Criterion 5:

MAINTENANCE OF FOREST CONTRIBUTIONS TO GLOBAL CARBON CYCLES

Montréal Process Criterion 5 (Montréal Process Working Group 2010); Northern Area Forest Sustainability Indicators 11.1, 11.2, 11.3, 11.4 (USDA FS 2010d)

The importance of forest contributions to global carbon cycles

Northern forests cover more than 42 percent of the region and are enormous reservoirs of carbon. Through photosynthesis, live trees emit oxygen in exchange for carbon dioxide they pull from the atmosphere. As a tree grows it stores carbon in wood above and below ground, and sequestered carbon comprises about half of its dry weight. Dead trees and down logs are also reservoirs of carbon. Forest soils sequester additional carbon in the form of incorporated organic matter. In temperate northern forest ecosystems, roughly as much carbon is sequestered in forest soils as is sequestered as live biomass. Forests that are converted to other land uses release the carbon stored in the trees. Trees growing in newly established forests (afforestation) can sequester additional carbon.

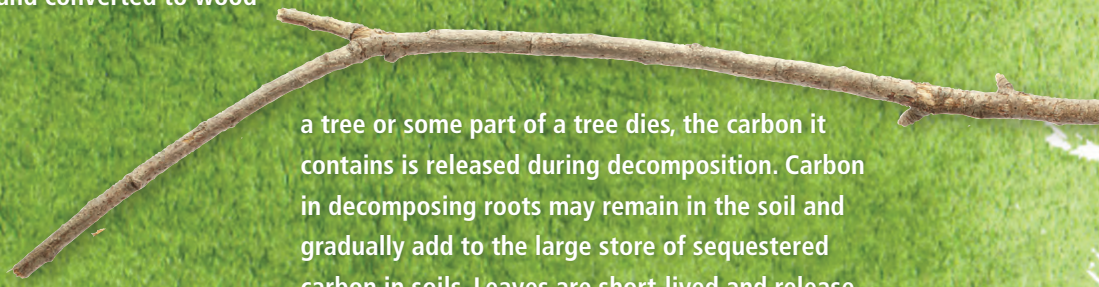
People and forests are closely linked through the carbon cycle. Human activities emit huge amounts of carbon dioxide during energy production, transportation, and other activities. Increases in atmospheric carbon dioxide have been linked to global warming. Because of their great extent and their capacity to sequester additional carbon or release carbon that is already sequestered, forests have an important role as sinks or sources of carbon in regional and global carbon cycles.

Global climate change associated with changes in atmospheric carbon dioxide levels could significantly impact the future conditions of forests, which would in turn affect the plants, wildlife, and people that depend on them. Maintenance of forest biodiversity and health are associated concerns.

Some forest management activities can increase carbon sequestration or offset human activities that emit carbon. Silvicultural practices that increase forest growth can increase the quantity of carbon sequestered in woody biomass. Wood product utilization can increase the quantity of carbon sequestered in durable wood products. Wood-based energy production can offset carbon that would otherwise be released by burning fossil fuels provided the carbon released during woody bioenergy production is reincorporated into new trees that replace those harvested for bioenergy. In contrast, energy generated from fossil fuels, such as coal and oil, emits carbon that has been sequestered underground for eons.

Key Findings for Criterion 5

- Through photosynthesis, trees pull carbon dioxide, a greenhouse gas, from the atmosphere and sequester it in wood and other tree parts.
- Forests sequester large amounts of carbon in soil organic matter and in the wood of living trees. As forests grow over time the amount of sequestered carbon increases.
- The total amount of sequestered carbon in U.S. forests is equal to approximately 27 years of carbon dioxide emissions for the U.S.
- The annual net increase in carbon sequestered in U.S. forests due to tree growth is equivalent to about 10 percent of the annual emissions of carbon dioxide and associated greenhouse gasses.
- When trees are harvested and converted to wood products, the carbon in those products remains sequestered until they eventually decompose or are burned.
- Using woody biomass to replace fossil fuels for energy production can reduce the release of carbon from the fossil fuels that would be used instead.
- In 2007, the equivalent of 2 percent of the energy consumed in the United States came from wood combustion by industrial (1.3 percent), residential (0.4 percent), utility (0.2 percent), and other (0.1 percent) users.
- Less than 1 percent of U.S. electric power is generated from wood.



