Scientists point to forests for carbon storage solutions

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Scientists who have determined how much carbon is stored annually in upper Midwest forests hope their findings will be used to accelerate global discussion about the strategy of managing forests to offset greenhouse gas emissions.

In an era of competing land use demands, the researchers argue that forests help stabilize the climate and are abundant sources of other ecological goods and services – such as cleansed air, fertile soil and filtered water. Quantifying the amount of carbon that forests can keep out of the atmosphere is one way of showing forests' value to energy policymakers, the researchers suggest.

"Demonstrating that forests have economic value because they offer carbon offsets might also help citizens have an appropriately broad appreciation for the things that forests do for them beyond providing recreation or wood used for construction or paper pulp," said Peter Curtis, professor and chair of evolution, ecology and organismal biology at Ohio State University.

Curtis is the senior author of a paper published in a recent issue of the journal *BioScience* that quantifies annual carbon storage capacity in forests in the upper Great Lakes region and details how historic land use, climate patterns and tree turnover influence forests' carbon storage trends.

The researchers' calculations suggest that carbon storage in Midwestern forests could offset the greenhouse gas emissions of almost two-thirds of nearby populations, and that proper management of forests could sustain or increase their storage capacity for future generations.

Based on measurements taken between 1999 and 2005 at a forest study site in northern Michigan, the scientists have determined that similar upper Midwest forests covering an estimated 40,000 square miles store an average of 1,300 pounds of carbon per acre per year.

Factoring in effects of climate, history and tree type, the researchers developed an equation suggesting that a heavily forested region in northern Michigan could store more than 350,000 tons of carbon per year. With the area population emitting about 573,000 tons of carbon annually, the forests would sequester approximately 62 percent of the region's human-caused carbon emissions – the equivalent of yearly emissions from about 225,000 cars.

Curtis said the concept of using forests to store carbon has steadily gained attention among policymakers, especially since the Kyoto Protocol was adopted in 1997 as a global program to reduce greenhouse gas emissions. Curtis is a believer in approaching carbon dioxide stabilization in the atmosphere through what he calls "small wedge" efforts.

"Biological carbon storage, mostly in forests, is one of those little wedges along with other ones you might think of, such as increased energy efficiency, using fluorescent light bulbs and the like. There is not one silver bullet," he said.

Effective use of forests for carbon storage requires knowing more than current storage statistics, he noted. Curtis and colleagues also have outlined historic factors that offer clues about what forests can be expected to store and release over future decades.

The research team conducted the measurements at the University of Michigan Biological Station (UMBS). The composition of this small forested region is representative of the forests stretching about 40,000 square miles – the equivalent of the land mass of Ohio – across the entire upper Midwest.

Most carbon in the UMBS forest is contained in the wood mass and soil organic matter – which, Curtis said, points to the importance of considering underground carbon reservoirs in carbon budgeting. Stem wood, leaves and debris contain about 42 percent of carbon in the forest.

The storage assessments for the past five years resulted from combining ecological and meteorological measurements at the Michigan forest site. Ecological estimates are based on the carbon content of wood, leaf litter, debris and roots as well as the release of carbon that occurs when soil and plants decompose. The meteorological measurements analyze the ongoing carbon exchange between the forest and atmosphere using instrumentation available at only a select few labs in the world.

In the case of the Michigan forest, carbon storage capacity is also affected by the repeated clear-cut harvesting and fire disturbance that occurred a century ago as well as climate variations that the scientists have documented and the species and age of trees the forest comprises. These conditions can be used to project future carbon storage trends in similar forests in the United States and around the world.

The scientists have recorded a rising average air temperature of almost 2 degrees Fahrenheit (1.1 degrees Celsius) and decreased solar radiation of 5 percent over the past 25 years at the Michigan study site. The current average temperature is about 45 degrees Fahrenheit.

Extending such changes to 2030, the researchers suggest the annual carbon storage affected by these climate changes will be reduced by between 1.3 percent and 28.5 percent, to a possible low of about 980 pounds of carbon per acre.

"We weren't surprised by the annual temperature increase, because that's happening everywhere, but the decline in solar radiation was very surprising," Curtis said. "It might seem like a small difference, but it's important from the standpoint of plants."

Plants use the energy from sunlight to manufacture carbohydrates and release oxygen through photosynthesis. Curtis said scientists believe the rising temperatures combined with the presence of water led to the increase in cloudy days.

The Michigan forest's storage capacity also is affected by its land use history. A period of deforestation between 1880 and 1920 was followed by abandonment of the land and a rash of wildfires. Forests with similar histories store significantly less carbon than stands without that kind of disturbance because of a resulting lower forest canopy and reduced soil fertility.

"Nothing this drastic would ever happen in the United States today. However, it's going on all the time in developing world, and a less damaging pattern of harvest and fire is increasing in the western United States. And there are lasting consequences of that," Curtis said. "The persistent legacies of poor management practices on forest carbon storage in northern Michigan should serve as a caution to contemporary forest managers."

Finally, the age and species of trees in forests also affect carbon storage capacity. Old growth forests store relatively little carbon. More carbon is stored in older wood, but the rate of accumulation decreases over time because a higher rate of decomposition in soil and dead wood lowers the net gain of carbon storage.

Curtis noted that some policymakers are concerned that aging Great Lakes forests will show a decline in carbon storage capacity.

"We contend the situation here is different because of the nature of the land use. We consider them 'old young' forests. Aspens are aging, but underneath the aspens, waiting for them to die, are lots of young pine, oak, beech and maple. Once they get their turn, they will rejuvenate these forests in terms of carbon storage," he said.

The scientists are accelerating this phenomenon – called succession – in a segment of the Michigan forest to test this hypothesis.

"If we're right, this will give people incentive to hold onto forests and not cut them down. Though a younger forest might be considered more productive, we contend cutting would set things back because it would cause a lot of disturbance," Curtis said.

He hopes the combined assessments can be used for global policy discussions about forests' ability to store carbon.

"We now know where carbon is in a forest – it's very important, if you're managing carbon, to know where it is. Now that we can document where carbon is, how it gets in there and how it leaves, what we have is an accounting problem," Curtis said. "Now we just have to do the bookkeeping."

Source: Ohio State University

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