Forest Carbon Assessment for Indiana State Forest Properties

DNR
Indiana Department
of Natural Resources

Joey Gallion

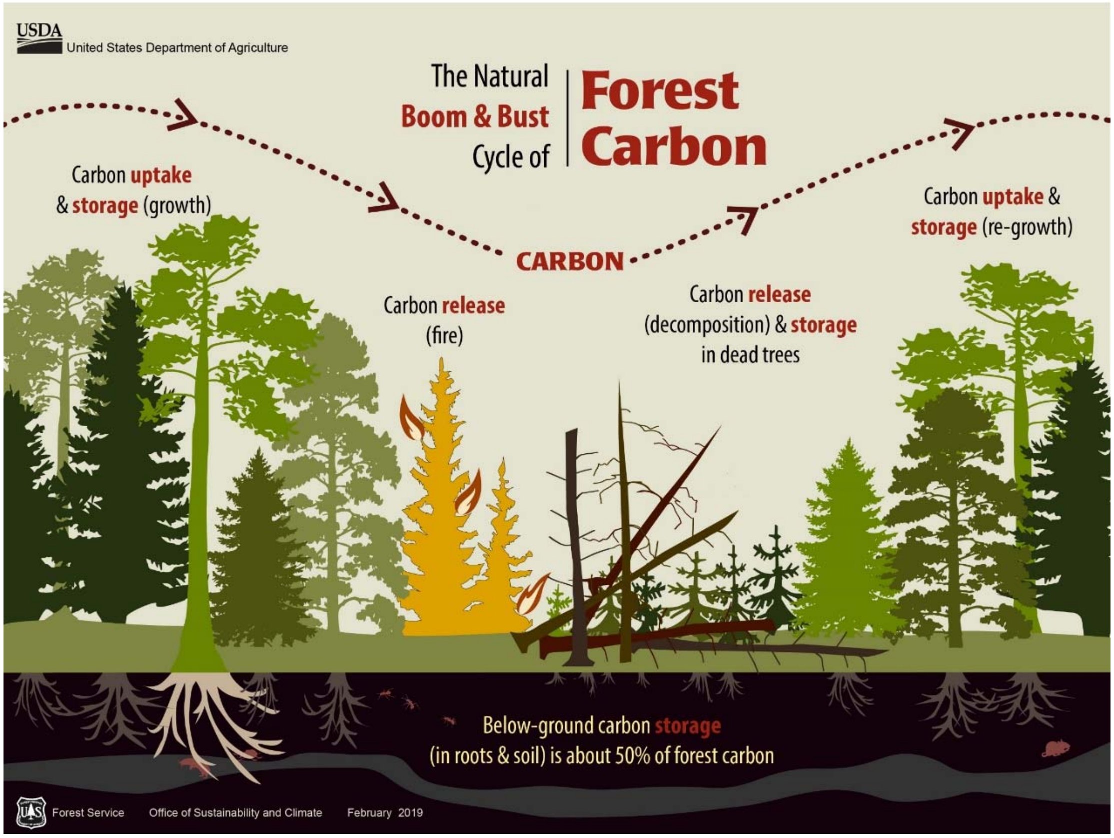
Forest Resource Information/Forest Inventory Program Coordinator

Carbon uptake and storage are a few of the many ecosystem services provided by forests. Carbon cycles through living organisms. Carbon dioxide (CO_2) is a gaseous component of the earth's atmosphere that plays several vital roles in the environment. Being a carbon source for plants is one of those roles. Through a process called photosynthesis, plants and photosynthetic algae and bacteria use energy from sunlight to combine CO_2 from the atmosphere with water to form carbohydrates. These carbohydrates are carbon-based sugars necessary for tree functioning and to make wood for growth. Every part of a tree stores carbon, including the trunks, branches, leaves, and roots. While the chemical composition of trees varies from species to species, **by weight, trees are about 50 percent carbon.**

Carbon is also found in soils. Carbon in soils come 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.** 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.

