Forest Carbon FAQs

What is forest carbon?

Carbon in forests comes from carbon dioxide in the atmosphere. This carbon is sometimes called *biogenic* carbon, because it cycles through living organisms. Trees draw carbon dioxide from the atmosphere through a process called photosynthesis. Plants use photosynthesis to produce various carbon-based sugars necessary for tree functioning and to make wood for growth. Every part of a tree stores carbon, from the trunks, branches, leaves, and roots. By weight, dried tree material is about 50 percent carbon. Trees also release carbon dioxide to the atmosphere as a function of their physiology. When some or all parts of a tree decompose after death or burn during fire, the carbon is released back to the atmosphere. Thus, the amount of carbon in forests closely mirrors the natural cycle of tree growth and death.

Carbon can also be found in soils. Carbon in soils comes from the organic matter from trees and other vegetation in varying degrees of decomposition. In fact, soil carbon represents about 50 percent of the total carbon stored in forest systems in the United States. Like vegetation, soils release carbon dioxide when soil microbes break down organic matter. Some soil carbon can decompose in hours or days, but most resides in soils for decades or centuries. In some conditions, carbon resides in soils for thousands of years before fully decomposing. Soil carbon is generally considered very stable, meaning it does not change much or quickly in response to vegetation dynamics. Exceptions are when soils are disturbed significantly, such as tilled for agriculture, with soil erosion, extreme fire events, or with permanent changes in certain types of vegetation cover.

What is fossil fuel carbon?

Fossil fuels formed from organic materials under geologic processes which took place over hundreds of millions of years. Therefore, when we burn fossil fuels for energy, carbon dioxide is released into the atmosphere, and there is no natural mechanism within that geologic cycle to re-capture or sequester the carbon from the atmosphere. This results in a net increase of carbon in the atmosphere or the ocean, which can also absorb some surplus carbon dioxide. Unlike forests and their products which present a closed loop cycle when allowed to regrow, fossil fuels represent an open system of carbon. Most fossil fuel carbon emissions remain in the atmosphere for thousands of years.

How much carbon is in trees?

The chemical composition of trees varies from species to species but is approximately 50 percent carbon by dry weight. Other elements in trees include oxygen, hydrogen, nitrogen, and smaller amounts of calcium, potassium, sodium, magnesium, iron, and manganese. Carbon is one of the most important elements that form the physical structure of the tree material in trunks, bark, branches, and even leaves. While all vegetation stores carbon, trees are particularly important because they live a long time and because of their comparably dense nature and large size. Because forests are largely composed of trees with large amounts of carbon, forests are akin to a sea of carbon.

How does carbon cycle through forest ecosystems?

Because forests are naturally dynamic systems, the carbon contained within forests is always changing. On the scale of minutes, forests can simultaneously take up and store carbon through photosynthesis and release carbon as trees respire and soils release carbon through decomposition by soil microbes. Over months and years, the balance of uptake and loss of carbon in a forest determines whether the forest is gaining or losing carbon stocks. The amount of carbon uptake and storage depends on the growing conditions and species of the trees in a given system. For example, in some temperate forests, a warm and wet climate can support forests that grow quickly and store a great deal of carbon. The opposite might be true of forests with a cold and dry climate. Younger forests generally take up and store carbon at greater rates than older forests.

Forests have natural boom and bust cycles that are reflected in carbon storage of that forest. Trees die for a variety of reasons and when they do, carbon is released back to the atmosphere. Sometimes, trees in small stands die from isolated events like wind storms, avalanches, or small fires. Other times, trees die in large numbers with natural disturbances like insects or disease, hurricanes, droughts, and large wildfires. Carbon can be released quickly from forests with these events, as in the case of intense fire, or slowly, with non-fire disturbances where carbon is lost mainly through decomposition. Standing dead and fallen trees can continue to store carbon but will decompose over years or decades eventually releasing carbon back into the atmosphere. This death and decomposition process set the stage for new tree growth as new trees have more access to light and nutrients released from decomposition, starting the uptake phase of the carbon cycle once again.

How is timber harvesting (e.g., logging, commercial thinning, salvage harvesting) a carbon mitigation strategy?