Carbon and Wood

A cubic foot of wood in a living oak tree weighs about 60 pounds (green weight)—roughly half composed of water and the other half composed of dry woody biomass, about 15 pounds of which is carbon (half of the dry weight or a quarter of the green weight). Carbon is found in cellulose, hemicellulose, lignin, and other compounds that form the wood and other parts of the tree. Woody biomass may be reported in dry tons or in green tons, and carbon is more often reported as equivalent tons of carbon dioxide than as elemental carbon—distinctions that are important when interpreting and comparing biomass and carbon statistics.

When trees grow they absorb carbon from the atmosphere in the form of carbon dioxide. Through photosynthesis trees sequester the carbon in wood, bark, leaves, flowers, roots, and seeds. When a tree or some part of a tree dies, the carbon it contains is released during decomposition. Carbon in decomposing roots may remain in the soil and gradually add to the large store of sequestered carbon in soils. Leaves are short-lived and release carbon back to the atmosphere quickly as they decompose. Carbon may be sequestered for centuries in the wood of living trees. Large dead and down trees may sequester carbon for decades as they decompose slowly and gradually release carbon dioxide back to the atmosphere.

Each year, per capita emissions in the United States—largely due to combustion of fossil fuels—produce 6 tons of carbon or the equivalent of 22 tons of carbon dioxide (USDOE 2009, USDA FS 2011e). That is the amount of carbon in about 800 cubic feet of wood (roughly 10 cords). Stacked as firewood it would equal a wood pile 4 feet high, 4 feet deep, and 80 feet long.

The amount of carbon that U.S. forests sequester each year is about 10 percent of total annual U.S. emissions of carbon dioxide and related greenhouse gasses.

The passages below report on the total quantity of carbon stored in forests, how forest carbon changes over time, the role of forest products in carbon sequestration, and the capacity to avoid carbon emissions from fossil fuels by using woody biomass for energy production. For consistency with other sections of this assessment, we report carbon in U.S. tons (2000 pounds) and acres or provide metric equivalencies to help link reported values to other sources, which—by convention—report carbon in metric units (2204 pounds or 1000 kg) and hectares (2.5 acres).

Indicators of forest contributions to global carbon cycles for northern forests

Carbon sequestered in northern forests

The two largest pools of sequestered carbon in a typical forest are in soil organic matter and in aboveground biomass (Fig. 37). Soil carbon changes slowly compared to aboveground biomass, which increases with forest growth and decreases with mortality or harvesting. Dead wood, litter on the forest floor, and tree roots are other large reservoirs of forest carbon.

The amount of carbon sequestered above ground in a forest is closely associated with wood volume or biomass. In general, more sequestered carbon occurs where more wood volume occurs (Fig. 19). However, inventorying carbon is more complicated than merely measuring aboveground forest volume because of the high proportion of carbon in soils, tree roots, and dead wood and because harvested forest products move sequestered carbon to other locations.