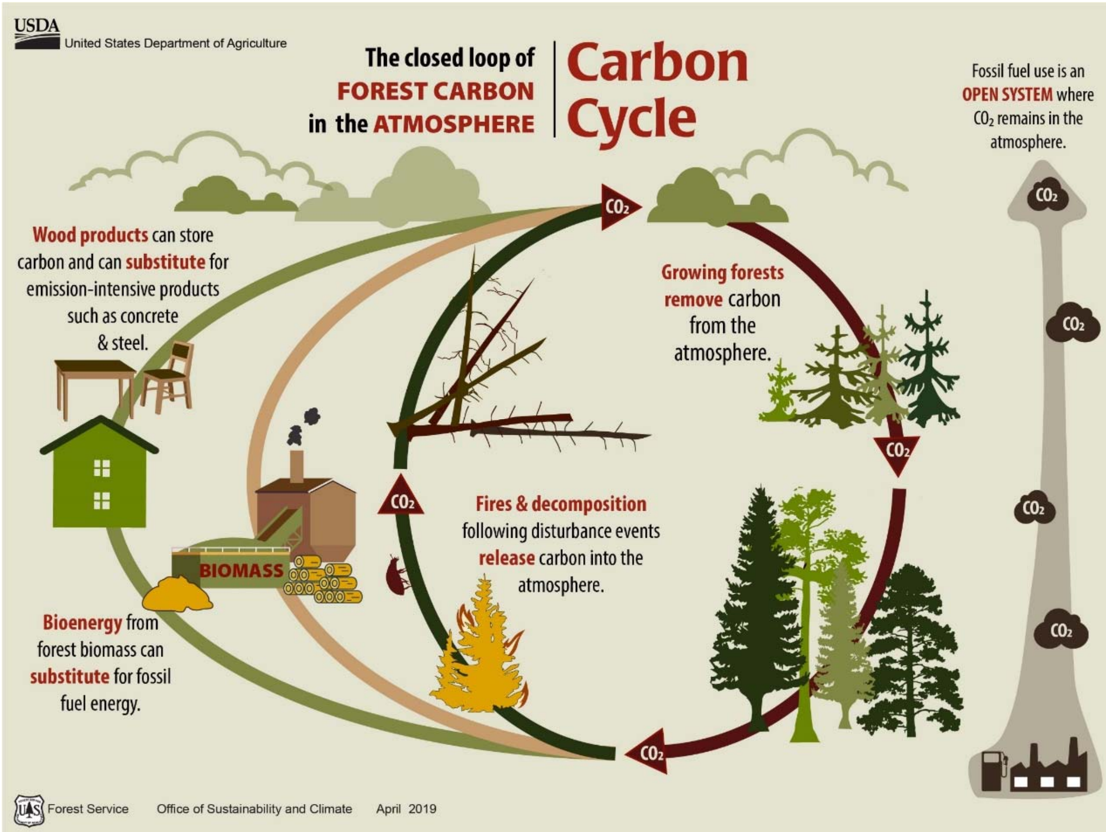
Fossil fuels were formed from organic materials under geologic processes, which took place over hundreds of millions of years. Therefore, when we burn fossil fuels for energy, carbon dioxide is released into the atmosphere, and there is no natural mechanism within that geologic cycle to re-capture or sequester the carbon from the atmosphere. Most fossil fuel carbon emissions remain in the atmosphere for thousands of years, representing an open system.

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 cells in trees respire, and soils release carbon through decomposition by soil microbes. Over months and years, the balance 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.**



