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Assessing drought-induced mortality of European beech and Scots pine in the Valais, Switzerland

Sabine Rothenbühler[1,2], Lorenz Walthert[3], Matthias Saurer[2], Holger Gärtner[2], Arthur Gessler[2], Andreas Rigling[2], Willy Tinner[1], Karma Tenzin[4], and **Kerstin Treydte**[2]

[1]Institute of Plant Sciences & Oeschger Centre for Climate Change Research, University of Bern, 3013 Bern, Switzerland
[2]Research Unit Forest Dynamics, Swiss Federal Research Institute for Forest, Snow and Landscape Research WSL, 8903 Birmensdorf, Switzerland
[3]Research Unit Forest Soils and Biogeochemistry, Swiss Federal Research Institute for Forest, Snow and Landscape Research WSL, 8903 Birmensdorf, Switzerland
[4]Ugyen Wangchuck Institute for Conservation and Environment, Thimpu, Bhutan

Tree mortality due to climate change and particularly drought is a globally observed issue and has been studied widely. However, the underlying physiological mechanisms are still not fully understood. One approach to assess the drivers of drought-induced mortality is to retrospectively investigate predisposing factors that have led to tree death by utilizing tree rings. Here we combine annual stem growth, and stable carbon and oxygen isotopes ($\delta^{13}C$ and $\delta^{18}O$) in tree rings of recently died and living trees of two species, drought tolerant Pinus sylvestris and drought sensitive Fagus sylvatica, in the Rhone Valley (Valais), the driest part of Switzerland.

Irrespective of specific drought tolerance, growth patterns of now-dead and living trees were significantly different in both species. Now-dead trees showed higher growth rates than living trees, for at least half of their life span. In the last two decades this pattern was reversed and growth of now-dead trees was at a lower level compared to living trees. In this recent time period, $\delta^{18}O$ records of now-dead trees of both species showed a distinct decrease, while no systematic difference was found in the tree-ring $\delta^{13}C$ records of now-dead and living trees. Climate correlation analysis revealed that stem growth of now-dead trees was more sensitive to climate compared to living trees and that the relationship between isotope-derived leaf gas exchange and climate weakened in the late period prior to death.

Our findings suggest that now-dead trees followed a more conservative water-use strategy in their declining phase. Decreasing values and weakened relationships to climate indicate a reduction in stomatal conductance, accompanied by reduced photosynthetic activity, since the ratio of photosynthesis to stomatal conductance remained unchanged. Overall, our results suggest a combination of hydraulic failure and carbon starvation as initiators of tree death at our study sites, probably in different stages of tree life. It is obvious that recent climate conditions already strongly affected the trees, such that in a future environment negative effects will most likely increase.