Title: **What Drives Variability in Carbon-Water Dynamics? The Value of Soil Moisture for Predicting Plant Water Potential and Ecosystem Fluxes**

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Project Abstract:

Carbon and water fluxes in arid and semi-arid ecosystems are notoriously difficult to predict due to their high spatial and temporal variability, and progress towards this aim is limited by the accuracy and resolution of existing data. In particular, measurements of shallow and deep soil moisture pools have the potential to greatly enhance our ability to predict ecosystem fluxes. Additionally, data on plant water potential (WP) could improve predictions of ecosystem fluxes since plant hydraulic status acts as the intermediary between soil and atmosphere. However, the sensitivity of ecosystem fluxes to atmospheric drivers, soil WP, and plant WP remains unresolved. We addressed this challenge using co-located continuous measurements of soil WP profiles, tree WP (via stem psychrometers), and ecosystem fluxes (via eddy covariance) at a site in southeastern Utah, along with a broader network of 21 arid flux tower sites in the western US where soil moisture has been monitored at multiple depths.

We found that ecosystem fluxes of carbon and water were highly sensitive to variability in soil WP, especially in shallow (<20 cm) layers. The sensitivity of fluxes to shallow soil WP greatly exceeded flux sensitivity to vapor pressure deficit, air temperature, and solar radiation, even in ecosystems dominated by deep-rooted woody vegetation. Tree WP was also most sensitive to shallow soil WP, and was tightly linked to ecosystem-scale carbon and water fluxes. However, using a model comparison exercise, we found that the inclusion of tree WP data did not improve predictions of modeled fluxes any more than the addition of just one layer of soil WP. Instead, we found that the inclusion of any additional depths of soil WP improved model fit. Our results indicate that prediction of ecosystem fluxes and plant WP can be greatly enhanced via denser networks of soil moisture observations and novel remotely-sensed soil moisture products (e.g., SMAP), especially in arid and semi-arid ecosystems with highly variable hydrological cycles.