Drought-sensitivity ranking of deciduous tree species based on thermal imaging of forest canopies

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Author(s) Scherrer, Daniel; Bader, Martin Karl-Friedrich; Koerner, Christian
Author(s) at UniBasel Körner, Christian ; Bader, Karl-Friedrich Martin ; Scherrer, Daniel ;
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Most climate change projections for Central Europe predict higher mean summer temperatures and prolonged summer drought periods. However, in diverse mixed forest stands we expect tree species specific responses to water shortage, as tree species are highly variable in rooting depth and physiological traits related to the water balance. Here, we assessed the drought sensitivity of the water relations of six deciduous forest tree species at four sites with contrasting water availability by airborne thermal imagery of canopy foliage temperature, sap flow and soil water potential. Canopy architecture had a consistent influence on canopy foliage temperature with 'dense canopy' species (Acer pseudoplatanus, Fagus sylvatica and Tilia platyphyllos) being warmer (0.5-1.5 K) than 'open canopy' species (Fraxinus excelsior, Prunus avium and Quercus petraea). While the canopy foliage was close to air temperature at the beginning of the drought period (Delta T(C-A) = -0.1 to 0.7 K) it strongly warmed up with ongoing drought, especially at the two 'dry' sites with a Delta T(C-A) of 3.5-5K. The pronounced canopy foliage warming at the 'dry' sites after 22 days of drought was associated with reduced transpiration rates as sap flow was curtailed by 20-35% in all species except F. excelsior and Q. petraea. Based on canopy foliage temperature and sap flow data, we considered A. pseudoplatanus the most drought sensitive species followed by F. sylvatica, T. platyphyllos and P. avium and the two ring-porous species F. excelsior and Q petraea being clearly the least sensitive ones. At drier sites, increasing summer temperatures and drought might change the competitive abilities of tree species in favour of those that are able to maintain transpirational fluxes and cooler canopies such as F. excelsior and Q petraea.

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