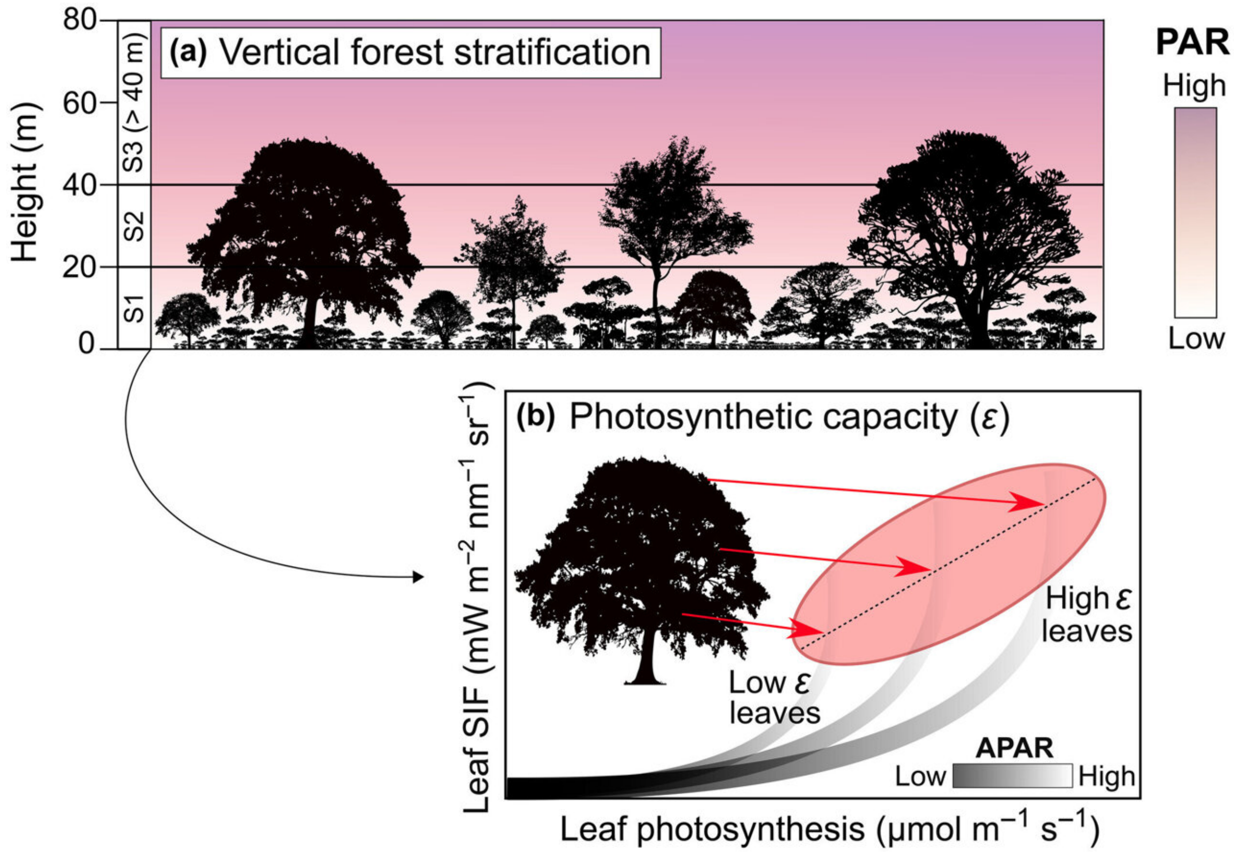
Amazon canopy trees reveal complex strategies for managing intense light and heat

June 15 2025, by Lauren Noel



(a) Forests vertical stratification illustrating variation in photosynthetically active radiation (PAR; in µmol m^{-2} s^{-1}). (b) Individual-level sampling approach using advanced tree climbing techniques to access different canopy levels and capture variations in absorbed PAR (APAR) by measuring *in situ* leaf chlorophyll fluorescence at three different crown positions with the MultispeQ (adapted from Magney et al., 2020). SIF, solar-induced Chl fluorescence. Credit: *New*

Phytologist (2025). DOI: 10.1111/nph.70183

In a recent study published in *New Phytologist*, researchers at Michigan State University have uncovered how Amazon rainforest canopy trees manage the intense sunlight they absorb—revealing resilience to hot and dry conditions in the forest canopy while also offering a way to greatly improve the monitoring of canopy health under increasing extreme conditions.

The study, led by doctoral candidate Leonardo Ziccardi with Associate Professor Scott Stark in the MSU Department of Forestry, shows how tropical trees act like giant solar antennas—absorbing vast quantities of light energy that must be carefully managed. When trees absorb more energy than they can use for photosynthesis, it must be safely dissipated, either as heat or re-emitted as light—a process called chlorophyll fluorescence.

"It's been a long journey," said Ziccardi. "Since 2019, we've run multiple field campaigns across seasons, climbing giant trees in the heart of the Amazon to understand how these forests respond to environmental changes. We've spent hundreds of hours up in the canopy doing measurements —some of the most intense and rewarding work I've ever done."

Ziccardi spent more than four years climbing trees nearly 200 feet tall in the central Amazon, measuring the fates of absorbed photons in thousands of leaves across many species, canopy heights, and light exposure conditions, producing a truly unique and unprecedented dataset.

Using a revolutionary handheld instrument—the MultispeQ, developed at MSU by co-author David Kramer in the MSU-DOE Plant Research Laboratory—Ziccardi captured how leaves in natural settings balance incoming light with their ability to photosynthesize or dissipate excess energy.

Leonardo Ziccardi using a MultispeQ device developed at Michigan State to measure leaf photosynthesis in the mid-canopy of an Amazonian forest. Credit: Rafael Francisco Grilo.

The findings offer a first-of-its-kind, high-resolution look at how the Amazon canopy navigates seasonal extremes. As the Amazon experiences increasing stress due to both greenhouse gases and deforestation leading to hotter and drier conditions in the canopy, understanding how trees manage light energy is essential to predicting their future survival.

Not only does this climate change lead to greater physiological stress due to more frequent extreme conditions related to lower soil water availability and dry and hot air, it can also increase the amount of sunlight hitting the forest. This happens because drier conditions have fewer clouds and that lets more sunlight through. This study helps address whether Amazon trees can absorb and use this extra light under stressful conditions.

Despite facing intense sunlight and atmospheric dryness, many canopy leaves were able to continue photosynthesizing, but only by increasing their allocation to energy dissipation pathways. For the first time in the Amazon, the study revealed a nuanced, three-phase response of leaves to rising light and drought conditions. Under low to moderate light, leaves balance energy use between photosynthesis and fluorescence, so these processes tend to increase and decrease together.

As light and drought stress increases, however, this balance breaks down. Heat-protective dissipation mechanisms become overwhelmed, photosynthesis drops, and fluorescence can spike—signaling potential damage to the photosynthetic machinery.

The implications are critical for scientists using satellite observations of fluorescence—the so-called solar-induced fluorescence, or SIF—to monitor Amazon forest health. While SIF is often used as a proxy for photosynthesis, this study shows that photosynthesis and fluorescence do not always go up and down together. Under high light and stress, this relationship breaks down and leaves may fluoresce more even as their photosynthetic machinery declines, potentially leading to overestimates of ecosystem productivity during droughts.

More information: Leonardo G. Ziccardi et al, Seasonal and intracanopy shifts in the fates of absorbed photons in central Amazonian forests: implications for leaf fluorescence and photosynthesis, *New Phytologist* (2025). DOI: 10.1111/nph.70183

Provided by Michigan State University