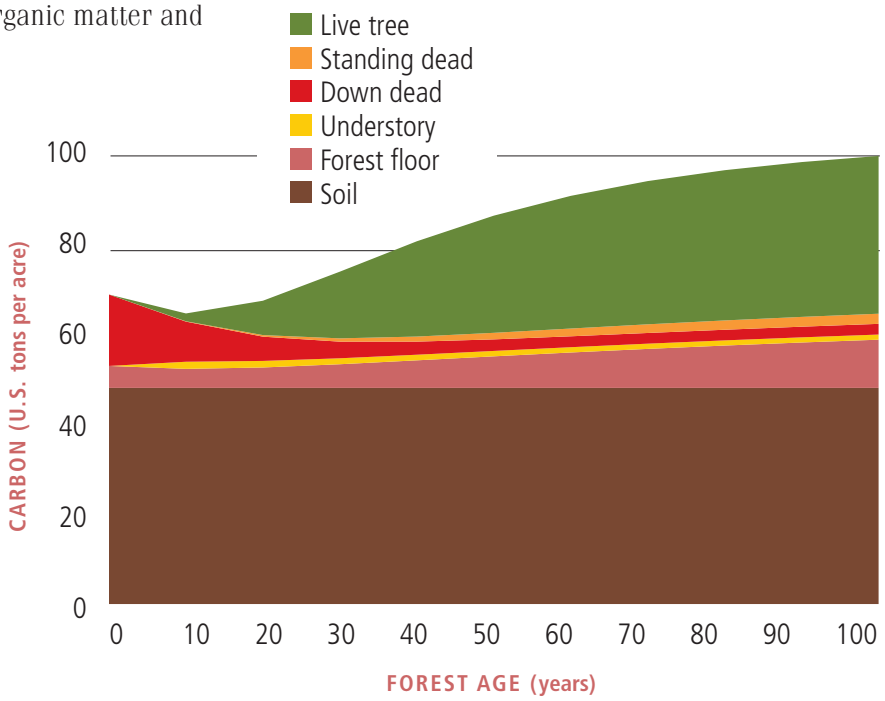
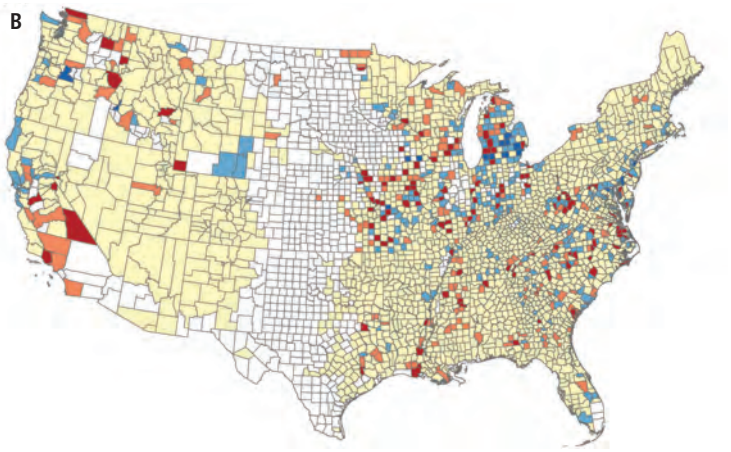


FIGURE 37

When and where carbon occurs in a typical forest—a composite summary for all northern forests showing average carbon by forest age and forest component; note that about 16 percent of live tree carbon is coarse roots (VanDuesen and Heath 2009).

Much of the carbon sequestered in U.S. forests is in Northern States (Fig. 38). This amount can increase over time as trees grow (above and below ground) and hold more carbon, or decrease as trees die or are harvested. As dead trees and down wood slowly decay, they release carbon gradually back into the atmosphere as carbon dioxide; if burned, they release carbon quickly. The total amount of sequestered carbon in U.S. forests is equivalent to about 27 years of carbon dioxide emissions for the United States (USDA FS 2011e). The annual increase in sequestered U.S. carbon from net annual forest growth is about 10 percent of U.S. annual greenhouse-gas emissions. Appendix Table A3 provides additional state-level detail on forest biomass and carbon.



