Microbial Communities and Carbon Cycling: Testing Positive Feedbacks to Climate Change

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Boreal forest ecosystems cover nearly 1.2 billion hectares of the surface of the Earth, equivalent to 17% of the total land surface and contain approximately 90 Gt carbon (C) in vegetation and 470 Gt C in soil organic matter and forest floor litter. Such large pools of C within the boreal forest ecosystem, equivalent to half of the total carbon within all forest ecosystems, make it particularly important to the global carbon cycle and global climatic change. If the carbon balance in boreal forest ecosystems is significantly altered, this could accelerate the rate of accumulation of carbon within the atmosphere, resulting in a positive feedback to climate change. The projected climate change for the boreal forest region includes increases in temperature between 1-3°C within 50 years and drier soils in summer. Warmer and drier expected climate patterns are expected to increase litter decomposition rates and soil respiration, increase permafrost melt and active layer thickness, and increase the frequency and intensity of wildfires with a resulting net loss of carbon to the atmosphere and a positive feedback to global climate change.

I propose that we can improve our understanding carbon cycling in boreal ecosystems responding to climate change through explicit consideration of the ecology of soil microorganisms. Soil fungi and bacteria play critical roles in carbon and nutrient cycling, but little is known about their distributions among ecosystem types, their response to changes in climate and fire regimes, and their potential to access recalcitrant permafrost carbon and black carbon thought to be biologically inert. My research is focused on the following areas:

1) What are the major controls on microbial community composition and function at the landscape scale?

2) Do increases in fungal biomass and diversity observed at the landscape scale translate into greater potential to degrade recalcitrant carbon sources?

3) Do fungal communities with powerful degradative enzymes have a high potential to degrade permafrost carbon and black carbon?

4) Does greater N availability and phenolic content in soil suppress ligninase enzyme activity of soil fungi and retard decomposition?

I examined these questions by sampling soils from fire chronosequences on well drained and poorly drained soils near Delta Junction, AK. Preliminary analysis suggests that fungal community composition differs among different drainage classes of soils, and that burning results in compositionally similar fungal communities, regardless of drainage class. Differences in fungal community composition between F (fibric), and A (mineral) soil horizons is greater than the effect of fire or drainage class. These compositional data will serve as background data for the further exploration of the functional response of soil communities to climate change.