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The Role of Microbial Traits in the Response of Soil Respiration to Warming Through the Soil Profile in the LBNL TES SFA

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The mechanisms and responses of soil organic matter (SOM) decomposition to warming remain some of the largest uncertainties in ecosystem-climate feedbacks. Moreover, current knowledge of these processes is mostly limited to surface soils, although over 50% of global soil carbon is contained in sub-soils below 30 cm. Soil physicochemical conditions, nutrient inputs, and organic matter chemistry change with soil depth, partly due to a decreasing influence of plant inputs and root-microbe interactions. Such factors select for microbial communities with distinct metabolic, physiological, and cellular properties (i.e., microbial traits) that may constrain SOM decomposition, and the trajectory and magnitude of the respiration response to warming through the soil profile.

In the LBNL TES SFA, we are investigating microbial responses and feedbacks to warming through the whole soil profile using continuous field-based warming experiments at temperate forest and grassland sites, and complementary short- to mid-term laboratory manipulations. We have previously observed that surface and sub-soils at the forest site harbor consistently distinct bacterial communities and that in situ warming over 18-30 months induced transient changes in both community composition and carbon use efficiency (CUE; determined based on substrate- specific metabolic modeling). This led us to hypothesize that the emergent soil respiration response to warming is largely driven by the interplay between selection of microbiomes with distinct metabolic and physiological traits through the soil profile, and their responses to varying environmental conditions.

In the current phase, we are: (i) investigating the dynamics of genome-derived functional and evolutionary traits (based on metagenomic analyses) through the soil profile, and their relationships with soil properties that co-vary with depth and environmental factors, including warming; (ii) implementing new stable isotope-based and substrate-independent methods to quantify microbial population growth rates, turnover, CUE, and nitrogen transformations; (iii) using laboratory incubations to infer generalizable, mechanistic relationships between microbial traits and critical environmental factors (substrate quality, and nutrient and water availability); and (iv) parameterizing microbial processes in soil biogeochemical models using microbial traits and leveraging laboratory experiments to benchmark models to scale short-term mechanisms to longer-term field observations. Initial results from laboratory experiments suggest that respiration in both surface and sub-soils is co-limited by carbon and at least nitrogen or phosphorus, and that warmed surface soils (after 5 years) are relatively more carbon limited than unwarmed surface and sub-soils. To elucidate interaction mechanisms between microbial physiology, nutrient availability and warming, we are currently quantifying gross microbial growth, turnover, and CUE.