Title: Linking root and soil microbial stress metabolism to watershed biogeochemistry under rapid, year-round environmental change

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Project Website: https://people.bu.edu/ptempler/workDetails/climateChangeWinter.html

Project Abstract:

Air temperatures are rising, while the winter snowpack is shrinking and soil freeze/thaw events are increasing in high latitude ecosystems. The severe thermal impact of soil freeze/thaw cycles in winter, coupled with warming during the growing season, reduces soil carbon (C) cycling, but increases nitrogen (N) and phosphorus (P) cycling in soil. Nevertheless, the root and microbial mechanisms leading to these shifts are unclear. We hypothesise that under climate change across seasons, microbes and plants exhibit a trade-off between stress metabolism and soil C, N, and P uptake (short term) and biomass stabilization (longer term) that scales up to impact C and nutrient export at the watershed-level. To test this hypothesis, we are conducting a model-data integration study using the Climate Change Across Seasons Experiment (CCASE) at the Hubbard Brook Experimental Forest (HBEF) and a plot-to-watershed-level biogeochemistry model, PnET-BGC. At CCASE, replicate field plots receive one of three climate treatments: growing season warming (+5˚C above ambient), warming + freeze/thaw cycles (+5˚C above ambient in growing season plus up to four freeze/thaw cycles in winter), and reference conditions (no treatment). We have found that warming + freeze/thaw cycles induces redox stress that selects for anaerobic N cycling-microbes, while potentially shifting the majority of microbial C-cycling activity from organic to deeper mineral soil horizons during winter. Soil microbes are also evolving under these conditions to increase decomposition of plant and soil C, but decrease decomposition of organic P, potentially decoupling C, N, and P outputs to associated aquatic ecosystems both temporally and spatially. Ongoing research couples new belowground biogeochemistry measurements at CCASE in organic and mineral soil horizons with soil metagenomic data and new high-throughput characterizations of trait and gene evolution in individual soil bacteria and fungi to reconstruct evolution of potential plant and microbial C, N, and P metabolism at CCASE over the past decade. We will incorporate

immediate and evolved responses of microbial C, N, and P cycling into new versions of PnET-BGC, including an evolutionary algorithm applied to specific C, N and P flux calculations. This research tesst our conceptual understanding of plant and microbial physiology responses to severe, compounding soil temperature perturbations across seasons, as well as the utility of a forest stand-level manipulative climate change experiment to understand the biogeochemical dynamics of a forest watershed undergoing rapid environmental change.