USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

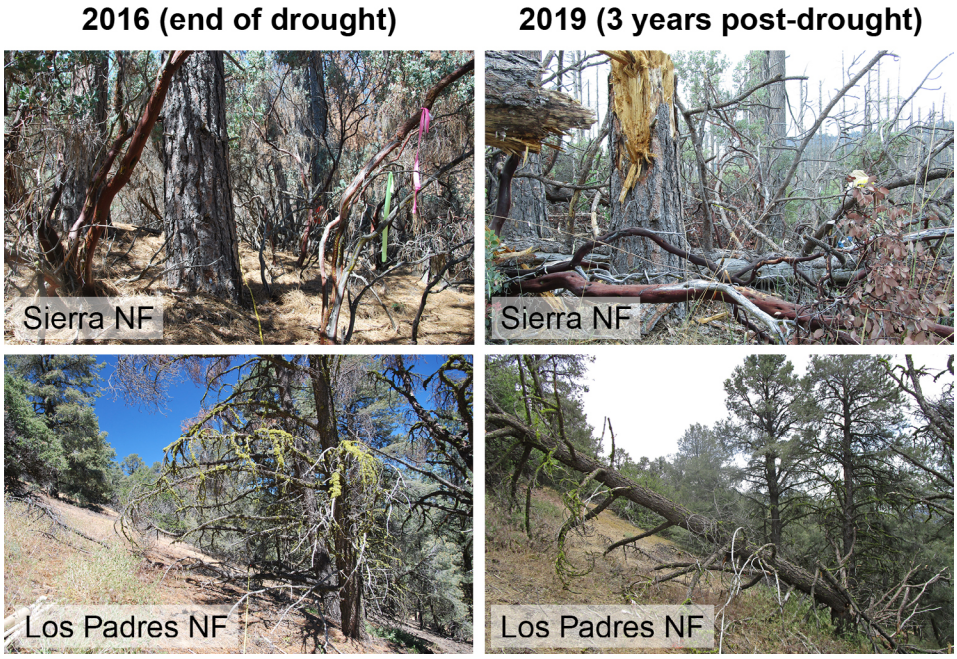
Rocky Mountain Research Station
Science You Can Use *(in 5 minutes)*
SEPTEMBER 2024

Trees Dying, Dangers Rising: Major tree mortality events rapidly increase forest fuels and snag hazards

An extreme multi-year drought with extensive bark beetle outbreaks in California from 2012 to 2016 killed an estimated 147 million trees. This included ponderosa pine, incense cedar, white fir, and pinyon pine, rapidly changing forests over vast areas. Recently published work by Rocky Mountain Research Station (RMRS) researchers Sharon Hood and Charlotte Reed found that major tree mortality events like these increase surface and canopy fuels—dead needles, branches, and logs—which may result in more extreme forest fires and increased emissions when these areas burn. Drought often triggers bark beetle outbreaks in forests, where low moisture can stress trees and make it easier for beetles to kill them.

The science team followed changes over 4 years at sites on the Sierra National Forest and Los Padres National Forest. They recorded tree characteristics and then tracked mortality, how long the dead trees remained standing, and how fuels changed. The researchers were primarily interested in the ways in which drought, bark beetle outbreaks, and existing conditions affected surface and canopy fuel loading, and what impact this might have on fire hazard and emissions.

When trees die from bark beetle attacks, they retain dry, flammable needles in their crowns (*canopy fuel*). Reed and Hood found that in both Sierra mixed-conifer and southern California pinyon pine forests, these needles generally fell quickly (within 4 years) after trees died. Over a similar time period, falling trees and their branches led to a surprisingly quick buildup of surface fuels. This accumulation of coarse, woody fuels is particularly problematic in forests where decades of fire suppression have increased forest density. High canopy fuel flammability may only last a few years after a big



Examples of changes in fuels over 3 years of sampling at sites with high (80-100 percent) tree mortality. Sites within two National Forests were sampled illustrating the differences in fuel build up from a mortality event across different forest types. Photos were taken from the same point in 2016, at the end of the drought period, and in 2019, 3 years postdrought.

tree mortality event, but surface fuels can continue to increase considerably as the dead trees decompose and fall to the ground. Long-term, these large mortality events can change fuels over thousands of square miles and may lead to unpredictable fire behavior. Of particular concern is the amount of smoke that may be generated during fires as the fallen trees ignite and smolder.

"We expected fuels to change quickly in areas of high mortality, but we were surprised with just how quickly the dead trees, especially pines, started falling," says Hood. Lots of standing dead trees (snags) create unsafe conditions and could limit how firefighters respond to fires that start in these areas. Hood further explains: "Fire behavior models weren't developed to predict burning conditions like those that occurred during this extreme drought. There is uncertainty about how intense fires will be and how quickly they can spread when there are huge swaths of dead trees, but our models predict that all those fallen trees will create more smoke and high emissions during a fire." The team found that $PM_{2.5}$ emissions, the tiny particles in smoke that are the biggest human health concern, were predicted to be higher in wildfires that occur on the Sierra National Forest affected by the drought and bark beetle outbreaks.

The study revealed that in areas with high levels of tree mortality, forest structure and fuels are changing quickly and may not be reflected in data layers used for planning and fire management. Fire behavior models also may not accurately predict fire behavior in areas with large areas of tree mortality. "Hopefully, this research heightens awareness about how quickly our forests can change under extreme mortality events and the potential long-lasting hazards that are created," says Hood.

KEY MANAGEMENT CONSIDERATIONS

- After drought-caused large tree mortality events in California, red needles in the crowns of bark beetle-killed trees quickly drop to the forest floor—with less than half of the needles remaining 2 years after tree death.
- Snags, especially pine snags, begin falling in the first 5 years of death, creating highly unsafe conditions for firefighters, forest managers, and the public.
- Current models may not accurately predict fire behavior in areas with high levels of tree mortality. Therefore, extreme caution is needed if wildfires occur in these areas because of high uncertainty in burning conditions.
- As snags fall and increase coarse surface fuels, fires may produce more smoke with higher emissions of $PM_{2.5}$ because of long-term smoldering.

FURTHER READING

Reed, C.C.; Hood, S.M.; Cluck, D.R.; Smith, S.L. 2023. Fuels change quickly after California drought and bark beetle outbreaks with implications for potential fire behavior and emissions. Fire Ecology. 19:16.

LEAD SCIENTIST

Sharon M. Hood is a Research Ecologist with the Fire, Fuel, and Smoke Science Program at Rocky Mountain Research Station. The primary focus of her research is on how fire affects trees and forest dynamics.

Charlotte Reed is an Ecologist with the Fire, Fuel, and Smoke Science Program at Rocky Mountain Research Station. She is currently involved in projects related to fire effects on postfire tree growth and resilience to drought.

Adrienne Bernhard is the author of this Science You Can Use in 5 minutes.