Stem water content changes our understanding of tree water use

We highlight two current research projects using METER soil moisture sensors to measure volumetric water content (VWC) in tree stems and share why this previously difficult-to-obtain measurement will change how we look at tree water usage.

Study #1: Soil moisture sensors in a tree?

In a recent research project, Ph.D. candidate Ashley Matheny of the University of Michigan used soil moisture sensors to measure volumetric water content in the stems of two species of hardwood trees in a northern Michigan forest: mature red oak and red maple. Though both tree types are classified as deciduous, they have different strategies for how they use water. Oak is anisohydric, meaning the species doesn't control their stomata to reduce transpiration, even in drought conditions. Isohydric maples are more conservative. If the soil starts to dry out, maple trees will maintain their leaf water potential by closing their stomata to conserve water. Ashley and her research team wanted to understand the different ways these two types of trees use stem water in various soil moisture scenarios.

Historically, tree water storage has been measured using dendrometers and sap flow data, but Ashley's team wanted to explore the feasibility of inserting a capacitance-type soil sensor in the tree stems as a real-time measurement. They hoped for a practical way to make this measurement to provide more accurate estimations of transpiration for use in global models.

Ashley and her team used meteorological, sap flux, and stem water content measurements to test the effectiveness of capacitance sensors for measuring tree water storage and water use dynamics in one red maple and one red oak tree of similar size, height, canopy position and proximity to one another (Matheny et al. 2015). They installed both long and short soil moisture probes in the top and the bottom of the maple and oak tree stems, taking continuous measurements for two months. They calibrated the sensors to the density of the maple and oak woods and then inserted the sensors into drilled pilot holes. They also measured soil moisture and temperature for reference, eventually converting soil moisture measurements to water potential values.

Results varied according to species

The research team found that the VWC measurements in the stems described tree storage dynamics which correlated well with average sap flux dynamics. They observed exactly what they assumed would be the anisohydric and isohydric characteristics in both trees. When soil water decreased, they saw that red oak used up everything that was stored in the

stem, even though there wasn't much available soil moisture. Whereas in maple, the water in the stem was more closely tied to the amount of soil water. After precipitation, maple trees used the water stored in their stem and replaced it with more soil water. But, when soil moisture declined, they held onto that water and used it at a slower rate.

Trees use different strategies at the species level

The ability to make a stem water content measurement was important to these researchers because much of their work deals with global models representing forests in the broadest sense possible. They want to figure out the appropriate level of detail for tree water-use strategy in a global model. Both oak and the maple are classified as broadleaf deciduous, and in a global model, they're lumped into the same category. But this study illustrates that if you're interested in hydrodynamics (the way that trees use water), deciduous trees use different strategies at the species level. Thus, there is a need to treat them differently to produce accurate models. Read the full study in Ecosphere.

Reference: Matheny, A. M., G. Bohrer, S. R. Garrity, T. H. Morin, C. J. Howard, and C. S. Vogel. 2015. Observations of stem water storage in trees of opposing hydraulic strategies. Ecosphere 6(9):165. http://dx.doi.org/10.1890/ES15-00170.1

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