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‘We Need to Hear These Poor Trees Scream’: Unchecked Global Warming Means Big Trouble for Forests

New studies show drought and heat waves will cause massive die-offs, killing most trees alive today.

BY BOB BERWYN, INSIDECLIMATE NEWS

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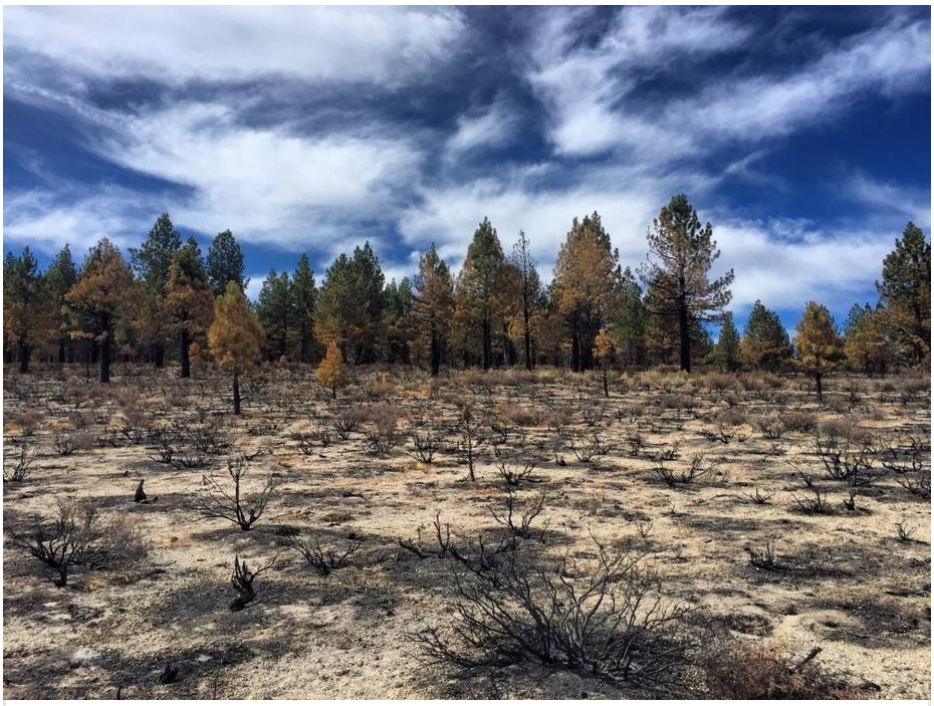


In Eastern California, the U.S. Forest Service is using controlled fires in Jeffrey pine forests to try and make them more resilient to climate change. Credit: Bob Berwyn

Tim Brodribb has been measuring all the different ways global warming kills trees for the past 20 years. With a microphone, he says, you can hear them take their last labored breaths. During blistering heat waves and droughts, air bubbles invade their delicate, watery veins, cracking them open with an audible pop. And special cameras can film the

moment their drying leaves split open in a lightning bolt pattern, disrupting photosynthesis.

"We really need to be able to hear these poor trees scream. These are living things that are suffering. We need to listen to them," said Brodribb, a plant physiologist at the University of Tasmania who led a recent study that helps identify exactly when, where and how trees succumb to heat and dryness.

The study, published April 17 in the journal *Science*, reviewed the last 10 years of research on tree mortality, concluding that forests are in big trouble if global warming continues at the present pace. Most trees alive today won't be able to survive in the climate expected in 40 years, Brodribb said. The negative impacts of warming and drying are already outpacing the fertilization benefits of increased carbon dioxide.

Trees and forests can be compared with corals and reefs, he said. Both are slow-growing and long-lived systems that can't easily move or adapt in a short time to rapid warming and both have relatively inflexible damage thresholds. For corals, a global tipping point was reached from 2014 to 2016. In record-warm oceans, reefs around the world bleached and died.

The detailed new information and modeling on how water stress kills trees suggests there is a similar drought threshold for tree mortality, beyond which forests could also perish on a global scale, he said.

"Nobody predicted the coral bleaching scenario. If a similar thing evolves with forests, that is pretty catastrophic," he said. "We're at a point where we can see the process, we can predict it. It's time to start making some noise about it. We can't afford to sit on our hands."

