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Hydraulic redistribution - a crucial water exchange process among Central European tree species

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Hydraulic redistribution (HR) describes a passive flux of soil water through plant roots driven by soil-water potential gradients. Its influence on the water balance of plants and ecosystems depends on interactions between soil processes and the physiological and morphological behavior of plants. This contribution comprises field and greenhouse experiments using stable water isotopes to trace and quantify the exchange of water through HR among several Central European tree species under drought.

The potential for water exchange through HR among tree species was tested in a split-root greenhouse experiment with Pseudotsuga menziesii, Quercus robur, Fagus sylvatica, Castanea sativa, Picea abies and Acer pseudoplatanus. Trees were planted with one individual (i.e. split-root plant) having its roots divided between two pots with an additional tree each. A gradient in soil water potential was established between the two pots and HR was observed by stable isotope labeling. Split-root plants redistributed deuterium enriched water from the moist to the dry side. The use of redistributed water by neighboring plants in the dry pots was assessed in real-time through laser spectroscopy of the transpiration water. Plants in the dry pots benefitted significantly with c. 61 % of the water in their roots originating from water released by roots of the split-root plants (Hafner et al. 2017).

In the field, redistribution of water by Fagus sylvatica trees was traced in six throughfall-exclusion plots (c. 150 m^2 each) within a mixed species forest co-dominated by Fagus sylvatica and Picea abies trees (c. 70-years old) in southern Germany (Kranzberg Forest; kroof.wzw.tum.de). Via plastic tubes deuterium tracer was applied to deeper (30-50 cm), moist soil layers, and samples of soil and plant root material were taken to quantify the flux of the label from deep soil to the dry shallow soil layers. Fagus sylvatica redistributed c. 2 % of the applied tracer into finer roots in the shallow soil layers. From there the labeled water also infiltrated into the surrounding rhizospheric soil, potentially available to neighboring shallow rooted Picea abies trees. About 66% of rhizosphere water originated from finer Fagus sylvatica roots.

We conclude that HR is a common phenomenon among Central European trees and plays an important role in their soil-plant-atmosphere system. Additionally, redistributed water represents an important water source for drought-stressed plants, with potential implications for ecohydrological and plant (eco-)physiological processes in Central European forests.

Reference: Hafner B.D., Tomasella M., Häberle K.H., Goebel M., Matyssek R., Grams T.E.E. (2017) Hydraulic redistribution under moderate drought among English oak, European beech and Norway spruce determined by deuterium isotope labeling in a split-root experiment. Tree Physiol. 37, 950–960.