EGU23-15805, updated on 21 Feb 2024
https://doi.org/10.5194/egusphere-egu23-15805
EGU General Assembly 2023

Drought resilience of a mixed beech-spruce forest - an experimental study linking responses from the rhizosphere to the canopy, from physiology to morphology, and from hours to years

Thorsten Grams
Technical University of Munich, School of Life Sciences, Ecophysiology of Plants, Freising, Germany (grams@tum.de)

This paper addresses the knowledge gaps on what determines tree responses to drought, their recovery, and survival following drought release, integrating physiological and morphological responses from the rhizosphere to the canopy of mature trees. I summarize 10 years of research on an experimentally induced drought and subsequent recovery in a maturing beech-spruce forest in southern Germany. Study objects 70- to 80-year-old trees that are readily accessible via canopy crane and grow in either mono-specific or mixed stands. We studied about 100 trees in 12 plots of roughly 150 m2 each. Tress were exposed to experimentally induced summer drought for five consecutive years by complete throughfall exclusion during the growing season (Kranzberg forest ROOF experiment, kroof.wzw.tum.de).

During the first two drought summers, when both species were not yet acclimated, drought stress intensity peaked with pre-dawn leaf water potentials near -2.0 MPa and concomitant severe declines in physiological (e.g. leaf gas exchange, phloem transport) and morphological (e.g. growth) responses. After overcoming the critical first two years of drought, significant morphological acclimation in the following three years, e.g. by adjustment of leaf area or rooting depths, resulted in relaxation of physiological stress, as evidenced, for example, by increased stomatal conductance and pre-dawn leaf water potential. Reduced water consumption of spruce and thus higher water availability, also for neighboring beech trees, significantly alleviated drought stress in the trees.

After a total of five years of experimentally induced summer drought, drought release was initiated in early summer 2019 by controlled watering. Physiological parameters such as stomatal conductance or xylem sap flow recovered with hours or days after drought release, including resilience of C allocation, e.g. sugar transport along the stems, as an important prerequisite for the recovery of tree functionality and productivity. Restored coupling between canopy and rhizosphere significantly supported spruce root growth, which recovered within a few days. In contrast, other morphological responses (e.g., leaf area recovery) took years to recover. With future increases in the frequency of drought events under ongoing climate change, tree species that recover more quickly will be favored.