Title: **Root Function - Process-Level Studies Focused on Mycorrhizae, Drought, Temperature and Neutron Imaging**

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Project Abstract: Assessment of root function *in situ* is extremely difficult, but advances in imaging technology are allowing unprecedented insight into root dynamics. Neutron imaging is highly sensitive to hydrogen ions, thus biological material and water are readily visible, which allows for *in situ* assessment of root structure, root growth, root water uptake, and internal root water transport. Results with various woody plants, maize, and switchgrass indicate significant variability in water dynamics across the soil-rhizosphere-root pathway, including root water uptake and hydraulic redistribution, hysteresis in water release curves and soil wettability. Measured root water extraction rates by cottonwood ranged from 0.003 to 0.02 g cm^{-2} h^{-1}, with lower rates for larger roots. Across species, root rhizosphere development increases with root size, stabilizing as roots reach ~2 mm in diameter. Analysis required development of a novel "RootProcessing" image analysis software to identify and segment roots, and analyze root, rhizosphere and soil water dynamics. Neutron radiography has also indicated significant root and mycorrhizal impacts to the soil hydraulic parameters, including hydraulic conductivity and residual water content. Results are important for testing and improving models of root water uptake and its linkages to root traits. Other key root processes that models are sensitive to include dynamics of root carbon allocation, relationships between roots and mycorrhizal fungi, root nutrient uptake, and root respiration and acclimation to temperature. Here, we leverage neutron imaging techniques to assess in situ root water dynamics, and hyphal exclusion or root exclusion chambers to asses in situ respiration dynamics in response to environmental changes.