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Physiological causes of tree damages and mortality in European tree species during the extreme summer drought 2018

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In 2018, an exceptionally severe summer drought affected forest ecosystems in wide parts of Northern and central Europe, causing striking leaf and canopy damages and tree mortality. At the recently established Swiss Canopy Crane II research site, we investigated the effect of this severe drought stress event on the water and carbon status of adult individuals of nine European tree species (Fagus sylvatica, Quercus petraea, Acer pseudoplatanus, Carpinus betulus, Fraxinus excelsior, Sorbus torminalis, Picea abies, Abies alba, Pinus sylvestris). Mid-day twig water potentials, measured bi-weekly throughout the season, reached very low values in summer and early autumn, coming close to, or even exceeding, the xylem pressure at 50% loss of hydraulic conductance (P50 value). Measurements of diurnal stem diameter variations revealed long-lasting stem shrinkages, indicating the development of sustained tree water deficits. Stomatal conductance was strongly reduced in P. abies, A. alba and F. sylvatica, while the other tree species maintained much higher values. Among the observed tree species, only F. sylvatica and P. abies developed visible drought stress symptoms, with strong leaf browning and necrosis in F. sylvatica (but no mortality) and canopy die-back and subsequent tree death in P. abies. The canopy die-back in P. abies was accompanied by a sudden decline of mid-day water potentials to exceptionally low values and a complete loss of xylem hydraulic conductivity, suggesting desiccation and hydraulic failure as the main cause of drought-induced mortality of P. abies. Still, the analysis of non-structural carbohydrates is underway to explore the effect of the exceptionally severe summer drought in 2018 on the carbon status of the investigated tree species. Taken together, our observations show the particular sensitivity of P. abies and F. sylvatica to drought, and these tree species may therefore be considered at high risk of decline under the conditions of a future climate with more frequent and intense droughts.