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K.ROOF II - Re-Watering after 5 Years of Repeated Summer Drought in Mature Beech and Spruce: Assessing Water Uptake and Allocation via Deuterium Labeling

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Every drought period will eventually end and plants will have access to water again. This phase of "re-watering" is a critical point that will either ensure survival or collapse of ecosystems. The drought years 2018 and 2019 have laid bare how vulnerable Central European forest-systems are, even under short-term water scarcity. To understand the effects of repeated summer drought and its release on mature forest stands we investigated the recovery of a mixed forest stand. After 5 years of repeated experimental summer drought on roughly 100 trees (with n = 6 plots) the second phase of the Kranzberg Forest Roof (k.roof) experiment was started, which focuses on the re-watering with Deuterium labeled water (^2H_2O) of the mature stand composed of European beech (Fagus sylvatica (L.)) and Norway spruce (Picea abies (L.)H.Karst.). According to our hypotheses the water household of the more anisohydric beech will recover faster and "stronger" (higher resilience) than the more isohydric spruce, due to the differences in stomatal control (hypothetical hydraulic regulation in beech vs. hormonal (ABA) control in spruce). We simulated a rainfall event to end our experimental drought and labeled the throughfall-exclusion (TE) and control (CO) plots of the k.roof experiment with roughly 13000 L for TE and 2000 L for CO of ^2H_2O enriched water, i.e. δ^2H 1500 and 400 ‰ respectively. We traced the ^2H_2O signal along the soil-plant-atmosphere continuum (SPAC) from the soil through the stems and branches up to the leaves with conventional and real-time techniques (xylem sensors connected to CRDS system). Additionally, we measured leaf water potential and pressure-volume (PV) curves to assess the release of the drought stress. The distribution of the "new" water within the soil happened within a few days and we could not find any differences between the beech, mix or spruce dominated sites. However, the water uptake of the trees was significantly delayed in spruce compared to beech, evident from both the deuterium tracer signal (in stems and leaves) and leaf water potential. However, release of osmotic adjust was not different in the two species. The data allow for estimating the drought resilience of the water household of a mature forest stand after five-years of repeated summer drought and subsequent re-watering. While both species recovered their water household after several months to the same level as the control trees, we found beech to react faster and stronger than spruce.