Incorporating below ground biology and soil physical properties into a soil carbon degradation model through experimenting across ecotypes

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Belowground processes are critical in understanding carbon (C) cycling, yet our understanding and modeling of the soil physical and biological processes that regulate soil organic matter (SOM) turnover are largely empirical and contribute to reduced confidence in terrestrial C balance under global change. Soil properties and biological communities contribute to C loss and gain, which vary significantly by ecosystem and soil type, but current C cycling models fail to incorporate these interacting factors. For example, mycorrhizal fungi are an integral link to carbon cycles in ecosystems because they exchange SOM-derived nutrients for plant-assimilated C, yet their activity, and how their regulation of carbon dynamic might change by soil type, is often not considered in models. The failure to consider the role of the integrated biological community - microbes, mycorrhizal fungi, and plant roots - on soil C turnover may render models incapable of predicting responses to environmental change. Our project will fill this knowledge gap by modeling and experimentally manipulating the biological community in situ across diverse ecosystems, thus increasing our ability to predict and model the extent to which soils in terrestrial ecosystems will be an atmospheric net C source or sink.

Our work has three aims: (1) to examine degradation of different soil organic C (SOC) substrates in situ in diverse ecoregions that are underrepresented in global carbon models, (2) to manipulate soil biological community access to SOC, and (3) validate the Microbial-ENzyme-mediated Decomposition (MEND) soil C model using field data. To achieve these aims, we will establish experiments that manipulate substrate complexity (starch and lignin) and biotic activity (roots and mycorrhizal fungi) in three distinct ecoregions (tropical lowland forest, peatland, temperate forest) that harbor three distinct, but common soil types. Since our prior work showed that soil types have different abilities to sorb substrates with differing complexities, we will examine breakdown of starch (intermediate complexity) and litter (high complexity). The rate of flux of these three substrates between SOC, dissolved organic C, and microbial biomass C depends on soil sorption properties and microbial enzyme activity in the MEND model. While the model uses parameters from microbial systems, we expect the presence of roots and rhizosphere organisms to contribute to soil C degradation indirectly through enzyme production and exudation (priming). Thus, we will manipulate root and fungal presence to determine if separate parameter sets stemming from each rhizosphere functional group is a necessary component of the model.