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Pore- to Core-Scale Controls on Ecosystem CO_2 fluxes: Water Dynamics Drive the Microbial Cycling of Soil Carbon

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Soil structure and water combine to regulate soil organic carbon and nutrient bioavailability, which in turn drive microbial activities. The physical structure of soil constitutes both the flow paths for resource transport in the aqueous phase and the habitat for soil microbes. The soil water is both the solution for solute transport and the reagent within which biogeochemical transformations occur. When soil moisture decreases, the hydrologic connectivity between soil pores decreases, and the concentrations of solutes in the remaining soil waters increases. The objective of this research was to measure the effect of drought vs saturation on the mobilization of soil C through the soil pore network, on the forms of soil C in the soil pore network, and on the C cycling activities of the soil microbial community. We used soils from Alaska, Washington, and Florida to test three hypotheses: i) Soils that have been subjected to a simulated drought will have greater proportions of complex C species, and microbial communities will experience local osmotic stress. ii) Soils that have been subjected to extended saturation will have a greater proportion of simpler C, and the soil microbial communities will be able to move through the hydrologic connections to access soil C. iii) Soils that were held at field-moist conditions will reflect the resource islands that occur as a result of discontinuous water connections and the he relative diversity of C molecules, microbial functions, and taxa will be highest in these soils. We combine advanced techniques for molecular characterization of soil C with tomography to reveal where in the soil matrix SOC persists, and in what forms. We imposed extreme water conditions, from drought through flood, and found that moisture history matters a great deal to the forms of C in soil, where they are located, and how they contribute to CO_2 emitted through heterotrophic respiration. Each soil responded differently to the extreme water conditions, however these differing responses may be attributed to fundamental differences in the abundance of fine pores in each soil.