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Revealing the bark water uptake of isotopically-enriched water by intact branches in the field and its potential contribution (or consequences) to (or for) transpiration estimates

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In plants, the constant demand for water driven by transpiration is supplied by uptake from the soil through the roots. Alternative water-uptake pathways through the leaves and the bark have been demonstrated for some species, mainly conifers. Alternative water-uptake pathways could allow plants to complement their water supply with canopy interception, fog or dew, sources often assumed unavailable as they are lost via evaporation before they can contribute to soil water recharge. Bark water-uptake has been putatively linked to repair of xylem embolism, although this has only been demonstrated in cut branches and/or under artificial conditions. We hypothesized that besides embolism repair, bark water uptake might also contribute to maintaining the transpiration stream in upper canopy branches when the xylem water column is subject to excess negative pressure, either because temperature drops, and water viscosity increases, or under high vapour pressure deficit and low soil water availability. We used a novel labelling methodology combining online measurements of the isotope composition (δ^2H and $\delta^{18}O$) of the transpiration stream with analyses of δ^2H and $\delta^{18}O$ from leaf, bark and xylem water in *Pinus sylvestris* and *Fagus sylvatica*. We conducted sampling campaigns in two study sites: a boreal (northern Sweden) and a temperate (northern Spain) forest. We applied semi-permeable bandages injected with ^2H-enriched water (0.8% ^2H_2O), on intact upper canopy branches (7-13 m), and monitored δ^2H and $\delta^{18}O$ of the transpiration stream with a Cavity Ring-Down Spectrometer (CRDS) in three branches (only *P. sylvestris* in Sweden) for 24 h and then sampled branch segments 2 cm upstream and downstream of the bandage. We determined δ^2H and $\delta^{18}O$ of leaf, bark and xylem water from sampled segments with a CRDS after cryogenic extraction. Xylem, bark and leaf water from segments downstream of the bandage were enriched in δ^2H with respect to their corresponding upstream segments. The δ^2H and $\delta^{18}O$ from leaf, bark and xylem water from upstream segments were similar to those of control branches (no bandages). Results were similar for both study species, sites and campaigns, indicating that bark water uptake is not restricted to gymnosperms and may be more ubiquitous than previously considered. Enrichment in δ^2H in the transpiration stream was also detected in one out of the three continuously monitored pine branches within the 12 h following the bandage application. Our results demonstrate that water taken up through the bark may be incorporated into the transpiration stream and that transpiration might not solely rely on water absorbed through the roots and transported through the main stem. This could imply, for example, that sapflux measurements would underestimate canopy transpiration. Combining empirical flux measurements with stable isotopes and/or other atmospheric tracers could render more realistic estimates of transpiration and help constrain partitioning of evaporation and transpiration and its coupling to gross primary productivity.