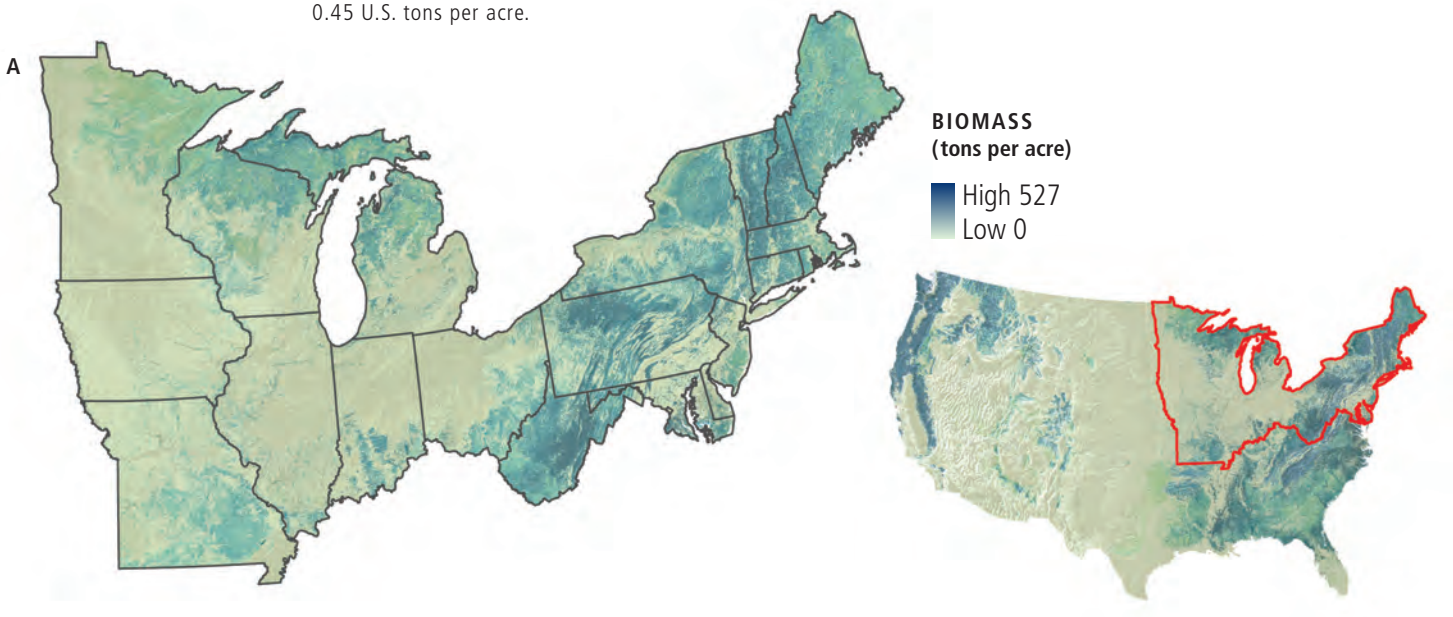


FIGURE 38

In 2006, (A) aboveground live tree biomass for Northern States (Blackard et al. 2008), and (B) estimated change in live tree carbon stock by U.S. county, accounting for harvest, land-use change and changes in live tree biomass of coarse roots, stems, branches, and foliage (Smith et al. 2009). In this case carbon change is reported as the equivalent mass in tons of carbon dioxide (CO_2) rather than carbon per se. One megagram (or metric ton) per hectare is equivalent 0.45 U.S. tons per acre.

Carbon Sequestered in Forest Products

When trees are harvested and converted to wood products, the carbon in those products remains sequestered until they decompose or are burned. Consequently, paper products typically sequester carbon for shorter periods than wood products such as building materials, flooring, or furniture. Even landfills sequester carbon in the form of discarded wood and paper products that decompose slowly because of compaction and lack of oxygen in the layers of landfill waste material. With the current mix of harvested materials and associate forest products, carbon in wood products from northern forests persists for a relatively long time.

Using Woody Biomass for Energy

The use of fossil fuels to produce energy releases carbon dioxide that was previously sequestered underground as coal, oil, or gas. By using woody biomass instead, society can reduce carbon from fossil fuels. Carbon that is already sequestered in the ground stays there (Malmsheimer et al. 2008) while carbon in woody biomass that is consumed for energy is released to the atmosphere instead. When forests harvested for biomass regenerate and grow, carbon is again sequestered in the wood growing on the regenerated forest. Thus, some carbon from using biomass for energy is cycled from the forest to the atmosphere and gradually back to the forest.

