps, roots and woody debris.

Forest Planner
The Forest Planner enables landowners to visualize alternative forest management scenarios for their properties. It compares user selected areas to forest stands from a national database to estimate management outcomes including

timber stocking and yields, harvest costs and revenues, carbon storage, and fire and pest hazard ratings. The tool does NOT account for the effects of projected climate change on future timber and carbon estimates.

Forest Vegetation Simulator (FVS)

Natural resource managers are increasingly interested in the effects of planned management activities on carbon stocks. The Forest Vegetation Simulator (FVS) is a family of forest growth simulation models that allow a user to explore how silvicultural treatments may affect growth and yield (and, therefore, carbon stocks). "Suppose" is the name for the graphical user interface for FVS.

Fuel and Fire Tools (FFT)

Fuel and Fire Tools (FFT) is a software application that uses fuels data classified as fuelbeds to let users perform a variety of calculations related to fire behavior and emissions. These include predicting surface and crown fire behavior, fuel consumption, pollutant emissions (including carbon emissions), and heat release. The FFT integrates several tools that were previously stand-alone into a single user interface (including the FCCS).

Global Carbon Atlas

The Global Carbon Atlas gives audiences a number of ways to visualize carbon dioxide emissions and flux data, and to compare between countries and regions over time (1960 – 2012). Its products are grouped into three main categories that are intended for users with varied technical backgrounds. All products are based on current datasets and models contributed by scientists and research institutions (see Contributors).

i-Tree

i-Tree consists of several different applications focused on quantifying the benefits of local trees for neighborhoods and communities. Each application has a unique focus, however several calculate the carbon sequestration and/or energy savings benefits of urban trees, including i-Tree Eco, i-Tree Streets, i-Tree Vue, and i-Tree Design (beta).

NASA - CASA Global CQUEST - Carbon Query and Evaluation Support Tools

This application from NASA provides datasets and a viewer for geographic data that support large-scale carbon inventory. The datasets combine NASA remote sensing technology, ecosystem process modeling, and field-based measurements to characterize impacts on the carbon cycle.

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