Just what is a 'resilient' forest, anyway?

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What does a "resilient" forest look like in California's Sierra Nevada? A lot fewer trees than we're used to, according to a study of frequent-fire forests from the University of California, Davis.

More than a century ago, Sierra Nevada forests faced almost no

competition from neighboring trees for resources. The tree densities of the late 1900s would astonish most Californians today. Because of fire suppression, trees in current forests live alongside six to seven times as many trees as their ancestors did—competing for less water amid drier and hotter conditions.

The study, published in the journal *Forest Ecology and Management*, suggests that low-density stands that largely eliminate tree competition are key to creating forests resilient to the multiple stressors of severe wildfire, drought, bark beetles and climate change.

This approach would be a significant departure from current management strategies, which use competition among trees to direct forest development.

Defining 'resilience'

But first, the study asks: Just what does "resilience" even mean? Increasingly appearing in management plans, the term has been vague and difficult to quantify. The authors developed this working definition: "Resilience is a measure of the forest's adaptability to a range of stresses and reflects the functional integrity of the ecosystem."

They also found that a common forestry tool—the Stand Density Index, or SDI—is effective for assessing a forest's resilience.

"Resilient forests respond to a range of stressors, not just one," said lead author Malcolm North, an affiliate professor of forest ecology with the UC Davis Department of Plant Sciences and a research ecologist with the U.S. Forest Service, Pacific Southwest Research Station. "'Resistance' is about surviving a particular stress, like fire—but there's a lot more going on in these forests, particularly with the strain of climate change."

Competitive nature

For fire-adapted forests in the Sierra, managing for resilience requires drastically reducing densities—as much as 80% of trees, in some cases.

"Treatments for restoring resilience in today's forests will need to be much more intensive then the current focus on fuels reduction," said Scott Stephens of UC Berkeley, a co-author on the paper.

The study compared large-scale historical and contemporary datasets and forest conditions in the southern and central Sierra Nevada, from Sequoia National Forest to the Stanislaus National Forest. It found that between 1911 and 2011, tree densities increased six- to seven-fold while average tree size was reduced by half.

A century ago, both stand densities and competition were low. More than three-quarters of forest stands had low or no competition to slow a tree's growth and reduce its vigor. In contrast, nearly all—82%-95%—of modern frequent-fire forests are considered in "full competition."

The study indicates that forests with very low tree densities can be more resilient to compounded threats of fire, drought and other climate stressors while maintaining healthy water quality, wildlife habitat and other natural benefits. Forests burned by high-severity fires or killed by drought lose such ecosystem services.

Wake-up call

The authors say the 2012-2016 drought, in which nearly 150 million trees died from drought-induced bark beetle infestations, served as a wake-up call to the forestry community that different approaches are required to help forests confront multiple threats, not only severe

wildfires.

A shift away from managing for competitive forests and toward eliminating competition could allow the few to thrive and be more resilient.

"People have grown accustomed to the high-density forest we live in," North said. "Most people would be surprised to see what these forests once looked like when frequent surface fires kept them at very low densities. But taking out smaller trees and leaving trees able to get through fire and drought leaves a pretty impressive forest. It does mean creating very open conditions with little inter-tree competition. But there's a lot of historical data that supports this."

"We think resilient forests can be created, but it requires drastically reducing tree density until there's little to no competition," said Brandon Collins of UC Berkeley, another co-author on the paper. "Doing this will allow these forests to adapt to future climate."

Additional co-authors include Ryan Tompkins of UC Cooperative Extension, and Alexis Bernal and Robert York of UC Berkeley.

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