Study Reveals the Big Climate Impact of the Way Drought Kills Trees

*By Jane Braxton Little, for **Water Deeply*** *Published Aug. 25, 2017*

New research into how drought kills trees has helped reveal a potentially huge climate consequence of an increase in dead and dying forests that one scientist cautioned could result in a "carbon death spiral."

Dead and dying trees are seen in a forest stressed by historic drought conditions in Los Padres National Forest on May 7, 2015, near Frazier Park, California. David McNew/Getty Images/AFP

THAT DEAD TREE in your back yard? You could say drought killed it.

Or you could say it died from hydraulic failure through partial or complete loss of xylem function from embolism that inhibits water transport through the vasculature, leading to tissue desiccation.

What that means – and why it matters to California and the rest of the world – are part of a new study published in the journal Nature Ecology and Evolution.

"I'm not trying to scare people about climate change but paint a picture with consequences," said Henry Adams, the study's lead author and an assistant professor in the department of plant biology, ecology and evolution at Oklahoma State University.

With drought “popping up around the globe,” it’s important to understand how it kills trees, Adams told me. The ability to predict which forests are most vulnerable allows managers to focus attention on them before drought flips their role from storing carbon to emitting it.

“If we understand the mechanisms of how trees die, we can make predictions and prioritize areas for management,” he said.

First we need to understand how healthy trees function. They get water from the soil, pulling it up through their roots through xylem, one of two specialized transportation tissues in vascular plants. The water flows into tree trunks and branches to leaves or needles. Sunlight turns the nutrients in water to sugar and sap, which nourish new growth.

When there is less water in the soil, trees pull harder. When they pull too hard they break the column of water in the xylem, creating air bubbles known as embolisms. This causes “hydraulic failure.” And this is what killed all of the trees studied by the research team of 62 scientists, said Adams.

But another process also causes trees to die when their response to drought deprives them of carbon.

“Trees aren’t stupid,” Adams said. To prevent losing precious water to the atmosphere through their needles and leaves, trees close the pores scientists call stomata. That keeps the water in the tree, but stomata do more than prevent water loss. They also let carbon dioxide in, allowing trees to carry out photosynthesis.

Dead trees are seen against a barren landscape in the Tejon Pass between the San Joaquin Valley to the north and Los Angeles to the south, in Lebec, California, January 22, 2014. (AFP/ROBYN BECK)

When trees close their stomata to wait out a drought, they are no longer making any food through photosynthesis. Instead, they are relying on stored sugars and starches. If the drought lasts long enough, they use up everything they have stored, and they die.

Carbon starvation contributed to tree mortality in at least 60 percent of the cases the researchers studied. They still don't understand the critical threshold for carbon starvation but know it plays a significant role in trees dying.

Scientists also know bark beetles contribute to tree mortality. That sticky resinous sap used to pitch out beetles is made from carbon. When trees become carbon-starved they are not only unable to metabolize the nutrients for survival; they are also unable to muster the carbon they need to defend themselves against beetles.

The connection between physiological stress caused by drought and defending against bark beetle attack is still an active area of research, Adams said. Entomologists have tended to approach tree mortality in the West through beetles, while physiologists have come at it from the drought perspective.

"We know that both matter," Adams said.

He and his colleagues analyzed drought-induced mortality in 26 tree species. They examined data from 19 recent experimental and observational studies from around the globe. The research will help scientists and land managers more accurately predict how trees will respond to environmental stresses that include insect damage and disease as well as drought, said Lina Patino, a section head at the National Science Foundation's Division of Earth Sciences, which cofunded the study.

That could be critical to California, where 102 million trees have already died in an epidemic officials are blaming on a combination of poor forest management, fire suppression and climate change. Most of the dead trees are in the southern Sierra Nevada and cover an area larger than the state of Massachusetts. As land managers scramble to respond, understanding the role drought is playing could help determine how and where to focus their attention, said Adams.

California may be among the largest epicenters of current tree die-off but is unlikely to be the last. Drought events are increasing globally. A separate study reported in the journal Nature found the impacts of drought have increased over the 20th century. If they become more frequent and severe, as the researchers predict, the time between droughts may become shorter than the time it takes to recover.

Led by Christopher R. Schwalm, a scientist at the Woods Hole Research Center, the study found the area worldwide recovering from drought per decade has increased since 1901 from around 135,000 square miles to nearly 450,000 square miles, an area larger than Texas and California

combined. In addition, the time it takes to recover has grown from as few as 15 months in the first decade of the last century to as many as 58 months between 2001 and 2010.

“The trend toward more ‘more extreme extremes’ is already underway,” Schwalm and his fellow researchers concluded.

This could lead to permanently damaged ecosystems. More ominously, it could lead to widespread degradation of the carbon land sink, the worldwide reservoir of soil that stores three times more carbon than vegetation and the atmosphere combined.

The effects of drought on carbon storage are a primary reason for doing the research Adams and his colleagues conducted. How trees respond to drought is important for models used to predict climate change. Plants take up a large portion of the carbon dioxide in the atmosphere. Fewer trees mean more CO2.

“I like trees,” Adams said, “but you don’t have to like them to appreciate what they do for the planet. Trees take a lot of carbon dioxide out of the atmosphere and store it. That’s a tremendous service.”

With all the dead trees in California, it is possible to project this service reversing. Instead of storing carbon, the state’s dead and dying forests could flip this fundamental function. Whether we see a huge rush of CO2into the atmosphere or not, Adams said California’s widespread drought creates the possibility of a carbon death spiral: “A positive feedback loop with negative consequences for humans.”

One management strategy to avoid drought-caused mortality could be thinning, he said. Fewer stems sucking up a limited supply of water might save a forest. California’s forests are denser today than in the past.

The drought research was conducted by scientists representing 14 countries on five continents. Bringing together many scientists with different perspectives contributed to a consensus view. By finding new answers to a basic question – what actually kills a tree in a drought – researchers can now focus on effective solutions, Adams said.