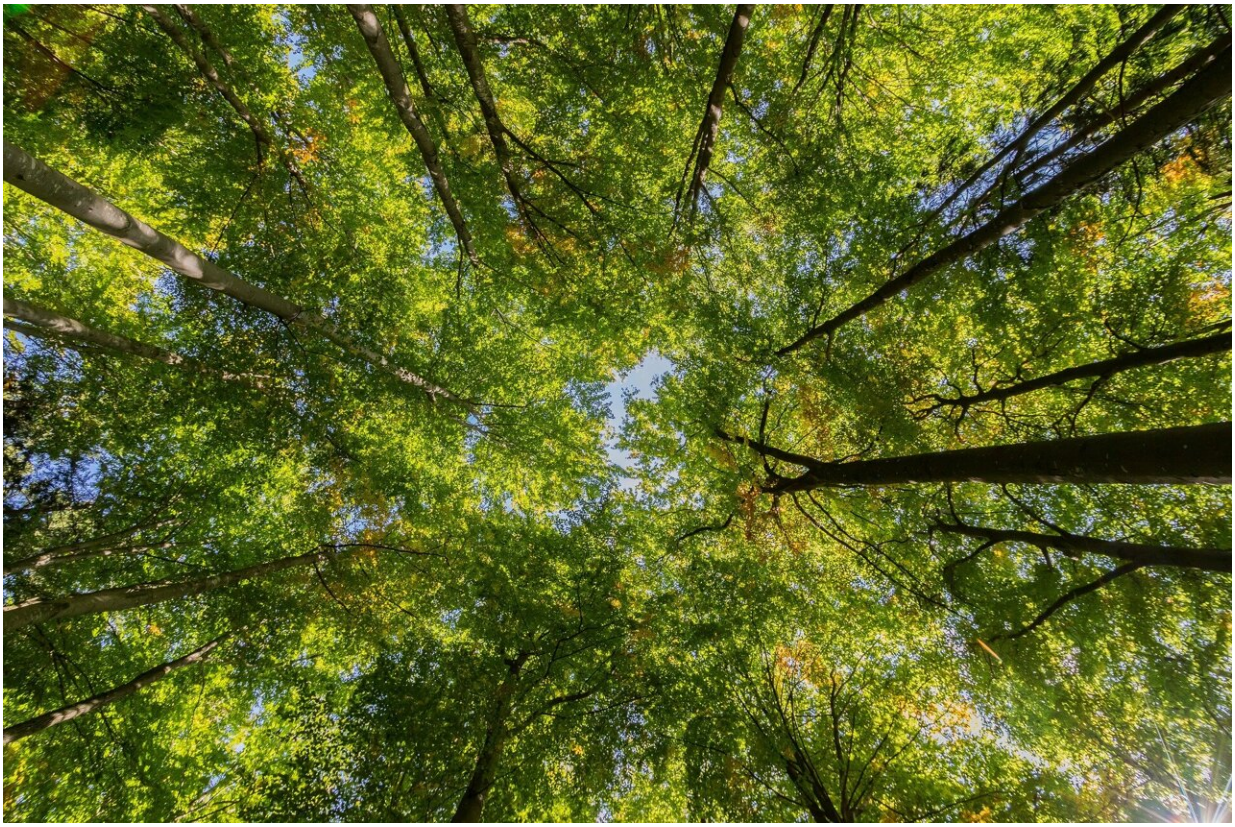
Global warming kills forests by restricting tree transpiration, shows study

March 21 2023, by Sarah Perrin



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UN International Day of Forests on March 21 is the perfect opportunity to showcase some of the important forest research being done at EPFL. For instance, one recent study found that the changes in relative

humidity caused by higher temperatures are having a significant impact on trees.

"The data clearly show that tree mortality is increasing at an exponential rate," says Prof. Charlotte Grossiord, the head of EPFL's Plant Ecology Research Laboratory (PERL). No stranger to forest health, she's studying the mechanisms behind forest ecosystems and how they're responding to climate change. This year, March 21 will mark not only the first day of spring but also the 11th annual UN International Day of Forests—an occasion to shine the spotlight on Grossiord's research. A study she published recently in *Journal of Applied Ecology* shows that the lower relative humidity resulting from higher temperatures is disrupting trees' natural transpiration process, putting many species at risk.

Forests cover some four billion hectares of land, or nearly 31% of the Earth's surface. To underscore the essential role they play and build awareness about the urgent need to protect them, the UN introduced an annual forest day in 2012. This year's theme is "Forests and Health." Forests are a vital food source for around a billion people and countless animals. They serve as a natural barrier to disease transmission between animals and humans, and are home to thousands of plants used as the basis for drug treatments—or that could hold the keys to drug treatments of the future.

