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Soil moisture availability and variability controls on microbial communities and SOM dynamics

Lisa Tiemann (1,2) and Sharon Billings (2,3)

(1) Natural Resources and the Environment, University of New Hampshire, Durham, NH, USA (lisa.tiemann@unh.edu), (2) Dept. of Ecology and Evolutionary Biology, University of Kansas, Lawrence, KS, USA, (3) Kansas Biological Survey, Lawrence, KS, USA

Many microbial communities are not resistant to changes in their environment, and the subsequently new and structurally distinct communities are not always functionally redundant with their predecessors. As a result, environmental change can lead to long-term changes in microbially-mediated ecosystem processes. More specifically, changes in soil moisture regimes can alter microbial physiology and resource demands, and therefore alter how microbes process soil organic matter (SOM). To better understand how antecedent moisture regime can influence current SOM transformations, and to better predict how future climate regimes may influence SOM dynamics in carbon (C)-rich soils, we assessed microbial communities and their C dynamics across four sites within a grassland precipitation gradient of 485 to 1003 mm y-1. The soil microbial communities residing at these sites are compositionally distinct from each other, yet all exhibit C mineralization rates and microbial biomass C highly correlated with contemporary site soil moisture. We used laboratory incubation and reciprocal transplant approaches to investigate how changing soil moisture regimes may influence these soils microbial communities and the SOM transformations they mediate.

To mimic projected future moisture regimes across this gradient, we brought soils into the lab and subjected them to different degrees of soil moisture variability for 72 weeks, altering the frequency of water additions but not the total amount added. In soils subjected to a long interval (LI) treatment intended to induce moisture stress with water applied once at the beginning of each two-week cycle, 1.4 to 2.0 times more C was mineralized compared to soils undergoing a short interval (SI) treatment, for which four wetting events were evenly distributed over each two-week cycle. This result was most pronounced in soils from the mesic end of the gradient, where rainfall is more evenly temporally distributed. These results drove an increase in estimates of mass specific respiration with enhanced moisture stress. We also reciprocally transplanted soils across the precipitation gradient. After two years, microbial community structure and SOM processing rates were distinct in all transplanted soils from their native controls. These changes were dependent on a significant interaction between the initial microbial community structure and the degree of change in environment, suggesting the importance of initial microbial community structure as a determinant of future structural trajectories, which can drive SOM transformations. Distinct from the incubation, where soil moisture variability was isolated, soils transplanted to drier sites with more variable precipitation exhibited lower mass specific respiration and lower rates of SOM break-down and C mineralization. It remains unclear why soil moisture availability versus variability, and therefore the incubation and field data diverged. However, these data suggest that although soil C mineralization is strongly coupled with the current soil moisture regime, the form of these relationships is dictated by antecedent community structure and relatively recent moisture regimes.