Don't look to mature forests to soak up carbon dioxide emissions

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Research published today in *Nature* suggests mature forests are limited in their ability to absorb "extra" carbon as atmospheric carbon dioxide concentrations increase. These findings may have implications for New York state's carbon neutrality goals.

Dr. John Drake, assistant professor in ESF's Department of Sustainable Resources Management, is a co-author of the paper in collaboration with

researchers at Western Sydney University.

The experiment, conducted at Western Sydney University's EucFACE (Eucalyptus Free Air CO2 Enrichment) found new evidence of limitations in the capacity of mature forests to translate rising atmospheric carbon dioxide concentrations into additional plant growth and carbon storage.

Carbon dioxide (CO2) is sometimes described as "food for plants" as it is the key ingredient in plant photosynthesis. With CO2 concentrations in the atmosphere increasing steadily due to human emissions, there is ample evidence that plant photosynthesis is going up. Experiments that have exposed single trees and young, rapidly growing forests to elevated CO2 concentrations have shown that plants use the extra carbon to grow faster. "Forests provide a wide array of environmental, economic and social benefits. Importantly, forests remove large amounts of carbon from the atmosphere and store it, which slows down our climate crisis," said Drake.

However, scientists have long wondered whether mature native forests would be able to take advantage of the extra photosynthesis, given that the trees also need nutrients from the soil to grow. Drake joined in the first experiment of its kind applied to a mature native forest to expose a 90-year old eucalypt woodland on Western Sydney's Cumberland Plain to elevated carbon dioxide levels.

The researchers combined their measurements into a carbon budget that accounts for all the pathways of carbon into and out of the EucFACE forest ecosystem, through the trees, grasses, insects, soils and leaf litter. This carbon-tracking analysis showed that the extra carbon absorbed by the trees was quickly cycled through the soil and returned to the atmosphere, with around half the carbon being returned by the trees themselves, and half by fungi and bacteria in the soil.

"The trees convert the absorbed carbon into sugars, but they can't use those sugars to grow more, because they don't have access to additional nutrients from the soil. Instead, they send the sugars below-ground where they 'feed' soil microbes," said Dr. Belinda Medlyn, distinguished professor at the Hawkesbury Institute for the Environment.

These findings have global implications: models used to project future climate change, and impacts of climate change on plants and ecosystems, currently assume that mature forests will continue to absorb carbon over and above their current levels, acting as carbon sinks. The findings from EucFACE suggest that those sinks may be weaker or absent for mature forests.

"While we can't say what we found in this one Australian forest directly translates to northeastern forests in the United States," Drake said this information has implications for forests in New York state.

"Forests of the northeastern United States for the last 100 years have been regrowing and providing an important carbon sink. As those forests transition to a more mature state, there are some uncertainties whether that will continue," said Drake.

The results may also impact New York's first statewide forest carbon assessment led by Dr. Colin Beier of ESF's Climate and Applied Forest Research Institute (CAFRI).

"Forests are increasingly seen in policy circles as a critical part of the solution to climate change, and that's certainly the case for New York, where the carbon absorbed by our forests and stored in trees, soils and harvested wood products will be essential for reaching our state's legislated goal of net carbon neutrality by 2050," said Beier, associate professor of ecology and CAFRI director.

"As we develop forest carbon accounting for New York, one of our biggest questions is how forest ecosystems and their many benefits to society, including reducing climate risk, will respond to a rapidly changing environment," said Beier. "This groundbreaking study fills a major gap and reduces this uncertainty, allowing us to make more reliable predictions and provide better guidance to policymakers, landowners, and forest managers."

"Forest carbon storage is vitally important in a climate change context," said Drake, adding "and the recent work in *Nature* would suggest mature forests might not store additional extra carbon as CO2 concentrations rise in the atmosphere."

Looking to restoration ecology to encourage forests to grow in some particular areas would be useful, said Drake "There are also possibilities for managing existing forests to increase their carbon storage."

Drake is working with colleagues Dr. Julia Burton, Dr. René Germain and Beier to develop and field test alternative forest management strategies that mitigate climate change by increasing the capacity of forests to adapt to changes in climate conditions as well as remove carbon from the atmosphere.

"We are not looking for a silver bullet," said Burton. "Climate-smart forest management will likely involve a variety of approaches."

"The limited capacity of mature trees to respond suggests the need for a diversity of age classes of trees (younger trees sequester, older trees store carbon) and species, including species that may be better adapted to future climate conditions," said Drake.

More information: The fate of carbon in a mature forest under carbon dioxide enrichment, *Nature* (2020). DOI: 10.1038/s41586-020-2128-9 ,

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