Study links tree genetics to biodiversity patterns

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A cottonwood grove nestled along a river near the Grand Canyon. Areas such as this are important to wildlife in the Southwest, but demands from development and water consumption, along with stress from climate change, threaten this habitat. A new study offers a model for reforestation efforts in these areas, though, which could make cottonwood groves more resistant to stress in years to come. Credit: Helen Bothwell

It's easy to think of trees as part of the landscape. But what if the trees

were the landscape?

That's what a new study by a researcher at the University of Georgia asks us to imagine. By considering each tree as a world that hosts its own populations of insects and fungi—and looking at the genetic variation that supports these communities—we can better understand the role trees play in the larger ecosystem.

But then the study took the concept a step further, widening the lens to investigate the influence of tree genetics on communities across a large swath of the North American southwest. It's the first time researchers have linked tree genetic variation to community biodiversity at the continental scale.

"Understanding this relationship between tree genotypes and the organisms they support offers a more comprehensive roadmap for reforestation efforts that also support healthy ecosystems," said Helen Bothwell, an assistant professor at the UGA Warnell School of Forestry and Natural Resources and lead author on the study.

"Diversity begets diversity. We know that different communities assemble on different tree genotypes, and we can now show that this relationship scales up to influence the maintenance of biodiversity even at very broad scales. Planting diverse reforestation stock is critically important for conserving the wealth of pollinators and predators that in turn contribute valuable services to our agricultural systems and serve as a food source for bird and wildlife populations."

Study focused on cottonwoods

Bothwell and her collaborators collected hundreds of samples from trees across more than 50 sites from California, Nevada, Utah, Arizona and northern Mexico. They focused on cottonwood trees, a foundation

species of riparian ecosystems in that region.

These river corridors are oases, biodiversity hotspots within the surrounding dry, rocky landscape. But these patches of green are among the most threatened in the United States, with less than 3% of their pre-20th century distribution remaining.

Demands from development, water consumption and stress from climate change also threaten cottonwood habitat. But the insights from the study, published in May in the journal *Forests*, can help inform reforestation efforts and create more resilient cottonwood groves in the future.

Many previous studies have documented strong relationships between tree genotypes and invertebrate and fungal communities on an individual tree scale within common gardens, she said. Common gardens are a valuable tool for studying genetic effects; by growing plants in a common environment, any remaining variation is due to genetic effects.

But now, the researchers wanted to know if insects and fungi could still detect this variation beyond the neat confines of the garden, where the messiness of nature takes over.

"We wanted to see how these communities of bugs and fungi relate to really broad, continental-scale species management. For example, do communities still respond to differences among whole populations of trees? Different watersheds? Or even broad geographic regions, like at the scale of the whole North American southwest?" said Bothwell.

After collecting tree, insect and fungal samples, the researchers began to see patterns emerge—for example, certain trees' characteristics corresponded with certain insect or fungal populations.

"And so, we correlated the patterns in genetics with the patterns in the

community members; these relationships were very strong at the local scale, but as we scaled up, environmental variation was having a larger effect," she said.

Trees' impact on regional biodiversity

But despite increasing environmental noise, she was still able to detect the influence of tree genetics on communities at very broad scales, across the whole of the southwestern United States and Mexico. This was surprising, she said, and highlights the importance of considering the influence of trees when aiming to conserve regional biodiversity.

This knowledge can affect future reforestation and conservation efforts in these disappearing cottonwood ecosystems, she added. Rather than collecting seeds only from nearby forests, land managers can look to nearby regions to bolster tree genetics.

"With climate change, there's a recognition that local may no longer be best—trees may now be 'locally maladapted' to where they established 50 or 100 years ago," said Bothwell. "So, if you're going to plant for future climate change, one option is to take a stepping-stone approach by collecting seeds both locally and from nearby regions with, for example, temperatures more similar to those predicted by climate models 50 years from now. By taking a mixed approach, you're maintaining local genetic variation while also including trees that may be better able to withstand future climate pressures."

Losing a tree like the cottonwood would be devastating to the southwestern landscape, Bothwell added, because of the wealth of associated understory plants, fungi, insects and wildlife they support. By better understanding the forces affecting the trees, land managers can also better conserve the plants and animals that live around them.

The communities that use trees as habitat are paying attention to the variation they harbor. In short, Bothwell said, planting diverse trees supports diverse communities.

"It's a powerful conservation model; you can think of it as an umbrella," she added. "If you understand the forest systems and we work to conserve that, we can also provide conservation benefits to whole communities of organisms that we don't have the time or resources to focus on individually. You get more conservation bang for your buck by focusing on conservation genetic management of foundation species—those species that have a large influence on their ecosystems, like trees."

More information: Helen M. Bothwell et al, Microevolutionary Processes in a Foundation Tree Inform Macrosystem Patterns of Community Biodiversity and Structure, *Forests* (2023). DOI: 10.3390/f14050943

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