Effects of Warming on Bacterial Growth and Element Fluxes in Soil

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Project Goals: This project aims develop and apply new methods to understand the ecology of soil microorganisms using stable isotope tracers and genomics. This new suite of techniques will investigate and describe the microbial ecology of nutrient cycling in soil environments as microorganisms grow and die. The work will focus on particular soil microorganisms, bacteria and fungi, that make up the majority of life in soil, and which are responsible for most of the nutrient transformations in soil that are vital to ecosystems, and to people. This project will also evaluate how soil microorganisms and the nutrient cycling processes they catalyze are sensitive to shifts in temperature, a major driver of biological processes.

Abstract

We are combining isotopes and genomics to understand the ecology of soil microorganisms, focusing on their responses to warming across biomes. The work relies on four long-term field experiments where temperature-treated and control plots occur in arctic, boreal, temperate, and tropical biomes. Our first step in evaluating nutrient uptake is to measure growth rates of microorganisms, *in situ*, because growth is an excellent integrator of resource assimilation. We conducted experiments to measure rates of growth of soil microorganisms in response to a large temperature gradient in the laboratory (5 - 45 degrees C) and in the field (using in situ warming experiments), and have found that soil bacterial growth rates are strongly sensitive to temperature in both contexts. We also find considerable taxonomic variation in the temperature responses of soil bacteria. Phylogenetic signals of these responses, while often significant, in general do not support phylum-level generalizations about bacterial traits. Rather, when signals are statistically significant, they appear to reflect finer-scale phylogenetic organization. In the field, warming in temperate and arctic ecosystems caused changes in bacterial growth that depended on the duration of exposure to the warming treatments, and responses were concomitant not only with changes in temperature but also with shifts in the plant community and with effects on soil processes. In general, we find that bacterial growth rates — and their responses to warming — scale to measured rates of biogeochemical fluxes, making it possible to estimate taxon-specific rates. In general, this work aims to ascribe element fluxes with taxonomic resolution, and to test the sensitivities of these

processes to temperature. The approach used here interrogates community and taxon-specific microbial controls over key biogeochemical processes in terrestrial environments, and test quantitative ecological and biogeochemical principles using genomics and isotope data, including theories of element limitation, growth efficiency, and nutrient use efficiency.

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