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In situ monitoring of tree water uptake depths, storage and transport reveals different strategies during drought and recovery

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Due to ongoing and likely intensifying climate change impacts, ecosystem water availability is altered across the globe. Humid tropical forests, which evolved under conditions of abundant water, might be particularly vulnerable to water stress. One important factor in a tree's resilience to a less reliable water supply from precipitation is a root system that reaches deep into the ground. However, accessing deep soil regions as well as observing active deep root water uptake is challenging. Consequently, the occurrence, functioning and importance of deep roots are not well understood.

The Biosphere 2 Tropical Rainforest in Arizona, USA offers a unique possibility to further investigate this knowledge gap as environmental conditions can be controlled and soil can be accessed from below. Within the interdisciplinary B2 WALD project, we imposed a two-month drought on the enclosed ecosystem. To identify deep water uptake, water labeled with ^{2}H isotopes was supplied through a drainage system in 2-3 m soil depth before the drought ended. To investigate tree reactions to the manipulations in water supply, we closely monitored atmospheric conditions, soil water content and isotopic composition as well as tree sap flow, stem water content and the isotopic composition of tree xylem and transpired water. Only few data sets exist, combining water stable isotope information with different hydrometric measurements within the same experiment. Additionally, we used novel *in situ* approaches to monitor the isotopic composition in soils, tree xylem and transpiration in high temporal resolution.

Combining all measurements in 10 tree individuals of 5 different species, we found contrasting reactions to the added deep water. Except of two understory trees, all canopy trees had access to it, suggesting that deep roots could be a common feature also in tropical tree species. Trees did not use deep water in the same way. We observed differences in the speed and timing of the reaction as well as in within-tree water dynamics. While some individuals first refilled their stem water storage, others used the deep water source to preserve their sap flow and transpiration stream. This not only impacted the time course of tree water isotopes but knowledge of

those different behaviors is pivotal in better understanding and predicting tree performance, survival and ecosystem water cycling. In summary, our data illustrates the need for an extensive network combining different measurements to correctly interpret tree water isotope dynamics, tree water use strategies and to further uncover the functioning of deep roots and assess their importance for ecosystem resilience in a changing climate.