Tropical plant species are as threatened by climate change as widely feared, study confirms

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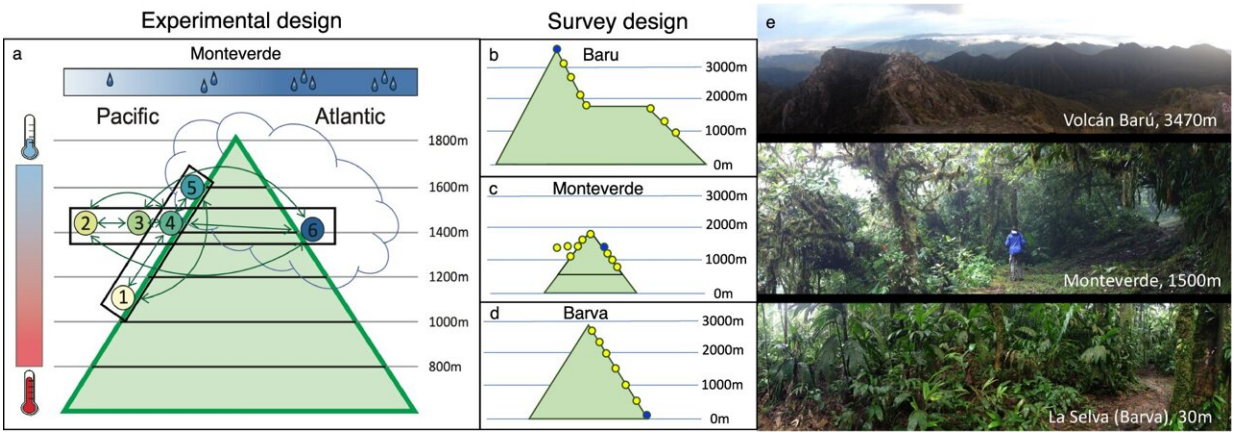

Experimental and survey design. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-49181-5

Brown University biologists who set out to better understand the effects of climate change on plant species in tropical mountain regions found that even small variations in temperature and moisture can have massive impacts, threatening not only plants that live there, but also the ecosystems they support.

Emily Hollenbeck, who conducted the research while earning her Ph.D. in ecology and evolutionary biology from Brown, made the discoveries

through a series of laborious yet informative experiments conducted in the Monteverde mountain region of Costa Rica.

Hollenbeck is devoted to learning how climate change affects tropical forests and as part of her dissertation work, spent five years leading research to document the occurrences of plant species called epiphytes on three mountains in Costa Rica and Panama. On one of the mountains, she transplanted plant species among sites that varied in elevation, temperature and aridity, and then observed and quantified the effects on the plants.

According to the study, published in *Nature Communications*, most epiphyte species struggled to survive outside their native ranges in climate conditions even slightly different from what they typically experience. The researchers concluded that their work strengthened earlier conjecture about risks of widespread extinctions from climate change in tropical mountain ecosystems.

"It's already obvious to people who live here, even those who aren't biologists, that the natural world has been shifting in striking ways over the last 20 or 30 years in response to climate change," said Hollenbeck, who is now president of the Monteverde Conservation League, a Costa Rican nonprofit focused on conserving and rehabilitating tropical ecosystems and their biodiversity. "It felt really important to conduct a very specific, well-controlled scientific study to provide context and evidence to support what we're seeing."

Canaries in a coal mine

While it is widely understood that climate change poses extinction risks for a variety of species, there is limited understanding of these dynamics. That's especially the case for tropical mountain regions home to some of the world's most diverse ecosystems, said study co-author

Dov Sax, a Brown professor of ecology, evolution and organismal biology who served as Hollenbeck's dissertation advisor.

Sax said that most estimates of extinction risk from climate change are based on correlative, statistical models that consider what sort of climate conditions species currently experience and whether those conditions are likely to be somewhere nearby in the future.

While these approaches work well in the United States and Europe where species' precise geographic distributions are well studied, Sax said they are poorly suited to tropical settings. There, the distributions of most species are often poorly documented, and it is unclear if species can tolerate conditions that differ from those occurring at their current locations.

"The field doesn't have a good handle on just how bad the extinction risk to tropical organisms might be under different levels of climate change," Sax said.

The study directly addresses these limitations for tropical epiphytes in mountains of Costa Rica and Panama, Sax said—and it took an extraordinary amount of work.

Hollenbeck, with the help of Brown research assistants, carefully surveyed the distribution of about 70 species of epiphytes across three mountain ranges. The researchers climbed up and down trees and traversed mountainous terrain to transplant about 1,500 individual epiphytes of 15 different species to a variety of elevations and climatic conditions above and below the elevations where they normally survive. The researchers monitored the plants every three months over the course of three years.

"We found that these species really are as sensitive to small changes in

climate conditions as has been widely feared, and which some previous, much smaller-scale experiments had found in the past," Sax said.

Even the plants with the widest survivable ranges, which were predicted to be the least vulnerable to change, fared worse than the researchers expected.

Additionally, the findings suggest starkly different outcomes from temperature conditions expected by 2100 under different climate change scenarios. Under temperatures associated with low-emission scenarios determined by the Intergovernmental Panel on Climate Change (1.5 degrees Celsius above pre-industrial levels), most of the plant species studied will survive.

But under emission scenarios that are moderately high (3.2 degrees Celsius above preindustrial levels), 5% to 36% of the study species may go extinct from all mountains in the region and 10% to 55% of species will disappear from the mountain on which they were studied.

"It is a little alarming just how close to a threshold or tipping point we are for these tropical species," Sax said, noting that Earth's surface temperature has already increased 1 degree Celsius since the pre-industrial era.

"On the one hand, this gives us hope if we really can dramatically slow climate change, but on the other hand it shows just how little additional warming is needed to lead to the massive extinction events that we have feared might occur."

Sax added that with a moderate amount of warming, a third of all epiphytes could be lost by the end of the century, which could have far-reaching and unpredictable downstream effects on the ecosystem, and ultimately, the surrounding populations and economy.

Hollenbeck, who lives in Costa Rica teaching science, running research fellowships and designing curricula for Avenues the World School, said the epiphytes in the tropical forest are like the canaries in a coal mine.

"Getting this level of concrete data involved a stupefying amount of fieldwork over a long time and applies to about 70 species of plants," she said. "But this research just scratches the surface in terms of how climate change is affecting different species."

More information: Emily C. Hollenbeck et al, Experimental evidence of climate change extinction risk in Neotropical montane epiphytes, *Nature Communications* (2024). DOI: 10.1038/s41467-024-49181-5

Provided by Brown University

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