Structurally complex forests better at carbon sequestration

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Jeff W. Atkins, Ph.D., a post-doctoral researcher in VCU's Department of Biology and co-author of the study, uses a lidar system to collect data in a forest at VCU's Rice Rivers Center in 2016. Credit: Julia Rendleman, University Marketing

Forests in the eastern United States that are structurally complex—meaning the arrangement of vegetation is highly varied—sequester more carbon, according to a new study led by researchers at Virginia Commonwealth University.

The study demonstrates for the first time that a forest's structural complexity is a better predictor of carbon sequestration potential than tree species diversity. The discovery may hold implications for the mitigation of climate change.

"Carbon dioxide, a potent greenhouse gas, is taken up by trees through the process of photosynthesis and some of that 'fixed' carbon is allocated to wood," said Chris Gough, Ph.D., corresponding author on the study and an associate professor in the Department of Biology in the College of Humanities and Sciences. "Our study shows that more complex forests are better at taking up and sequestering carbon in wood and, in doing so, they leave less carbon dioxide in the air."

The study, "High Rates of Primary Production in Structurally Complex Forests," will be published in a forthcoming issue of *Ecology*, a journal of the Ecological Society of America.

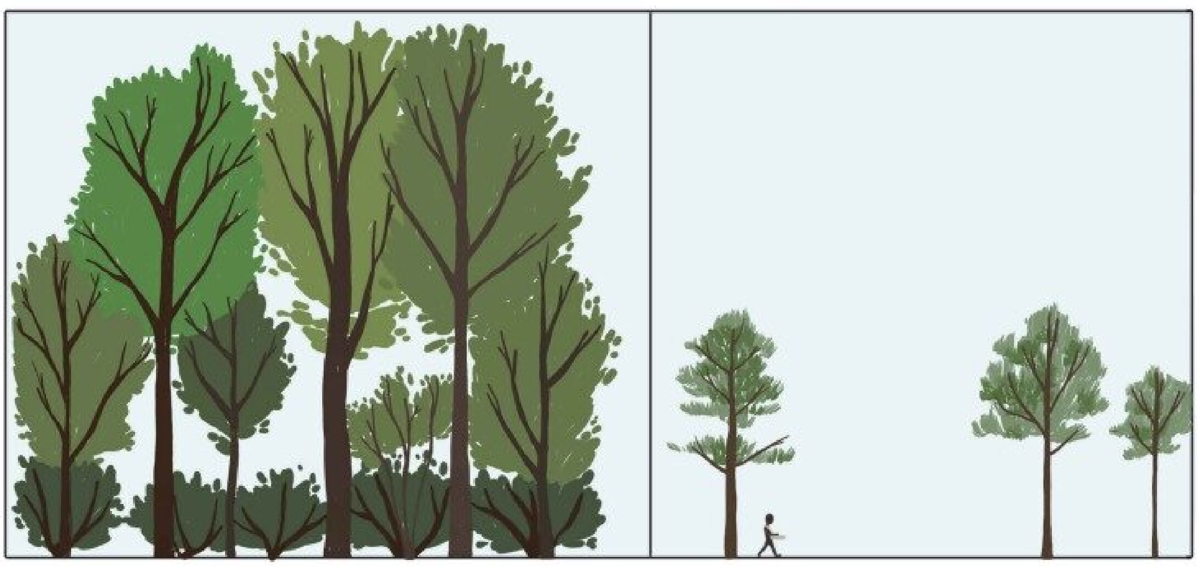
Carbon sequestration is the process by which atmospheric carbon dioxide is taken up by trees, grasses and other plants through photosynthesis and stored as carbon in soil and plant biomass, such as tree trunks, branches, foliage and roots. Carbon sequestration in forests and wood helps offset sources of carbon dioxide to the atmosphere, such as deforestation, forest fires and fossil-fuel emissions, according to the Forest Service of the U.S. Department of Agriculture.

Why are structurally complex forests better at carbon sequestration? Gough suggests that multiple layers of leaves may optimize how efficiently light is used to power carbon sequestration in wood.

"In other words, forests that are structurally variable and contain multiple layers of leaves outperform structurally simple forests with a single concentrated band of vegetation," he said.

To conduct the study, the researchers used a combination of their own data, as well as data from the National Ecological Observatory Network, or NEON, which is funded by the National Science Foundation. NEON is generating long-term, publicly available data for different ecosystems in the U.S., with the aim of understanding decadeslong ecological processes.

VCU biology post-doctoral scholar Jeff Atkins, Ph.D., led field data collection with researchers from the University of Connecticut and Purdue University serving as collaborators and co-authors.



This illustration shows on the left a stylized structurally complex forest sampled in the Great Smoky Mountains, while the right panel shows a structurally simple pine savannah in Florida. Credit: Catherine McGuigan

Understanding how forest structure drives carbon sequestration is important for ecologists, climate modelers and forest managers.

"Many of the ecological indicators of forest growth and carbon sequestration fail to explicitly account for complexity," Gough said. "We wanted to test whether more novel indicators of structural complexity are superior predictors of carbon sequestration in wood. We also wanted to know whether these predictors extend to a number of different forest types residing in various parts of the eastern half of U.S., from Florida to New Hampshire to Wisconsin."

The study builds on previous research supported by the National Science Foundation that demonstrated how laser-based technology called lidar can map the distribution of leaves within a forest canopy at very high resolution.

The new study suggests that using lidar to map forest structure could predict the potential of forests to sequester carbon in biomass better than conventional approaches characterizing biodiversity and leaf quantity.

"This could be a major advance because we can likely use aircraft and, just in the last year, satellite data to collect the data needed to predict carbon sequestration from structural complexity," Gough said. "If we can estimate structural complexity from satellites in the future, then it may be possible to greatly improve our capacity to estimate and predict global forest carbon sequestration."

The study's results show what ecologists can do when they embrace new technologies and apply them to fundamental questions such as: What affects forest growth and carbon sequestration?

"These results, we hope, push the science forward by showing that how a forest is put together matters for carbon sequestration," Gough said.

"And this relationship extends broadly to a number of different forests, from evergreen to deciduous and mid-Atlantic to Midwest."

While the researchers found that structural complexity outperformed species diversity measures as predictors of carbon sequestration, they noted that diversity is also important as one of many components that determine how structurally complex a forest is.

"We think structural complexity measures are powerful because they integrate multiple features of a forest that are critical to carbon sequestration," Gough said. "It takes tree diversity to produce a variety of leaf and plant shapes and, additionally, a critical quantity of leaves to supply the building blocks required to assemble a structurally complex forest capable of sequestering lots of carbon."

In addition to Gough, the paper was authored by Atkins, Robert T. Fahey, Ph.D., an assistant professor of forest ecology and management at the University of Connecticut, and Brady S. Hardiman, Ph.D., an assistant professor of urban ecology at Purdue University.

More information: Christopher M. Gough et al, High rates of primary production in structurally complex forests, *Ecology* (2019). DOI: 10.1002/ecy.2864

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