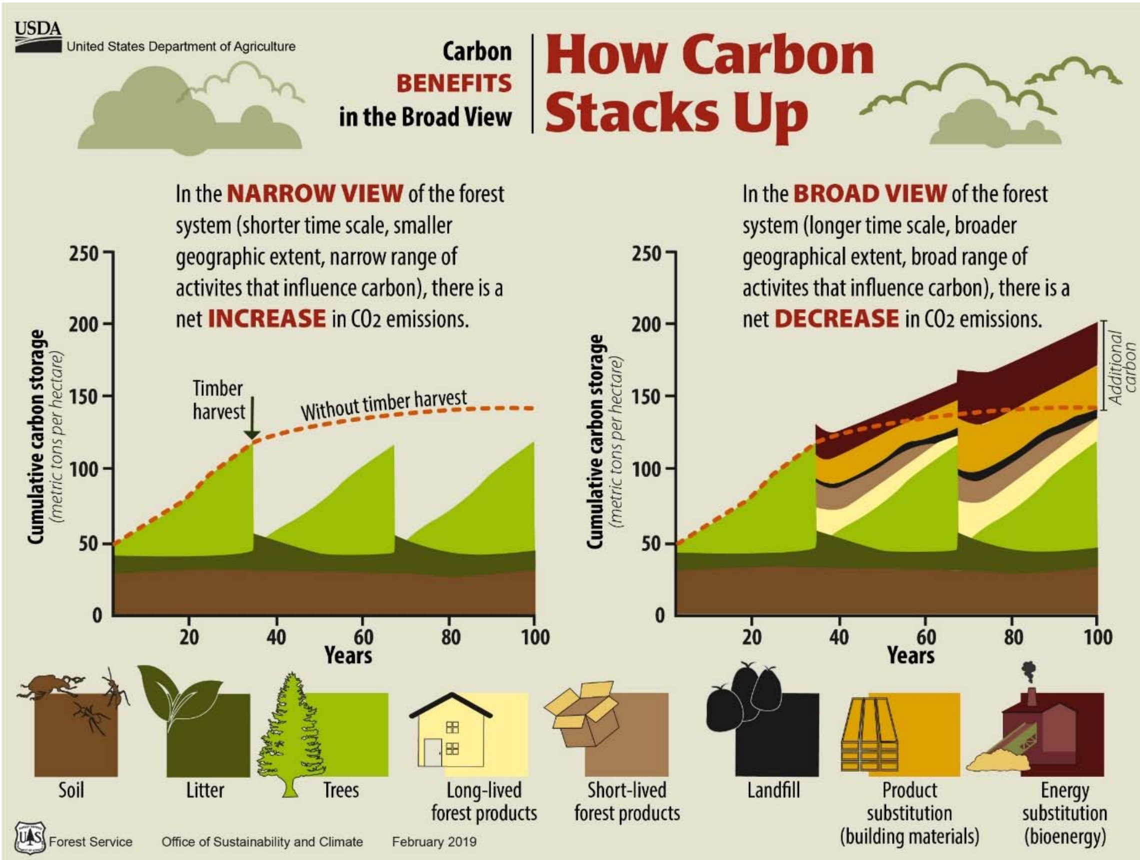
Forests have natural boom and bust cycles that are reflected in carbon. Trees die for a variety of reasons, and when they do, some carbon is eventually released back to the atmosphere. Sometimes, trees individually or in small pockets die from isolated events like wind or ice storms, or small fires. Other times, trees die in large numbers with natural disturbances from insects or disease outbreaks like the recent/ongoing emerald ash borer event, or droughts and tornados, both of which Indiana experienced in 2012. Carbon can be released quickly from forests with some events, as in the case of an 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 gradually decompose over years, releasing some carbon back into the atmosphere. This death and decomposition process sets 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.

When management activities, such as timber harvests, occur on forests, the forests regrow and eventually recover the amount of carbon lost during harvesting. **Not all carbon is removed during a harvest.** Portions (carbon in the roots, stump, tops, leaves, and other residues) remain in the forest and transfer carbon mainly to the soil through the decomposition process. Additionally, most carbon in the trunk portion of harvested trees is transferred to wood products, which can store carbon for months to decades and even centuries, depending on the commodity produced (e.g., paper, furniture, single-family homes). Carbon is also stored indefinitely when forest products enter landfills at the end of their usable life. In addition, certain harvested wood products produce less emissions when substituted for products made with energy from fossil fuels. An example is using a wood beam in place of producing a more energy-intensive steel beam. Wood can also be substituted directly for fossil fuel energy production, such as burning wood or wood pellets in place of coal.