What's more, forests are a crucial ally in the fight against climate change. They capture and store over half of the carbon that's emitted worldwide in their soil and vegetation, are a breeding ground for biodiversity, and operate as natural filters in the water cycle.

However, the UN estimates that 10 million hectares—the equivalent of around 14 million soccer fields—of forestland disappear each year due to deforestation, and a further 35 million are destroyed by insects. According to Global Forest Watch, 119 million hectares have burned to

the ground over the past 20 years as fires occur more frequently and with greater intensity. In addition to this lost tree cover, scientists are also worried about forest health.

Making life a struggle

"The direct effects of the more frequent and intense droughts and the lastingly higher temperatures are now easily visible in tree health," says Grossiord. The hotter, dryer climate is making life a struggle for trees, as reflected in their prematurely yellow leaves and dried-out branches, for example—turning them into easy prey for insects (such as the bark beetles common in Europe) and fungi.

Grossiord and her research group are meticulously studying all these phenomena. They've set up a 1.2-hectare site in Valais Canton where they compare the health of trees subject to the full impact of droughts with those that have been watered regularly over the past 20-plus years.

Lately, her research group has been looking specifically at the consequences of changes in relative humidity levels caused by higher temperatures. "This is having an important effect on trees, but until now it hasn't really been studied," says Grossiord. "These changes are causing worrying atmospheric droughts which are directly impacting tree transpiration and temperatures. All that can eventually pose a threat to their survival."

Air at higher temperatures can hold more water vapor, but the recent series of droughts means there's less water in forest ecosystems. As a result, the gap between the amount of vapor that air can contain and the amount it actually does contain—what's called the vapor pressure deficit (VPD)—is increasing. "The rising VPD is bringing us closer to desert-like conditions than to tropical-forest ones, and can explain the swift deterioration in the health of many trees," says Grossiord.

Strength in diversity

Plants protect themselves from heat and drought by closing their stoma, or the pores on leaves that enable gas exchange with the air and, crucially, that allow plants to absorb the CO_2 they need to live. With their stoma closed, trees can neither take in CO_2 effectively nor carry water up to their leaves. They become weakened and eventually die. "We saw a striking example of this during the record heat wave that swept through the western US and Canada in summer 2021," explains Grossiord. "Temperatures reached nearly 50°C and trees turned brown in the space of just a few hours. When it gets too hot, plants stop conducting photosynthesis and perform only respiration, meaning they release CO_2 into the air."

That said, some species are more resistant than others to warm temperatures and can better adapt. Oak trees, for example, hold up well in hotter, drier climates, whereas beech trees—quite common at central-European latitudes—will probably disappear or migrate to the north. "That's why plant diversity and interaction are so important in a forest, and it's another focus area for our research at PERL," says Grossiord. "That's also why single-species crops are so problematic. They're much more likely to be wiped out in the event of extreme weather or a parasite infection, since all the plants respond in the same way."

In light of both the faster aging process—with growing seasons getting shorter and shorter—and the galloping tree mortality rates, forest ecosystems might eventually become unable to play their essential role. We're already seeing signs of this in Switzerland and the rest of Europe, but what about elsewhere in the world? "It's hard to quantify this process on a global scale because in many regions, we don't have enough data or reliable information sources," says Grossiord.

"But we're seeing that forests in general are becoming younger. That's

due partly to industrial forest plantations—like eucalyptus—but also to extreme weather events that tend to kill older, more vulnerable trees first." Unfortunately, older trees are also the ones with the highest carbon-storage capacity.

Assisted migration

So what can we do to protect the world's forests? According to Grossiord, it's simple: we need to halt deforestation, take better care of existing forests, and reduce our carbon emissions, which are the source of the problem. "Even if we plant new trees, we can't expect plants to absorb all the carbon that we'll emit if we continue along the current trajectory," says Grossiord. "Climate change will reduce forests' absorption capacity, and newly planted trees can never replace natural forests, whose complex ecosystems have evolved over hundreds or even thousands of years."

One idea that warrants further study, in her view, is assisted migration. That involves importing species that are more resistant and acclimated to warmer climates. "If the trees that form our existing tree cover disappear within the next 30 years and we don't import new species from southern regions, we could simply end up with no more forests," she says. "But any form of assisted migration should be done in a carefully thought-out manner with an emphasis on diversity."

More information: Christoph Bachofen et al, Stand structure of Central European forests matters more than climate for transpiration sensitivity to VPD, *Journal of Applied Ecology* (2023). DOI: 10.1111/1365-2664.14383

Provided by Ecole Polytechnique Federale de Lausanne

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