No CO_2 Greening

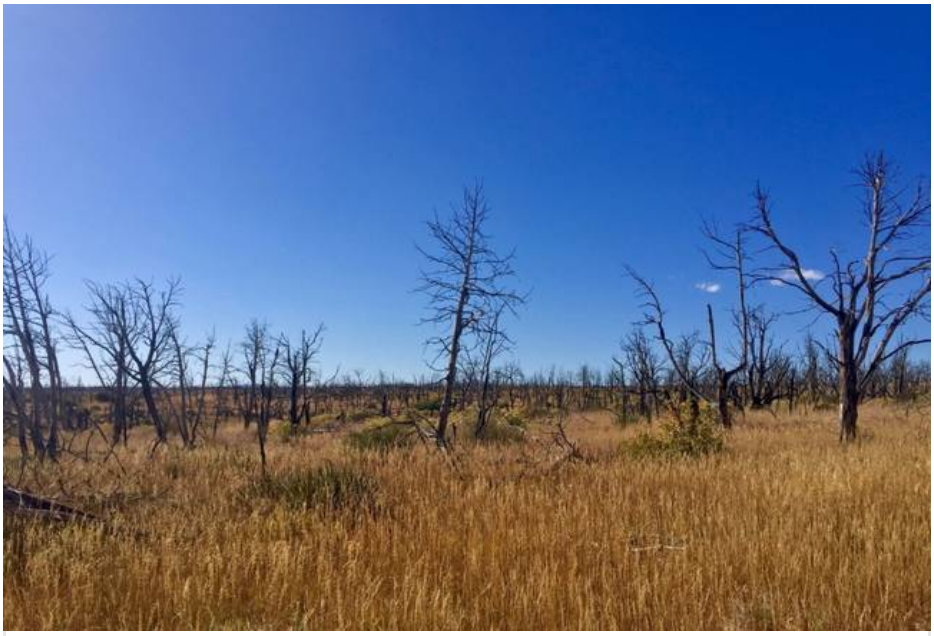
The new paper shows that the hope that rising carbon dioxide would green the planet is probably misplaced. Studies have shown that increased carbon dioxide in the atmosphere boosts photosynthesis, spurring plant growth by chemically combining the carbon with water and ground nutrients.

But there will "probably be more browning than greening," said University of Arizona forest scientist **Dave Breshears**, who was not involved in the new research.

"The review ends on a hard note, with high confidence that we're going to have a lot of impacts with hotter droughts in the future," he said. Mass forest die-offs will proliferate and expand. The trend toward more extreme heat waves and droughts is lethal for forests. But despite the grim outlook, it's important not to paint an entirely desperate picture, he said.

"It's our choice of how much worse we want it to get. Every little bit of reduction of warming can have a positive effect. We can reduce the tree die-off. Are we going to make the choices to try and minimize that?"

Breshears has used tree mortality data to try and make near real-time projections for tree die-offs in the Southwest. This would help adapt forest management, including firefighting, to rapidly changing conditions in a region where an **emerging megadrought** has already weakened and killed hundreds of millions of trees, including Rocky Mountain lodgepole and piñon pines, as well as aspens.



Piñon pines in Colorado's Mesa Verde National Park have been killed by beetles and wildfires and in many areas it's become too warm and dry for new trees to sprout from seed and grow. Credit: Bob Berwyn

Elsewhere, African cedars and acacias are dying, South America's Amazon rainforest is struggling, and junipers are declining in the Middle East. In Spain and Greece, global warming is shriveling oaks, and even in moist, temperate northern Europe, unusual droughts have stressed vast stands of beech forests.

At the current pace of warming, much of the world will be inhospitable to forests as we know them within decades. The extinction of some tree species by direct or indirect

action of drought and high temperatures is certain. And some recent research suggests that, in 40 years, none of the trees alive today will be able to survive the projected climate, Brodribb said.

"That's one of the potential scenarios, and we need to know if that's right. We have to establish the consequences of rising temperatures unequivocally for policy makers," he said.

The stakes are high, since trees are the foundation for terrestrial biodiversity and because they capture and store about one-third of human-caused CO2 emissions within their dense wood frames. A global loss of forests could lead to a surge in heat-trapping carbon dioxide, causing more warming, and would also eliminate habitat for countless other animals, plants and fungi, with a rippling effect that reaches humans.

"The closer people are to the land and living at subsistence level, it's going to hit those people hardest," Breshears said.

Shifting Forests

Forests in warm and semi-arid regions may suffer the most in the decades ahead, but there may also be big changes in store for cooler, wetter regions. Some forests that need a lot of moisture could dry up with just a small decline in precipitation because rapid warming magnifies the loss of moisture from soils.

Even if forests don't die, they will fundamentally change. A recent **study** published in the journal *Global Change Biology* zoomed in on the evergreen forests in the Stubai Valley in Tirol, Austria. At 3.6 degrees Fahrenheit (2 degrees Celsius) of global warming, which will be reached during the last few decades of this century, the dense stands of spruce and fir will change to a mix of oaks and pines, more like forests on the drier southern fringes of the Alps in Italy, the projections showed.

