Fire and Ice: Examining fungal mechanisms of recalcitrant carbon decomposition in response to fire in the boreal forest landscape.

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Heterotrophic microbial communities within boreal forest ecosystems control the fate of large pools of soil organic carbon (C) through decomposition and mineralization, yet the factors that control microbial communities are not well understood. Boreal forest ecosystems contain approximately 470 Gt C in soil organic matter and forest floor litter, giving it significant impact on the global C cycle. Here we examine the landscape level variation in microbial community composition in order to understand 1) the primary factors that control microbial communities in boreal forest ecosystems and 2) how variation in community composition can affect the cycling of C. Soil drainage and fire are two of the most important factors affecting boreal forest structure and function. We hypothesized that the biomass and diversity of soil fungi would increase with successional stage (5 and 60-120 yrs post-fire), and with decreasing soil moisture. We further hypothesized that increased fungal biomass and diversity would increase the capacity of the soil microbial community to decompose recalcitrant carbon. Fungal community composition and diversity were analyzed by Denaturing Gradient Gel Electrophoresis (DGGE) and Denaturing High Performance Liquid Chromatography (DHPLC) of the fungal internal transcribed spacer (ITS) region of community DNA. Fungal biomass was analyzed by Quantitative PCR (QPCR) of the ITS region. Functional analysis of the microbial community was performed using oxidative enzyme activities (required to degrade recalcitrant C) and QPCR of phenol oxidase functional genes. Fire and higher soil moisture reduced the diversity and size of the soil fungal community by 50-75%, correlating to reduced (50-75%) phenol oxidase enzyme activities, primarily in the fibric (F) horizon. Lower phenol oxidase enzyme activities may in turn reduce the decomposition of recalcitrant carbon, or the slow pool of carbon used in modeling studies. We also discovered a fungal population, characterized by a dense white mycelia appearing in a small number of F horizon samples from unburned soils that has 10-fold higher phenol oxidase enzyme activities than the surrounding soil community. This organism, when present, dominates the soil fungal community. As such, it may be an example of a single microbial population that strongly affects the turnover of soil C at small scales within boreal ecosystems, yet what controls its distribution or activity is unknown.