Mozambique forest stores huge amounts of carbon: Laser technique puts new value on miombo woodlands

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Dry, tropical forests are often overshadowed in popular and scientific perception by wet and tall rainforests. They are less obviously charismatic or exotic and so may seem less important. But dry tropical forests are vital ecosystems that support the livelihoods of millions of people.

One type of dry, tropical forest in Africa is miombo woodland. These forests stretch across more than two million hectares in Africa, including Angola, Tanzania, parts of the Democratic Republic of Congo, Malawi, Mozambique, Zambia and Zimbabwe. Their name comes from the Bemba word (miombo) for the dominant types of trees in the woodland, Brachystegia.

Miombo woodlands—like other forests—absorb large amounts of carbon dioxide (CO_2) from the atmosphere during photosynthesis. They store the carbon in trees, shrubs and in the soil, too, making them an important part of the carbon cycle across Africa and the global climate system. Knowing how much carbon these trees absorb and store is crucial for understanding climate change.

We're a group of environmental scientists that have conducted research, using laser pulses, to measure exactly how much carbon is stored in the tree trunks and branches of a forest in Mozambique's Gilé National Park.

We did this by shooting nearly 450 billion laser pulses—from the ground, drones and helicopters—at 50,000 hectares of the forest, to produce a very detailed 3D image. From this we get a very accurate measurement of the forest, including the size and volume of the woody parts of the trees.

By estimating the volume of the wood in the forest using our laser measurements, we can calculate how much carbon is stored in the trees.

We can do this because we know how much the wood weighs per cubic meter. Around half that wood mass is carbon.

We found that these forests may store nearly twice as much carbon in tree trunks and branches (also known as "aboveground biomass") than previously thought.

We hope that our research highlights the value of these miombo woodlands and their impact on climate.

The area covered by miombo woodlands has reduced by nearly 30% since 1980—down from about 2.7 million to 1.9 million square kilometers. They're under increasing pressure from climate change, fires, grazing and land use change for agriculture.

Because of these pressures, and because the forests also support people's livelihoods and the environment, it is crucial to monitor how the world's miombo woodlands are changing.

What we researched

Our study was a collaborative effort between UK-based carbon data platform Sylvera, Mozambique's National Fund for Sustainable Development, the World Bank and Mozambican researchers familiar with the ecology of the study area.

Our aim was to get an accurate estimate of how much carbon was being stored in the 50,000 hectares of the forest's aboveground biomass.

It is very difficult to get an accurate estimate of forest biomass at large scales. One way scientists try to do this is using satellite and aircraft observations of the size and types of forest. Another way is to measure individual tree stem diameter and species and record this growth manually over time. But these approaches are quite indirect and rely on estimating what we cannot physically measure (the amount of carbon stored in a tree) from what we can measure (tree trunk diameter, forest area).

We used lasers, known as LiDAR (light detection and ranging). LiDAR is an alternative approach to estimating forest aboveground biomass—one we have helped develop.

We also made careful manual measurements of the size and shape of more than 1,000 trees in the study area, to help us check the LiDAR measurements.

This technique has been used before. I was part of a team who used LiDAR to successfully map the amount of carbon trapped in Oxfordshire's Wytham Wood, in the UK.

Using this type of LiDAR technology is more effective in measuring carbon. This is because it is a much more direct measure of the volume of wood in forests and doesn't rely on having to do that very indirectly, relating things we can measure (tree trunk diameter, forest area), to things we can't (mass).

What we found

We found that the 50,000 hectares of forest may store 1.71 million tons of carbon in tree trunks and branches.

Our approach therefore found that the aboveground biomass (and hence carbon) stored in this miombo woodland was 1.5 to 2.2 times greater than previously estimated.

We found that 50% of the aboveground biomass, and therefore carbon, was stored in the largest 11% of the trees. Because they store so much biomass, it is particularly important to get the measurements of these trees right. Yet until now, large trees have been under-researched in terms of their stored biomass because they are so difficult to cut down and weigh.

Our study shows that previous estimates of how much carbon is stored in miombo forests at a large scale are more uncertain than scientists thought. The approach of combining LiDAR with ground-based measurements will enable better models to be developed.

Why it matters

If our findings in Mozambique were replicated across all miombo woodlands, this would imply that these forests might be storing 3.7 PgC (billion tons of carbon) more than currently estimated.

This is a huge amount of carbon—equivalent to about 10% of annual global CO_2 emissions from fossil fuels and industry.

In other words, these forests could have a more potent ability to sequester carbon from afforestation and reforestation efforts. Unfortunately, this could also mean that when miombo woodlands are lost, larger amounts of carbon will be emitted into the atmosphere.

Our study shows that conserving miombo woodland has additional economic benefits. One practical economic consequence of our work is the increased value of this woodland to carbon markets aimed at encouraging forest protection and restoration.

More generally, our results offer a new insight into the carbon storage of potentially overlooked dry tropical forests, with implications for how we understand and manage them. We are continually reminded of how little we know about trees and forests and we undervalue them at our peril.

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