The magnitude and timeframe on which these carbon dynamics play out vary greatly depending on the forest attributes, disposition 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 (cleared for agriculture or development) after harvesting and will remain as productive forestland for the foreseeable future. The Indiana DNR Division of Forestry does not expect significant changes in land-use cover or productivity as a result of any harvesting on lands managed by them.

According to the best available science, harvesting and the use of harvested wood products can play an important role in reducing carbon emissions. 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. In other words, that means looking at what the atmosphere actually “sees” in terms of carbon entering or leaving the atmosphere. This requires looking at how forest 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. Increased risk of carbon loss through disturbances, such as wildfires and insect epidemics, can undercut the potential goal of maximizing carbon storage on the forest. In some cases, a more effective way to reduce carbon in the atmosphere is through various types of harvesting activities. This approach initially reduces the amount of carbon stocks on the forest, but often 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 were unmanaged**.



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. The length of time carbon is "stored" in these products can range from days to centuries—or indefinitely, when they reach landfills. **Carbon remains in these products until the product is burned or decomposes.**

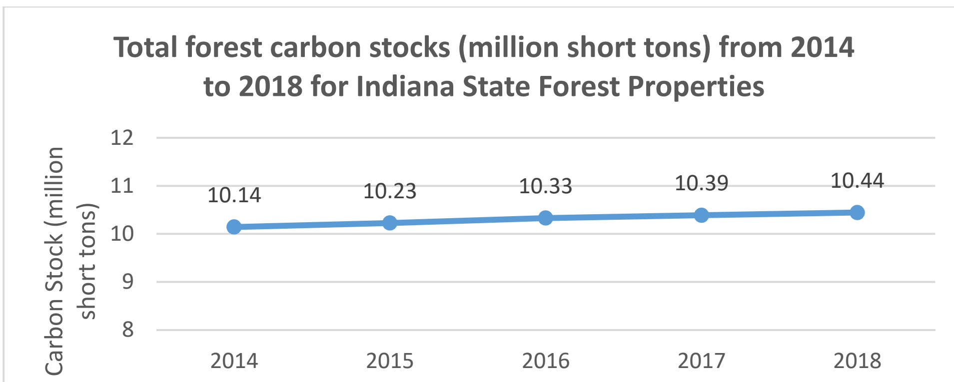
Modern harvesting practices leave little waste. Some logging residues, such as leaves and branches, stay on the forest to be used as firewood or to decay and return nutrients to the soil. Mills are generally efficient at using "mill residues" such as sawdust and bark. These materials often heat milling 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 byproduct of conventional forest product streams, such as milling residues, with some use of whole trees killed by insects, disease, or natural disturbance.

As comparative background information for state forests (i.e., forests managed by the Indiana DNR's Division of Forestry), the Forest Service conducts quantitative analyses on forest carbon stocks and carbon emissions relating to management alternatives when the potential effects are large, practical to measure, and when this information provides meaningful evidence to inform the decision. For example, a quantitative analysis of carbon emissions might be appropriate for some large fossil fuel extraction projects. But unless vegetation management projects and related activities are done at a very large scale, their impact of on forest carbon stocks and emissions is extremely small. In context, **the amount of carbon affected by most forest management activities is small compared with the total carbon**

stocks on the forest, and negligible to the scale of national and global carbon emissions. Thus, quantitative analyses usually do not provide meaningful inferences about the potential impact of management alternatives at relatively small scales typically associated with projects or a collection of projects on state forests. The DNR Division of Forestry 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 conducted are consistent with carbon mitigation strategies, although carbon management might not be the primary purpose.