"We found that at warming levels above 2 degrees Celsius a threshold was crossed, with the system tipping into an alternative state," the researchers wrote. Even warming that corresponds with the current policy goals of the Paris climate agreement could "result in critical transitions of forest ecosystems. Overshooting the climate targets could be dangerous, because "ecological impacts can be irreversible at millennial time scales once a tipping point has been crossed."

Forests on a Knife Edge

The new paper reinforces the observational evidence that global warming has pushed many of the world's forests to a knife edge, said University of Utah forest researcher Bill Anderegg. In the West, you can't drive on a mountain highway without seeing how global warming affects forests, from wildfires to die-offs caused by beetles or other pathogens, he said.

In some areas, researchers have documented how forests are struggling to grow back. For example, in parts of the Four Corners region, hardly any new piñon pines have sprouted to replace trees killed by beetles in the early 2000s because it's too warm for seeds to take hold and grow.

And older trees conserve their energy to survive drought and fend off beetles rather than producing seeds. As result, there were almost **no piñon pine nuts to be harvested** last fall on the Navajo Nation, where the nutritious nuts have been part of cultural tradition for centuries.

"The risks of climate change to forests are substantial and going up faster than we thought," Anderegg said. The new physiological models of trees and ecosystems helps pinpoint exactly when and where forests are vulnerable, with the aim of making credible forecasts for forests in this century, giving landowners and policymakers more useful tools, he added.

Accurate new information is also valuable for climate policy, because many national carbon-reduction targets based on the Paris climate agreement include tree planting as a key tool to reduce emissions. But rapid forest change and catastrophic die-offs could put a monkey wrench in those plans. And in addition to the direct tree-killing effects of heat and drought, interactions with other disturbances like insects and other pathogens will magnify forest die-offs, he said.

Restoration and Resilience?

University of Montana forest ecologist **Diana Six** said the conclusions in the new research weren't surprising because she's always been skeptical of the projected beneficial effects of carbon dioxide triggering photosynthesis in plants.

"I was always amazed by the early predictions for enhanced growth of forests, especially in the West," she said. Many of the models only included warmer temperatures or higher CO2 effects. The projections were made mainly by economists who assumed that only temperatures and CO2 affect tree growth, she added.

"No one seemed to consider water. With warmer temperatures and a longer growing season comes greater demand for water and we are getting less, not more, in most cases. That should have been a big red flag," she said.

Six's research focuses on tree-killing bugs, and she said it's clear how global warming and insect devastation fit together. Heat causes drought-weakened trees to release different chemicals from healthy trees, and the bugs "are incredibly good at finding them," she said.

And global warming has weakened a lot of trees in the West.

"Even with average rainfall it's still a drought for trees now much of the time because of increased temperatures. Trees are tough, but they can only take so much. Some of the

forests look like they're fine, but they're not, they are already near thresholds," she said.

Some mature trees can survive conditions that aren't supportive for them anymore. They have deep roots and can hunker down in survival mode for decades in dry conditions, but that doesn't mean conditions exist for new growth. And not all old trees can survive.

"Some recent research shows that a lot of our forests may be genetically maladapted to the changing climate. We're losing big trees faster and regeneration is not keeping up. This is not a sustainable pattern that we're seeing," she said.

But there is also critical information to be gleaned from the trees that aren't killed.

"The trees that survive are very different genetically and chemically, and they also grow very differently. In some cases it's the slower-growing trees that survive," she said. That's important information for forest restoration and resilience planning, she added.

"There are ways we can help our forests adapt, with space, sizing and composition. But eventually, you really have to get at adaptation. You have to get trees on the landscape that can survive in new conditions," she said.

That would include leaving the few trees that survived massive beetle outbreaks, rather than cutting them down during the salvage logging of beetle-killed trees. Often, the loggers are eager to harvest the remaining live trees because they are worth more, but Six said it's exactly those survivors that could help seed a new forest that's more resistant to insects and warming.

The survivors may hold some of the secrets to ensuring that at least some forests will survive human-caused global warming. And they show that there is already some natural adaptation under way. The die-offs are natural selection working on a large scale, and for some trees, that might be enough to trigger an evolutionarily adaptive response, she said. After all, conifers have a huge amount of genetic diversity and have survived drastic climate change on a geological time scale over millions of years.

"Some of the things we are seeing are dreadful and devastating, but there are studies showing trees can adapt quite rapidly on an evolutionary level. But if we keep cranking up the temperature, there is never going to be enough adaptation possible," she said.

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