**Title**: Root Dynamics and Ecosystem Legacy, Exploring Responses and Dynamics at Three Midwestern United States AmeriFlux Sites

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**BER Program**: [ESS]

**Project**: Water foraging with dynamic roots in E3SM; the role of roots in terrestrial ecosystem memory on intermediate timescales

**Project Website**: NA

**Project Abstract**:

The effects of stress events, such as drought or heatwave, on forest ecosystems typically persist for months or years after the initial event itself, a phenomenon often referred to as legacy. As extreme events increase in frequency and duration, the compounding effects associated with extended legacy may influence how forests will respond to climatic change. Forests respond to stress by allocating resources to where they are most needed, by redistributing fine roots deeper into the soil during times of drought. These belowground changes may ameliorate stress in the short term while also leading to long term costs and therefore protracting the response to the initial event. These expected changes to root systems in response to stress, and other dynamics that lead to legacy are not present in modern Earth System Models, reducing our ability to predict ecosystem responses to stress. Here, we utilize the Exascale Earth Systme Model (E3SM) in conjunction with a dynamic root module - where plants can forage for water and nitrogen - to understand how root systems respond to stress and how these changes influence legacy. Firstly we, examined the role of legacy globally, with and without root dynamics. We found that by allowing roots to forage, the timetable of recovery from stress events is altered differentially between dry and humid ecosystems. We then use point scale simulations in three forest flux sites in the Midwest, Morgan Monroe State Forest (US-MMS), Missouri Ozarks (US-MOz), and Sylvania Wildernsess (US-Syv), where eddy covariance tightly constrains carbon and water fluxes. We conducted a sensitivity analysis at these three sites, using an ensemble of simulations assessing the response to root longevity and fine root to leaf allocation. We then partition the sources of legacy in these systems between long term responses to weather events, and implicit legacy related to the land-use and biological history. Future

work will compare these modeling results with tree ring observations from these sites and linking E3SM to a dynamic allocation module. These analyses improve our understanding of legacy effects and forest response to stress, creating opportunities for improved predictive and mechanistic understanding of future conditions.

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