In 2007, about 2 percent of all U.S. energy consumption came from wood combustion by industrial (1.3 percent), residential (0.4 percent), utility (0.2 percent), and other (0.1 percent) users. Electric utilities throughout the North use wood for part of their energy production (Fig. 39), but less than 1 percent of U.S. electric power is generated with wood (USDOE EIA 2010).

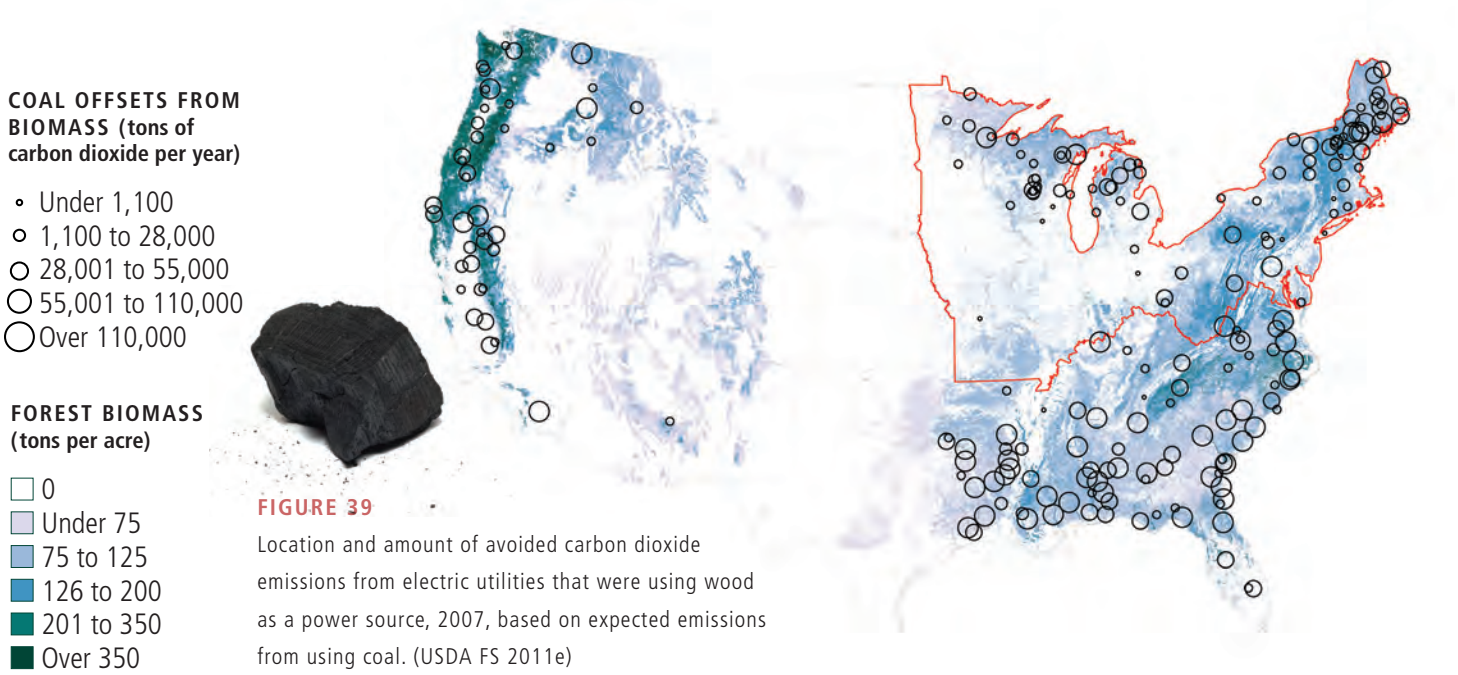


FIGURE 39

Location and amount of avoided carbon dioxide emissions from electric utilities that were using wood as a power source, 2007, based on expected emissions from using coal. (USDA FS 2011e)