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Monitoring tree species-specific water uptake strategies via continuous in-situ stable water isotope measurements

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Water isotope tracing techniques in combination with laser-based isotopic analyses have advanced our understanding of plant water uptake patterns providing opportunities to carry out observational studies at high spatio-temporal resolution. Studying these highly dynamic processes at the interface between soils and trees can be challenging under natural field conditions, as available water resources are difficult to control. On the other hand, the results of small pot experiments in the greenhouse using tree seedlings are often difficult to transfer to mature trees. Here, we setup a controlled outdoor large pot experiment with three different, 4-6 meter high and 20 year old trees: *Pinus pinea, Alnus spaethii and Quercus suber.* We took advantage of stable water isotope techniques by tracing plant water uptake from the root zone through the xylem via isotopically labelled irrigation water. We combined ecohydrological observations of sapflow, photosynthesis, soil moisture and temperature and soil matrix potential with high resolution measurements of water stable isotopes in soils and trees to understand how soil water is used by different tree species. We monitored the isotopic composition of soil and xylem water in high temporal resolution with in-situ isotope probes installed at different depths in the soil and different heights in the tree stem. We further compared the water isotopic composition of our in-situ monitoring setup with destructive sampling methods for soil and plant water (vapour equilibration method and cryogenic extraction).

Our results from the continuous monitoring showed a distinct difference in the xylem sap isotopic signature between *Quercus* on the one hand and *Alnus* and *Pinus* on the other hand. This is likely due to different water use strategies of these tree species. The tree xylem isotopic signature of *Alnus* and *Pinus* responded to the isotopic label within one day and six days at 15 cm and 150 cm stem height, respectively. The peak isotopic signature in the tree xylem due to the label application was similar to the isotopic signature of the soil in 30 cm (for *Alnus*) and 15 cm (for *Pinus*). *Quercus* showed a delayed and much slower increase in the xylem isotopic signature in response to the label and the highest values were significantly lower than the corresponding soil isotopic signatures. Our methodological comparison showed that the isotopic signature of the destructive samples (from both methods) had a larger spread and this spread tended to become larger with subsequent labeling. Destructive soil samples showed a wider isotopic variation than

destructive xylem samples. The in-situ isotope measurements in comparison showed a relative constant small to medium spread for soil and xylem isotopic measurements. Our in-situ isotope probes therefore seem to be a potential alternative or supplement to destructive sampling offering much higher temporal resolution. The continuation of the labeling experiments in 2020 will allow us to further study tree-species specific water uptake strategies, which will become important under future climatic conditions in terms of development of adaptation strategies for sustainable forest management.