Douglas-fir in Klamath Mountains are in 'decline spiral,' research shows

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Dead Douglas-fir trees in southwestern Oregon's Klamath Mountains. Credit: Chris Adlam, Oregon State University Extension Service

Increases in mortality among Douglas-fir in the Klamath Mountains are the result of multiple factors that have the iconic tree in a "decline

spiral" in parts of the region, a new study by the Oregon State University College of Forestry and OSU Extension Service indicates.

Findings, which include a tool landowners and managers can use to assess a stand of trees' risk as the climate continues to change, were published in the Journal of Forestry.

Douglas-fir, Oregon's official state tree, is the most abundant tree species in the Klamath Mountains, growing among ponderosa pine, sugar pine, white fir, incense cedar, Oregon white oak, California black oak and Pacific madrone.

Dead Douglas-fir that are standing, as well as recently fallen Douglas-fir, can increase the potential for hotter, more extreme wildfires, the researchers note.

So far, Douglas-fir in the region have been most likely to die at low to moderate elevations on the fringes of the Applegate, Rogue and Umpqua valleys, areas that receive less than 40 inches of precipitation annually, they added.

"Douglas-fir mortality in southwestern Oregon occurs during and after drought on hot, dry, harsh sites that no longer provide enough water for the trees," said OSU's Max Bennett, who led the study. "It's not just a lack of rainfall from years of drought; elevated summer temperatures and atmospheric aridity are also contributing to increased stress in trees, and stressed trees are more susceptible to insect and fungi infestation."

Douglas-fir trees provide vital wildlife habitat, sequester and store carbon and serve as a keystone species. A versatile timber tree, it is a source of softwood products including boards, railroad ties, plywood veneer and wood fiber. Oregon leads all U.S. states in softwood production and most of that is Douglas-fir.

Native Americans traditionally used the wood of Douglas-fir for fuel and for tools, its sap as a sealant and many parts of the tree for medicinal purposes.

Historically, cultural burning likely reduced the amount of Douglas-fir in the areas currently experiencing mortality, Bennett said, adding that fire suppression over the past century has allowed for significant expansion of Douglas-fir.

Since 2015, southwestern Oregon has regularly experienced periods of below-average precipitation coupled with above-average temperatures and lower-than-usual humidity, particularly in the trees' growing season, the researchers say, and this has coincided with a major uptick in Douglas-fir mortality.

The paper notes that between 1975 and 2019, an estimated nearly half-million trees were killed by the flatheaded fir borer, and more trees died from 2015 to 2019 than had done so in the previous four decades.

"Our results are consistent with recent OSU research showing the sensitivity of Douglas-fir to higher atmospheric aridity, or vapor pressure deficit," Bennett said. "Douglas-fir can't handle the strain of hot, dry air as well as other species like oak."

Bennett, OSU colleague Dave Shaw and Laura Lowrey of the USDA Forest Service identified hotspots of Douglas-fir mortality via data from the long-running Aerial Detection Survey, a partnership of the Forest Service and the Oregon Department of Forestry.

They collected field data from a series of plots and also factored in climate information from OSU's PRISM Climate Group, as well as data and projections for climate water deficit, a measure of moisture stress faced by trees.

The scientists' analyses suggest Douglas-fir mortality in the Klamath Mountains arises from multiple causative agents working in concert to produce a decline spiral, rather than because of a single, specific reason as is often thought to be the case when trees die.

However, flatheaded fir borers were the predominant, final killer of trees, they said. Populations of the insect appear to be rising, and also its aggressiveness in killing large Douglas-fir with diameters of 12 inches or greater, the researchers believe.

"A key factor in our study area was an overabundance of Douglas-fir trees growing on sites that are now too dry to provide water for all of the growing trees," Bennett said. "Stressed trees stop growing and defending themselves from pests as well as they otherwise would."

Projections of future climate water deficit suggest that areas of Douglas-fir mortality will increase substantially over the next three decades, the authors say, with each hot drought year leading to more mortality.

The researchers have developed a susceptibility and mortality risk measuring tool that combines numerous environmental variables. Landowners and managers can use the tool to predict a stand's chance of infestation by flatheaded fir borers, other insects and fungi and the likelihood and intensity of mortality events.

"In southwestern Oregon, forest management that steers toward oaks, pines and other more drought-tolerant species may be warranted in places with less than about 40 inches of average precipitation a year," Bennett said. "But some individual trees and patches of Douglas-fir will likely persist on these dry sites at least for a time, so it's important not to use an all or nothing approach."

More information: Max Bennett et al, Recent Douglas-fir Mortality in

the Klamath Mountains Ecoregion of Oregon: Evidence for a Decline Spiral, *Journal of Forestry* (2023). DOI: 10.1093/jofore/fvad007