Forest margins may be more resilient to climate change than previously thought

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Dry forest margins in the western United States may be more resilient to climate change than previously thought if managed appropriately, according to Penn State researchers. The researchers studied forest regeneration at four sites that had experienced wildfires in the eastern Sierra Nevada Mountains in California. The sites sit at the forest margin, a drier area where forest meets sagebrush grassland and which may be the most vulnerable to climate change-driven forest loss. Credit: Lucas Harris / Penn State

A warming climate and more frequent wildfires do not necessarily mean the western United States will see the forest loss that many scientists expect. Dry forest margins may be more resilient to climate change than previously thought if managed appropriately, according to Penn State researchers.

"The basic narrative is it's just a matter of time before we lose these dry, low elevation forests," said Lucas Harris, a postdoctoral scholar who worked on the project as part of his doctoral dissertation. "There's increasing evidence that once disturbances like drought or wildfire remove the canopy and shrub cover in these dry forests, the trees have trouble coming back. On the other hand, there's growing evidence that there's a lot of spatial variability in how resilient these forests are to disturbances and climate change."

The researchers studied forest regeneration at four sites that had experienced wildfires in the eastern Sierra Nevada Mountains in California. The sites sit at the forest margin, a drier area where forest meets sagebrush grassland. These dry forest margins may be the most vulnerable to climate change-driven forest loss, according to the researchers.

Large fires in the area tend to consume the forest starting from the steppe margin then sweeping up the mountain, said Alan Taylor, professor of geography and ecology who has worked in the area for decades.

"You wouldn't see forest anymore over 10 or 20 years, and it seemed like the lower forest margin was getting pushed way up in elevation because it's so dry near the sagebrush boundary," Taylor said. "My research group wanted to look at this in detail because no one had actually done it."

Harris and Taylor's research team measured tree diameters and litter depth, counted the number of seedlings and saplings and identified tree species at the research sites. They also quantified fire severity, the amount of moisture available for plant growth and water deficit, an indicator of drought intensity. They then fed the data into five models to see how the probability for tree regeneration varied based on fire severity, climate and location, and remaining vegetation and canopy cover. They report their results today (Sept. 21) in *Ecosphere*.

The researchers found that 50% of the plots at the sites showed signs of tree regeneration, and water balance projections through the end of the current century indicate that there will be enough moisture available to support tree seedlings. The key is to prevent severe fire disturbances through proper management, according to the researchers, because tree regeneration was strongly associated with mature trees that survived fires.

Researchers conducted fieldwork in the eastern Sierra Nevada Mountains in 2017. They measured tree diameters and litter depth, counted the number of seedlings and saplings and identified tree species at the research sites. Credit: Lucas Harris / Penn State

"In these marginal or dry forest areas, management approaches like prescribed burning or fuel treatments that thin the forest can prevent the severe fires that would push this ecosystem to a non-forest condition," said Taylor, who also holds an appointment in the Earth and Environmental Systems Institute. "The study suggests that these low-severity disturbances could actually create very resilient conditions in places where most people have been suggesting that we'll see forest loss."

The researchers also noticed a shift in tree composition from fire-resistant yellow pines to less fire-resistant but more drought-resistant species like pinyon pine. They attributed the shift to drying and fire exclusion policies in effect over the last century.

"The shift could be beneficial if the species moving in is better suited to present and near-future climates," said Harris. "However, it could be dangerous if a bunch of fire-sensitive species move into a place and then it all burns up. Many trees would die, and we could see lasting forest loss."

California's climate is projected to warm, but many climate models also forecast an average increase in winter precipitation, especially in the northern part of the state and in the mountains, continued Harris.

"On the one hand, you have greater drought intensity for sure, but also you're going to have these wetter periods where there's more moisture

available for tree growth in the spring and maybe into the early summer," he said. "So if the trees are able to survive that drought stress and take advantage of the additional moisture present in some years, they might be able to maintain or even expand their distribution."

This forest system is important for recreation, carbon storage, biodiversity and wildlife habitat, said Taylor. It also comprises part of the western side of the Great Basin, the largest area of contiguous watersheds that do not empty into an ocean in North America.

"There's not much forest in the Great Basin, which is a huge area of sagebrush grassland in Utah, Idaho, Oregon, Nevada and Arizona," Taylor said. "So the forests of the eastern Sierra Nevada Mountains represent a significant component of the forest found in that system."

More information: Lucas B. Harris et al. Rain-shadow forest margins resilient to low-severity fire and climate change but not high-severity fire, *Ecosphere* (2020). DOI: 10.1002/ecs2.3258

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