Root water uptake depth determines the hydraulic vulnerability of temperate European tree species during the extreme 2018 drought

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We took advantage of the European 2018 drought and assessed the mechanisms causing differences in drought vulnerability among mature individuals of nine co-occurring tree species at the Swiss Canopy Crane II site in Switzerland. Throughout the drought we monitored leaf water status and determined native embolism formation in the canopy of the trees as indicators of drought vulnerability. We also determined hydraulic vulnerability thresholds (Ψ; 12; -, Ψ; 50; - and Ψ; 88; -values), corresponding hydraulic safety margins (HSMs) and carbohydrate reserves for all species as well as total average leaf area per tree, and used stable isotopes to assess differences in root water uptake depth among the nine species as variables predicting differences in drought vulnerability among species. Marked differences in drought vulnerability were observed among the nine tree species. Six species maintained their water potentials above hydraulic thresholds, while three species, Fagus sylvatica, Carpinus betulus and Picea abies, were pushed beyond their hydraulic thresholds and showed loss of hydraulic conductivity in their canopies at the end of the drought. Embolism resistance thresholds and associated HSMs did not explain why the co-existing species differed in their drought vulnerability, neither did their degree of isohydry, nor their regulation of carbohydrate reserves. Instead, differences in structural-morphological traits, in particular root water uptake depth, were associated with the risk of reaching hydraulic vulnerability thresholds and embolism formation among the nine species. Our study shows that structural-morphological traits, such as root water uptake depth, determine how quickly different species approach hydraulic vulnerability thresholds during a drought event and can thus explain species differences in drought vulnerability among mature field-grown trees.

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