Overhaul in tropical forest research needed

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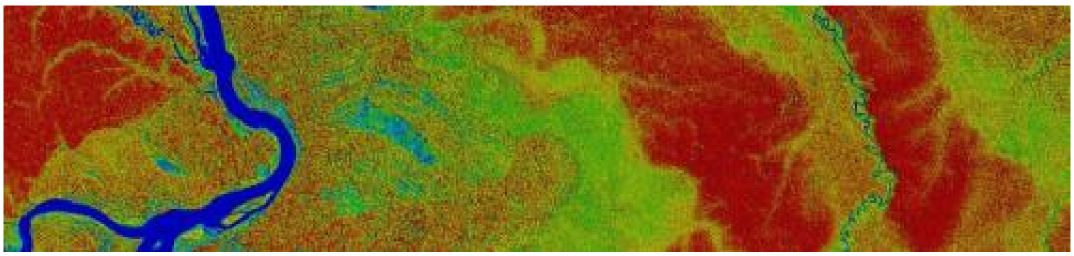

This image from the Carnegie Airborne Observatory shows the large variation in tree canopy height across multiple landscapes in southeastern Peru. The tallest trees are in dark red, with green and blue colors representing shorter trees and forest canopy gaps. Single field plots are used to represent these landscapes, often resulting in substantial biases. Credit: Greg Asner

New work from a team led by Carnegie's Greg Asner shows the limitations of long-used research methods in tropical rainforest ecology and points to new technological approaches for understanding forest structures and systems on large geographic scales.

When forests grow, they absorb carbon dioxide from the atmosphere, and store the carbon in plant branches, trunks, roots, and soils. Tropical forests, in particular, store more atmospheric carbon as biomass than any other land ecosystem on Earth. As a result, the importance of large-scale measurements and monitoring of tropical forest structure and biomass has rapidly increased throughout the science, conservation and climate change-policy communities.

For decades, the primary method of studying tropical forests has been field inventory plots—specially selected areas assumed to represent their surrounding forested landscapes. And the norm has been to extrapolate findings from these plots to much larger geographic scales. In the Amazon, fewer than 500 field plots, typically about one hectare in size (2.5 acres) or less, are used to represent more than 500 million hectares (1.2 billion acres) of forest.

The Carnegie team used advanced three-dimensional forest mapping techniques provided by the Carnegie Airborne Observatory (CAO) to determine how representative typical field plots actually are of their surroundings in forested landscapes. Their study stretched from the lowland Amazon to treeline in the Peruvian Andes. Their findings, published by *Proceedings of the National Academy of Sciences*, indicate that field plots alone often give scientists substantially biased results.

"We found highly variable and inconsistent performance of field plots relative to actual forest conditions across both Amazonian and Andean landscapes," noted lead author and Carnegie post-doctoral researcher David Marvin.

The worst biases from field plots were associated with the number and size of forest canopy gaps, which are used to estimate rates of tree damage and mortality, as well as regrowth. The study also found landscape-scale biases in measurements of aboveground carbon stocks when based on fieldwork alone. Factors that create these biases, which reached 98 percent in the study, include placement of field inventory plots, which for practical reasons must be accessible to field teams, and the tremendous natural variability of tropical forests.

Yet the team emphasized that despite the observed biases, field plot networks are still valuable resources in other ways.

"The plots examined by our study were created for a variety of reasons other than large-scale estimates of forest structure and biomass, and such plots have been instrumental in understanding and interpreting many forest processes," Marvin said. "Field plots can also serve the important purpose of calibrating and validating remote sensing data."

The researchers also asked whether field networks can be improved by expanding of the total number of plots. But using direct observations of forest structure and biomass from the CAO, the team found that an impractical number of field plots would be needed to achieve high accuracy. Such investments are expensive and difficult to maintain over long time periods, especially in remote tropical regions.

The team's results show that a fundamental shift is now needed in the way fieldwork is approached.

"Ultimately these results do not devalue the importance of field monitoring, which is still essential for the in-depth understanding of tropical forests, including many features beyond biomass and structure," says Yadvinder Malhi of Oxford University, a co-founder of forest monitoring networks in the Amazon and Andes, who was not involved with the study. "But they do point to innovative and intelligent new approaches that can combine the best of field monitoring and remote sensing to understand processes and change in these remote and complex tropical forests at landscape and larger scales."

"With the advent of new 3-D mapping techniques, we can make much more tactical and cost-effective decisions on where to focus our fieldwork, and we can use fieldwork to more deeply interpret the maps created from the air," said Asner, who has spent two decades working on the ground in tropical forests worldwide. "We can now estimate the canopy structure and carbon content of a forest as accurately from the air as we can in the field, but from the air, we can make measurements everywhere—something that is impossible on the ground."

More information: Amazonian landscapes and the bias in field studies of forest structure and biomass, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1412999111

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