Timber harvesting has an initial impact on forest carbon stocks and releases carbon to the atmosphere through use of fossil fuels in management activities and in decomposition of any woody waste material. However, this statement portrays an incomplete picture of carbon in the forest and how it interacts with the atmosphere and effects climate. This narrowly focused view considers only carbon dynamics on the forest, and assumes all physical carbon leaving the forest (e.g. timber products) enters the atmosphere immediately. This view does not consider long-term forest carbon dynamics and the many pathways forest carbon can take before eventually re-entering the atmosphere.

The Forest Service, following the more holistic view outlined by the International Panel of Climate Change, considers forest carbon dynamics and where the carbon goes once it leaves the boundaries of the forest. In some cases, carbon emissions from harvesting activities can be less than the carbon emissions associated if the same forest is unmanaged, particularly in cases where forests are experiencing high rates of mortality.

When forests are harvested or thinned, and maintained as forests, they regrow and eventually recover carbon lost during harvesting. This cycling of carbon in the forest is sometimes called a “closed loop.” Additionally, some carbon in harvested trees is transferred to wood products, which can store carbon for months to decades and even centuries depending on the product (e.g., paper, furniture, single-family home). Carbon storage continues when forest products enter landfills at the end of their usable life.

Further, harvested wood products generally produce less emissions when substituted for energy-intensive materials made with fossil fuels. For example, using a wood beam in place of the production of a more energy-intensive steel beam. Wood can also be substituted directly for fossil fuels in energy production, such as burning wood pellets in place of coal, or 'co-firing' woody waste material with natural gas.

For many forests, recurring timber harvests on a sustainably managed forest will effectively "store" more carbon over time than if the forest is unmanaged. "Store" in this sense refers to carbon in the forest, carbon in harvested wood products, and the avoided carbon emissions in the atmosphere. New tree growth restarts the process of storing carbon on the forest, even as the previously harvested trees continue to store carbon in wood products and emit fewer emissions when substituted for fossil fuel-intensive materials. In some cases where wood substitution is high, such as in tall wood buildings, avoided carbon emissions are substantial.

The magnitude and timeframe of these carbon dynamics vary greatly depending on forest attributes, type of harvested wood products, and environmental factors. A key assumption, however, is that the forestland will not be permanently converted to a non-forest condition after harvesting and will remain productive for the foreseeable future. The Forest Service does not expect significant changes in land-use cover or productivity as a result of harvesting.

Why does the Forest Service support timber harvesting (e.g., logging, commercial thinning, salvage harvesting) when isn't the best approach to minimize carbon emissions is to keep carbon in trees?

According to the best available science, harvesting and the use of harvested wood products can play an important role in reducing carbon emissions along with good management for healthy forests. According to the International Panel on Climate Change, the best way to explain the effects of forest management is to take the viewpoint of the atmosphere when considering impacts of carbon. That is, what the atmosphere actually "sees" in terms of carbon entering or leaving the atmosphere. This requires looking at how management influences forest carbon stocks, the emissions associated with harvesting activities, and how carbon is stored in harvested wood products once it leaves the forest. This perspective also considers whether or not there is an associated permanent change in land-use or land cover that will alter the ability of the harvested area to regrow as a forest and continue to remove and store carbon from the atmosphere in the future. Reducing conversion of forestland to non-forestland is an agreed principal globally to reducing emissions. National Forest System lands provide a buffer against land-use change, keeping forests as forests.

Increased risk of carbon loss through disturbances, such as wildfires and insect epidemics, can undercut the goal of maximizing carbon storage on the forest. In cases where forests are risk for carbon loss through such disturbances, a more effective way to reduce carbon in the atmosphere is through various types of harvesting and management activities. This approach initially reduces the amount of carbon stocks on the forest, but transfers carbon to wood-based products or energy use. When considering the whole system—both forest carbon and use of forest products—carbon emissions can be much lower than if the forest was unmanaged.

What is substitution?

