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Water's journey from forest soils to maple sap

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In spring, leafless maples generate positive pressure in their trunks through a unique process involving gas bubbles in their fibers, which compress or decompress following freeze-thaw events. The resulting water movements are completely different from those documented in trees during the growing season since they do not rely on leaf transpiration. These movements are much smaller, locally generated and they alternate between upward and downward directions, which, in theory, limits the tree's ability to move water over long distances.

While we harvest substantial amount of water each spring from the sap of maples in maple syrup productions (up to 100 ltr per tree!), one might wonder where all this water comes from. Is there long-distance transport within a leafless maple? Is root uptake even possible under these peculiar conditions?

In this experiment, we assessed the origin of water we harvest in maple sugaring using tracers (heavy water) that we injected in the forest soil for roots uptake, or into the trees at canopy, trunk or stump heights. We took samples from the sap of 55 experimental trees every day of the sugaring season to monitor isotope ratios and detect the enriched water we added to the system. We also measured the natural water isotopic signal at the site for control trees, to account for shifts in water phases occurring in spring (rain and snow) that comes with distinct isotopic signatures.

We expected to find a dynamic system of water origins in the maple sap, slowly shifting from water stored within the tree in nearby locations, to remote transport and newly acquired water by the roots as the season progresses and the tree rehydrates from its winter desiccation.

This system had never been studied before and there were many unknowns with the use of tracers at the root-soil interface in nearly water-saturated soils. Consequently, we not only tracked water from sources to maple syrup, but also developed a methodology using tracers under snow cover and in excessively wet soils, as in northern ecosystems during spring.