How to save plants from climate change. The answers may be the language of their tissues and physiology

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Redwoods and oaks that thrive on California's coastline and coastal mountains might soon start finding it harder to survive. Human-caused climate change is altering the temperatures and rainfall patterns to which those and other trees are accustomed, and many have already been pushed close to the edge of what they can endure.

Identifying suitable new habitats will soon become a matter of life or death for some California native species, according to Lawren Sack, a UCLA professor of ecology and evolutionary biology. But if those trees could talk, where would they tell scientists they wanted to live?

In a new study, a team led by Sack and other UCLA biologists deciphered a secret language in leaves and woody stems that points to the species' optimal habitats. Scientists could use that information to better identify new locations where they could establish new populations of plants and to develop better protections for their existing habitats.

Surprisingly, scientists and conservationists don't yet have a reliable way to determine the optimal environment for any given plant species; they tend to base their judgments primarily on the locations where plant species currently grow. But for many plants, their current habitats aren't ideal.

California, for example, has a wealth of species unique to certain climate niches and found nowhere else in the world. But agriculture, industry and urban growth have pushed many of them to the edges of their habitats, and climate change has only exacerbated the problem. So while it might seem logical to move species to habitats like those where they're currently located or to only protect their current habitats, either approach could imperil the species' future survival.

The new research, published in *Functional Ecology*, describes a statistical model that estimates each species' preferred temperature and amount of rainfall based on its height; the size, wilting point, anatomy and chemical composition of its leaves; and the density of its wood.

Then, using that data, the scientists created a statistical model that predicts what temperatures and rainfall amounts each species preferred—not merely not what it could tolerate. The model also enables the scientists to estimate how mismatched a plant is from its native climate.

"Plant species can directly reveal to us their climate preference and their vulnerability to potential climate change in the 'language' of their leaves and wood," said Sack, the paper's senior author. "Now that we know this, if you give us a leaf and a piece of wood, we can give a good scientific prediction of where the plant prefers to live.

"We are tuning in to what the plants are telling us about their preferences, in the language of their tissues and physiology, aiming to help them survive escalating climate challenges."

Sack, working with UCLA postdoctoral scholar Camila Medeiros and an international team analyzed 10 distinct leaf and wood traits from more than 100 species in a range of environments mostly within the University of California Natural Reserve System. The ecosystem types the scientists analyzed—desert, coastal sage scrub, chaparral, montane wet forest, mixed riparian woodland and mixed conifer broadleaf forest—cover about 70% of California's land area.

"The correspondence of leaf and wood traits with species' climates is striking," said Medeiros, the paper's first author. For example, species native to warmer, drier climates tend to be shorter in stature, with thicker and denser leaves and lower wilting points—traits that enable them to continue photosynthesis when water is scarce and to grow faster when water is more readily available.

"The reflection of species' preferred climate in their wood and leaves evidently arose from millennia of evolution that matched plant physiology to climate across California," Medeiros said.

"We also found that many plants in the ecosystems we sampled were occupying locations that differed in climate from what we estimated to be their optimal niche. As climate change ensues, we think this will tend to aggravate the sensitivity of many species, including common trees like the California buckeye and shrubs like the purple sage and California lilacs."

Scientists have long been divided over whether plants' functional traits could be used to accurately predict their climate preferences. And until now, no test combined all of the available state-of-the art measurement technologies—for example, vapor-pressure osmometry to determine plants' wilting points—with advanced statistical modeling.

"Some previous studies analyzed individual approaches one by one, but our study was new in simultaneously applying all of them, and this gave us unprecedented predictive power," Medeiros said.

Medeiros also said the approach could be used to help prioritize which threatened species are most in need of conservation.

More information: Camila D. Medeiros et al, Predicting plant species climate niches on the basis of mechanistic traits, *Functional Ecology* (2023). DOI: 10.1111/1365-2435.14422

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