Substitution refers to the use of forest products in place of more energy-intensive products, such as materials and energy derived from fossil fuels. When we substitute wood products for fossil fuels and fossil fuel intensive materials, the unused fossil fuel carbon remains stored in the ground and does not enter the atmosphere. Conversely, the amount of biogenic carbon from forests released can be sequestered on relatively short timescales. Fewer emissions can be produced when wood is used in place of, or substituted for, products that require a lot of energy to manufacture, such as some steel or concrete products. Wood is as a direct substitute for coal or natural gas when used as energy generation from wood pellets and woody waste material from timber processing.

What is leakage and spillover?

Carbon “leakage” is the shift of emissions from one place to another due to efforts to avoid emissions. For example, if a timber producing country entirely curtails their timber harvesting, other countries may increase production to meet demand. Leakage can be quite significant but is very difficult to measure because of societal reliance on the forest system and use, rapid and global nature of market adjustments, and difficulty identifying cause and effect.

Spillover is like leakage, but the effects are positive. For example, an innovation in technology or approach in one area that results in fewer emissions in another technology or approach, which also reduces emissions. Another example is adoption of better forest management practices that result in lower rates of mortality over time.

Why isn’t the Forest Service doing carbon mitigation projects?

The U.S. Forest Service is obligated by law to balance multiple goals for the public benefit. The Forest Service considers carbon among a suite of benefits that forest provide and not in isolation. In many instances, Forest Service vegetation management activities align with carbon mitigation strategies identified by the best available science.

Is the Forest Service participating in carbon markets?

No. Congress has not given the U.S. Forest Service the authority to allow National Forest System (NFS) lands to participate in carbon markets or produce carbon credits. However, organizations can partner with the U.S. Forest Service in needed restoration work to improve carbon sequestration, forest health, and resilience to climate change.

Why would storing carbon in harvested wood products be better than keeping it in the trees if so much of the tree is wasted in the process?

The amount of carbon from a tree that is ultimately stored in wood products varies significantly depending on harvesting practices (e.g., cut to length vs. whole tree) and stand characteristics (e.g., age, defect, forest type). Thousands of products can be produced from wood. Carbon “stored” in these products can range from days to centuries.

Modern harvesting practices leave little waste. Some logging residues, such as leaves and branches, stay in the forest and become firewood, or decay and contribute to forest habitat and nutrient cycling. Mills are generally very efficient at using “mill residues,” such as sawdust and bark. These materials often heat and power milling operations or are used for other wood products, such as particle board. The use of mill residues makes an important contribution to the carbon reduction potential of harvested wood products and forest management in general. For example, most biomass for energy production is a by-product of conventional forest product streams, such as milling residues, with some use of whole trees killed by insects, disease, or natural disturbance.

Finally, disturbance is a natural part of the forest cycle. In some locations, fire is important while in most areas pests and disease routinely alter the forest composition. Even if these forests were left unmanaged, they would experience mortality and carbon loss. Management and harvest allow society to utilize and store that carbon at times for longer periods than in the forest.

Fuels reduction treatments will reduce forest carbon storage if they are maintained. With the probability of wildfire so low in many forest types, how can this have any carbon benefit?

The U.S. Forest Service balances multiple goals for the public benefit, and thus, carbon does not have priority over the many other services that forests provide. Many management activities the U.S. Forest Service conducts is consistent with carbon mitigation strategies, although carbon management might not be the primary or only purpose.

Hazardous fuel reduction treatments (treatments) are done primarily to protect lives and property in and around communities. The goal is to reduce the probability of severe wildfire. Severe wildfires pose a greater risk to communities and cause more damage to trees, often killing them as well as impacting carbon stored in the soil. In many locations, fire is a natural part of the cycle and fire suppression results in increased fuel loads in those forests.

An approach to carbon mitigation is to maximize carbon stored in the forest system, but this often comes with risk. In some ecosystems, increased carbon stocks have a concurrent increase in risk of carbon loss through wildfires and insects and disease. Treatments lower carbon stocks to a more stable level if they are maintained.

From a strictly carbon perspective, there will be instances where these treatments will have a positive effect on carbon and some that will not. The carbon costs of treatments would need to be weighed against the probability of losing greater amount of carbon should the forest have a high-severity wildfire at some point in the future. Forest type, conditions, site variation, and differing fire regimes make it extremely difficult to make general conclusions about the carbon outcomes of fuel treatments.