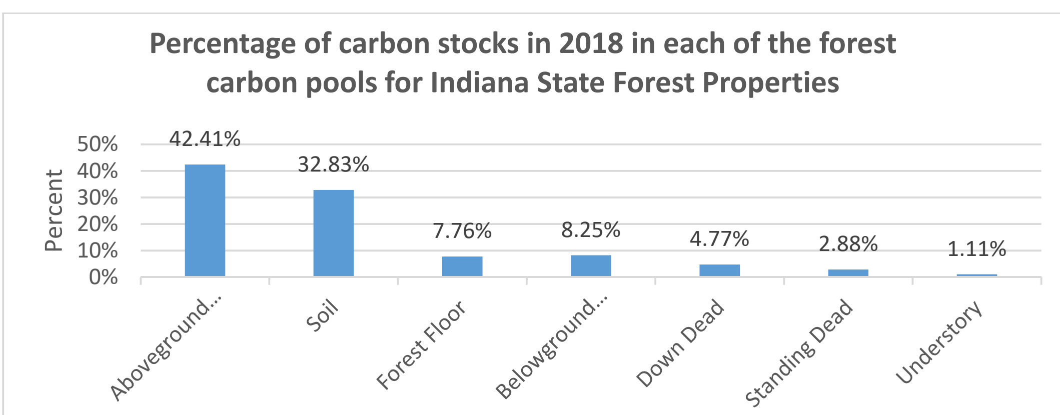
Continuous forest inventory (CFI) data has begun to provide carbon estimates for the Indiana State Forest system lands. We will be able to use this as baseline data and monitor carbon estimate trends over time. Early data indicates that annual carbon stock estimates are fairly consistent since the inception of measurements (2014) at just over 10 million short tons (Fig. 1). It is too soon to discuss trends (although slightly increasing each year) because we don't have a historical baseline to compare with, but will as we annually add data.

Figure 1.

