

Tree hydraulics and water relations: Why trees die as a result of drought

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When trees die during a period of drought, they die of thirst. Researchers from the University of Basel have demonstrated in a field study that a rapid collapse in the hydraulic system is responsible for tree

death. And they found out that the trees possibly die more rapidly than previously thought.

The heatwave of summer 2018 was an exceptional situation—both for nature and for research. Although admittedly hard on our native woods, it also presented an opportunity for researchers at the University of Basel to closely study the reaction of [trees](#) to this weather phenomenon.

The research group led by Professor Ansgar Kahmen had already set up a research area in the Basel-Landschaft municipality of Hölstein the previous year. Their aim was to study the [tree canopy](#) 30 meters above ground using a crane to determine how [native tree species](#) such as the Norway spruce respond to climate change.

Researching in real-life conditions

Shortly afterwards, the heatwave of summer 2018 descended. "This was a unique opportunity for us," says forest scientist Dr. Matthias Arend, a member of Kahmen's research group and the lead authors of the study. "It was the first time we were able to observe in nature what drought can do to large, old trees."

As part of their study, the researchers studied 10 randomly selected Norway spruces, all more than 100 years old and about 30 meters tall, in order to measure the seasonal fluctuations in the water balance in the canopy.

With its flat root system, the Norway spruce is particularly susceptible to collapse, says Arend: "The tree dies because the hydraulic system that transports the water upwards from the soil collapses."

Death is extremely sudden

Arend emphasizes that the observation that trees suffer during drought is not new. What is much more important, he says, is to understand the processes that lead to this tree death, and this is exactly what the researchers have achieved in the study published in the scientific journal *PNAS*. "This is the only way for us to ensure better modeling processes in future," explains Arend.

The study also made a surprising finding: "The hydraulic system collapses extremely quickly," he says. The researchers assume that this critical point is reached when a large proportion of the roots in the drying soil lose contact with the soil moisture. "Forecasts are very difficult, because it is not a slow, linear process, but one that happens very suddenly, with the system of water uptake and transport failing in the space of just a few days."

The new results diverge from the previous mortality threshold values identified in the lab, which means that the [hydraulic system](#) of a tree collapses much sooner than previously thought. This happens because dehydration does not progress linearly and the tree cannot recover from the hydraulic collapse, and dies as a result.

In search of new tree species

The researchers conclude that the Norway spruce in particular responds more sensitively to drought than previously assumed. "As we can expect extreme periods of drought to become increasingly common in future, we have to think about other tree species that may be able to deal better with the lack of water," says Arend.

He and his team have been able to observe this finding first-hand: in 2018, the Norway spruce suffered most as a result of the [drought](#). It is the most important conifer both in Switzerland and in central Europe. The results of the study are representative of northern Switzerland as a

whole, and can also be applied to other conifer species.

More information: Matthias Arend et al. Rapid hydraulic collapse as cause of drought-induced mortality in conifers, *Proceedings of the National Academy of Sciences* (2021). [DOI: 10.1073/pnas.2025251118](https://doi.org/10.1073/pnas.2025251118)

Provided by University of Basel

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