Up-and-coming forests will remain important carbon sinks

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(PhysOrg.com) -- The aging forests of the Upper Great Lakes could be considered the baby boomers of the region's ecosystem.

The decline of trees in this area is a cause for concern among policymakers and ecologists who wonder whether the end of the forests' most productive years means they will no longer offer the benefits they are known for: cleansed air, fertile soil, filtered water and, most important to climate change analysts, carbon storage that offsets greenhouse gas emissions.

A team of ecologists led by Ohio State University researchers says, however, that coming up right underneath the old forests is a new generation of native trees that are younger, more diverse and highly competitive. They represent a vast unknown compared to what ecologists have long theorized about how forests work as carbon sinks, but these researchers expect the next generation to carry on the important work of carbon storage.

"There's a conventional theory that aging forests, for a variety of reasons, store less carbon over time. We contend that that may be true in certain systems that are less species-rich. But in our forests in the Midwest, the tree species we will end up with are much different from what we started with," said Peter Curtis, professor and chair of evolution, ecology and organismal biology at Ohio State and a lead investigator on this research.

"We argue that in this case, as forests age, they get rejuvenated with younger individuals of different species – a more complex and diverse community will be replacing the old guard. They may even outdo the boomer generation and be more productive."

Curtis and colleagues base their predictions on preliminary findings from a project in which they have accelerated the generational shift in part of a forest in northern Michigan. By cutting strips of bark from thousands of aspen trees to hasten their death, the scientists are able to observe the characteristics of the trees that will replace this 100-year-old cohort.

So far, the scientists are finding that the canopy created by the newcomers' leaves use light more efficiently to manufacture carbohydrates and release oxygen through photosynthesis than did the aspen canopy that preceded it. The researchers also are able to use sophisticated instruments to quantify nitrogen cycling in the transitioning forest, and observe that nitrogen losses throughout the system are small even with the death of thousands of trees. As long as nitrogen remains available – within tree wood and leaves as well as in the soil – for the trees to renew themselves annually, the forest will continue to function as an effective carbon sink.

Curtis presented portions of the research Wednesday (8/10) at the Ecological Society of America annual meeting in Austin, Texas.

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

Aspens compose the vast majority of old trees in the region, cropping up quickly after a period of deforestation between 1880 and 1920 that was followed by abandonment of the land and a rash of wildfires.

Curtis describes aspens as trees that "live fast and die young." Their seeds spread easily and that allowed the species to revegetate the deforested areas rapidly, but they do not grow well in shade underneath their own canopies. Because of that weakness, the aspens are being replaced by tree species that were once native to the region but take longer to get established.

Aspens live only about 100 years on average, compared to the oak, sugar maple, beech, hemlock and pine species that are replacing them, which can live for as long as 600 years.

The researchers previously calculated that the Midwestern forests could offset the greenhouse gas emissions of almost two-thirds of nearby populations by storing an average of 1,300 pounds of carbon per acre – a total of 350,000 tons – per year.

To test the forests' future carbon storage capacity, the researchers launched the Forest Accelerated Succession Experiment (FASET) in 2008, girdling almost 7,000 aspen trees across about 100 acres. Girdling involves cutting a strip of bark from the circumference of a tree trunk. To date, about 75 percent of the aspen trees are dead, and about 15 percent have fallen.

Their demise is making way for a more diverse forest, Curtis said. Though some ecological theories suggest that a simple system – say, all pine or all aspen – can be more productive in the short term, a more complex system is needed to withstand the inevitable disturbance that will accompany climate change, he said.

"The more diverse system can solve problems that are thrown at it by the environment," Curtis said. "Adaptation is a key word here. As animal and plant species are moving around or changing seasonally, a diverse and resilient ecosystem is going to be much better able to provide ecological niches and the goods and services that we can hope to get from it."

So far, the accelerated succession is showing that with the loss of the aspens, the light-use efficiency of the forest canopy increased.

"Even with fewer leaves, the leaf area was better distributed. It's happening quite rapidly. As soon as you take away these aspen, you get a lot more nitrogen and more light, and other species react to that very quickly," Curtis said. "There was more nitrogen available because aspens weren't there to take it up, and dead leaves and dead roots were releasing nitrogen."

Considering the magnitude of the disturbance of killing thousands of trees, the researchers were surprised to see that the system lost almost no nitrogen. Plants use nitrogen, which becomes available through the decomposition of organic matter, to produce the next year's leaves and wood. Plants also need nitrogen to take up carbon.

Clear-cutting trees would allow nitrogen to drain out of the bottom of the system because no roots would exist to intercept that loss, Curtis explained. Though the rapid loss of aspens did lead to about a 10 percent loss of nitrogen, almost that same amount was recaptured in atmospheric nitrogen that comes down to the land surface in rain.

The wood mass and soil organic matter are vital to a forest's carbon-storage capacity; in the UMBS forest, stem wood, leaves and debris contain about 42 percent of the carbon there. Though forests also release carbon dioxide into the atmosphere, the instrumentation used by these researchers to analyze the ongoing carbon exchange between the forest and atmosphere has been able to confirm the forest's status as an important national carbon sink, 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's group has received $1 million in additional funding from the U.S. Department of Energy to continue evaluating forests' role in storing carbon.

Provided by The Ohio State University

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