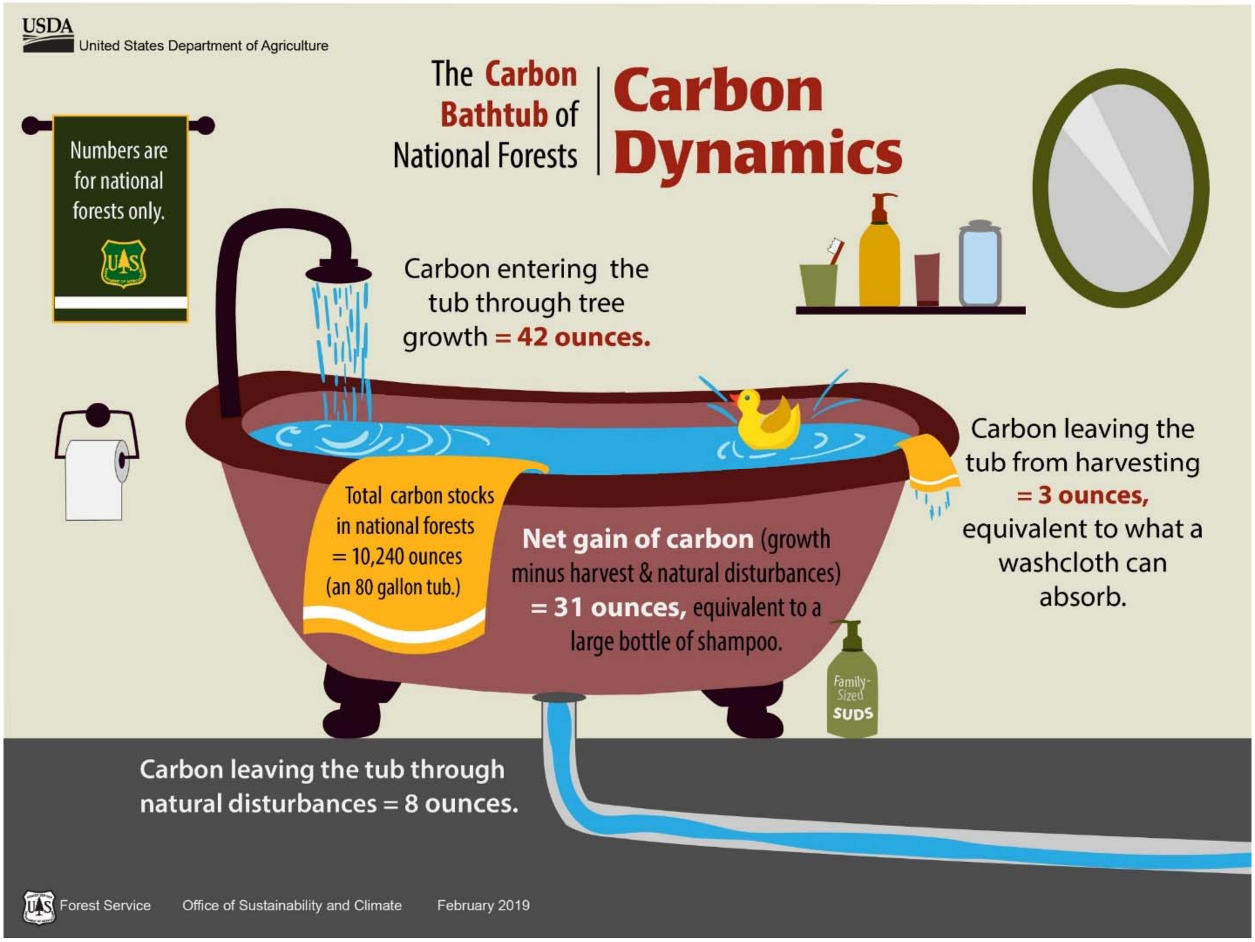


In 2018 about 42.4 percent of the forest carbon stocks on the Indiana State Forests are stored in the aboveground portion of live trees, which includes all live woody vegetation at least 1 inch in diameter (Fig. 2). The soil carbon pool, which consists of organic material in the mineral soil to a depth of one meter (excluding roots), is the second largest carbon pool, storing another 32.8 percent of the forest carbon stocks. The remaining forest carbon stocks can be found in the forest floor (litter), below-ground portion of live trees, down dead material, standing dead trees, and the understory.

Figure 2.



While timber harvesting may be perceived as the most prevalent disturbance on the Indiana State Forests, recent disturbances are significant if not more prevalent. A tornado in 2012 devastated approximately 1,200 acres at Clark State Forest. A severe drought in 2012 caused many trees, especially tulip poplar and older oaks, to die. The emerald ash borer has/is eliminating most of the ash component in the forests as this invasive insect continues to move and become established throughout the state.



The biggest influence on current carbon dynamics on the Indiana State Forests is the legacy of intensive timber harvesting and land clearing for agriculture around the turn of the 19th/20th century (before state ownership), followed by a period of forest recovery and more sustainable forest management beginning in the early to mid-20th century. This has promoted a carbon sink scenario; however, stands are now mostly of middle to older age. The rate of carbon uptake and sequestration generally declines as forests age. This may lead to a potential age-related decline in forest carbon stocks in the future.

Climate and environmental factors, such as elevated atmospheric CO_2, have influenced carbon accumulation on Indiana State Forests. Recent warmer temperatures and precipitation variability may have stressed forests, possibly causing climate to have a negative impact on carbon accumulation. Conversely, increased atmospheric CO_2 may have enhanced growth rates and helped to counteract ecosystem carbon losses due to climate.

The effects of future climate conditions are complex and uncertain. However, under changing climate and environmental conditions, Indiana State Forests may be increasingly vulnerable to a variety of stressors. These potentially negative effects might be balanced somewhat by the positive effects of a longer growing season, greater precipitation, and elevated atmospheric CO_2 concentrations; however, it is difficult to judge how these factors and their interactions will affect future carbon dynamics on the Indiana State Forests.

Forested areas on the Indiana State Forests will be maintained as forestland in the foreseeable future, which will allow for a continuation of carbon uptake and storage over the long term. Forestland conversion for development on private ownerships is a concern in Indiana, and this activity can cause substantial carbon losses. Therefore, Indiana State Forests will continue to have an important role in maintaining carbon stocks for decades to come.

REFERENCES

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