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Global analysis of deviations in climate sensitivity of tree-growth after extreme drought events

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In the course of climate change, forests around the globe will be exposed to more frequent and more severe extreme drought events. Direct and lagging impacts of drought events on forests, so-called drought legacies, are often estimated from tree-ring derived secondary growth measurements which easily translate into biomass and are available globally. However, secondary growth is a result from multiple internal mechanisms and therefore does not reveal potential impacts on the underlying physiology, such as hydraulic dysfunction, repair mechanisms and altered carbon allocation. Instead, the carbon demand of these impacts translates to less carbon being available for secondary growth which therefore results in temporarily altered relationships between climate and growth.

Here, we advance the concept of drought legacies by additionally quantifying simultaneous “functional legacies” as climate sensitivity deviations (CSD) of secondary growth. We quantified legacies in both growth and climate sensitivity after extreme drought events using linear mixed-effects models on a global-scale, multi-species tree-ring dataset. We further differentiated the responses by clade, site aridity and hydraulic safety margins in order to determine common factors which convey heightened or lessened vulnerability to extreme drought events.

Our results show that while depressed growth was common after droughts across most of the analysed groups, although with varying legacy lengths, post-drought climate sensitivity deviations were more nuanced. The climate sensitivity of growth was decoupled for gymnosperms with small hydraulic safety margin, i.e. those with a more risk-prone hydraulic growth strategy. In comparison, the climate sensitivity of growth tightened for angiosperms growing in arid sites, a response which occurred in conjunction with a post-drought growth overshoot. These responses are consistent with current understanding of impaired hydraulic function and increased carbon allocation towards xylogenesis, respectively. In conclusion, climate sensitivity deviations reveal physiological responses not discernible from growth legacies alone and therefore serves as a promising avenue for a more comprehensive identification of drought impacts on tree growth at large scales.