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Acclimation of leaf photosynthesis in mature Beech and Spruce during 5 years of repeated summer drought

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Forest ecosystems have been globally experiencing drought events with increasing duration and frequency in the last decades. Under these circumstances, perennial trees must adjust to long-term water-limiting conditions for their survival. However, the acclimation ability of mature trees is still poorly understood.

This contribution presents observations from a 5-year summer throughfall-exclusion experiment on mature European beech (*Fagus sylvatica*) and Norway spruce (*Picea abies*) in southern Germany (Kranzberg forest roof experiment (KROOF)). Precipitation throughfall was completely excluded from spring to late fall (i.e. March to November) between 2014 and 2018.

In the first two drought years, predawn leaf water potential of both species significantly decreased as low as -1.8 MPa, leading to a significant reduction in CO_2 assimilation rates and stomatal conductance, in particular in spruce with a reduction of up to 85% compared to controls. However, although the soil water content was similar throughout the measurement periods, this decrease in predawn leaf water potential was diminished in the fourth and fifth year of the drought treatment, leading to a parallel increase in leaf photosynthesis. Especially, CO_2 assimilation rates and stomatal conductance of beech that were reduced by 40% in the second and third drought year, showed similar values to the controls in the fourth and fifth drought year.

Thus, both species seem to have ability to attenuate water stress under long-term drought. While drought-stressed spruce trees significantly reduced their total leaf area two years after the start of the drought treatment, leading to more available water per leaf area, beech trees seem to have maintained their total leaf area even under long-term drought. These observed drought responses and acclimation strategies of both species are discussed taking belowground perspectives into account.