Quantitative, Trait-Based Microbial Ecology to Accurately Model the Impacts of N Deposition on Soil C Cycling in the Anthropocene

Edward Brzostek[1*], Ember Morrissey[1], Zachary Freedman[1], Nanette Raczka[1], Juan Piñeiro[1], Joseph Carrara[1], Christopher Walter[1], Steve Blazewicz[2], and Peter Weber[2]

[1] West Virginia University, Morgantown, WV;
[2] Lawrence Livermore National Laboratory, Livermore, CA

Contact: erbrzostek@mail.wvu.edu

Project Lead Principle Investigator: Edward Brzostek

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Atmospheric nitrogen (N) deposition in the eastern United States has enhanced C storage in temperate forest soils. However, it remains unclear whether this soil C will persist as N deposition declines across the region. At the heart of this knowledge gap is the failure to link N-induced shifts in microbial biodiversity with traits that control microbes' ability to breakdown, assimilate or stabilize soil C. Given that this uncertainty directly impedes the ability of predictive models to project future soil C stocks, there is a critical need to determine how N-induced shifts in key microbial traits drive soil C stabilization. To address this uncertainty, our objectives are to 1) Quantify variations in taxon-specific and community- level microbial traits across gradients in microbial community composition, the distribution of ectomycorrhizal (ECM) and arbuscular mycorrhizal (AM) trees, and N availability and 2) Integrate these data into a novel predictive framework that enhances our ability to project the regional soil C consequences of N deposition in temperate forests.

To meet our objectives, we have used quantitative stable isotope probing, metabolomics, and biogeochemical approaches to quantify microbial traits and their impacts on soil C cycling across scales. Under ambient deposition, we have found that soil microbes influenced by AM trees have greater flexibility in their decomposition pathways than soil microbes influenced by ECM trees. In AM soils, the identity of the soil microbes decomposing litter as well as the resulting metabolites varied as a function of litter quality. Remarkably, in ECM soils, we found that litter quality did not result in significant shifts in decomposing microbes or metabolites. In a study of ten N fertilization experiments across the eastern United States, we have found evidence that suggests N fertilization enhances microbial C use efficiency leading to greater stabilization of C on mineral surfaces. Most recently, we have found that N fertilization reduces N use efficiency of soil microbes to the same degree in AM and ECM soils at the Fernow Experimental Forest, WV. On the modeling front, we used these results to refine our plant-microbial interactions model, FUN-CORPSE. When challenged with long-term data records from Fernow, the refined model accurately captured shifts in decomposition and the mineral stabilization of soil C in response to N fertilization. Collectively, these results highlight the importance of integrating state-of-the- art data streams into models to improve predictions of the response of temperate forests to shifts in N availability.