Title: Responses of bacterial and fungal communities under nitrogen amendment differ by microhabitat in arid ecosystems

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http://www.lanl.gov/science-innovation/capabilities/bioscience-biosecurity-health/environmental-microbiology/soil-carbon.php

Project Goals: Anthropogenic N deposition is a chronic and increasing condition in temperate regions that may strongly influence C cycling dynamics. One major theme of our Science Focus Area is to determine the influence of chronic N deposition on microbial C cycling processes in two major biomes of Earth's temperate regions, forests and arid grass/shrublands. In both biomes fungal and bacterial biomass is concentrated in shallow surface soil strata where C and N cycling are major processes. Arid lands cover ~40% of the terrestrial surface of the earth, and are expanding in many regions as a result of desertification. Historical inputs of N to drylands are generally low, but are increasing due to human activities. This poster will illustrate correlations among the resident fungal and bacterial communities, their enzyme activities, and local geochemistry in microhabitats of biocrust-dominated soils of an arid shrubland (Nevada) and an arid grassland (Utah), and the ability of phylogenetic rRNA gene surveys and soil enzyme assays to detect shifts in community structure and concomitant changes in C cycling processes in response to altered N conditions. Overall our goal is to provide an understanding of the active and responsive components of arid land soils that contribute to C cycling, their collective responses to environmental change.

We are using high throughput sequencing methods to target the soil bacterial and fungal communities, which together are responsible for the majority of nutrient cycles, including the N and C cycles. These studies were conducted at experimental N deposition field experiments located in an arid shrubland (Nevada) and an arid grassland (Utah) in the Southwestern US. To predict the functional effects of community shifts, we are simultaneously measuring relative microbial biomass, soil chemistry and enzyme assays to link specific environmental shifts to community responses and their functional consequences.

In the shrubland, bacterial and fungal biomass was significantly higher in association with interspace biocrusts (0-1 cm depth) when compared to homogenized 0-10 cm depth, and was higher in association with shrub canopies than in the interspace. Both communities showed differences in taxonomic composition across soil depth and with plant or biocrust association. For example, the bacterial phyla Acidobacteria, Actinobacteria, and Chloroflexi and the fungal classes Leotiomycetes, Sordariomycetes, and Eurotiomycetes were significantly higher in soils below the biocrust layer. Members of these taxa harbor a wide variety of C decomposition abilities, from use of C_1 compounds to complex lignocellulose, and their stratified location suggests microhabitat-specific C cycling activities. Although N amendment (at 8 or 15 kg/ha/yr) significantly increased available N and P by 30% and 25%, respectively, the responses of the fungal community were limited. Fungal richness changed and the Sordariomycetes increased. In contrast to the fungal response, the bacterial community responded with a decline in richness and shifts in taxonomic composition. Carbon use efficiency (CUE) calculated from soil enzyme activity ratios was increased at the highest N application rate in all microhabitats, illustrating a shift in soil C cycling pattern.

In congruence with the shrubland, soil fungal and bacterial community composition was significantly different in the interspace biocrusts, 5 cm below the biocrusts, and in association with grass root zones in the arid grassland. However, the response patterns of fungal and bacterial communities to N amendment (at 2-8 kg/ha/yr) were not significantly different in this system when assessed two weeks or several months after application. Although plant richness, diversity, and cover showed no response to N addition, there were strong linkages between plant and soil properties and microbial community structure.

In the shrubland there is evidence for shifts toward fungal-dominated nutrient cycling in response to N additions. By combining sequence-based community analyses with soil and enzyme activity measures, we may identify key responsive community members with relevance as indicators of community change and with utility for modeling soil processes. Both of the field experiments were short-term (2 years), using ecologically relevant (low) concentrations of N that may actually be deposited in these regions. Extending such studies out for longer time periods would likely demonstrate more consistent responses.

The climatic conditions and nutrient cycles in arid ecosystems differ dramatically from well-studied mesic systems. They are characterized by highly variable environmental conditions due to sporadic precipitation events, extreme temperature fluctuations and UV radiation stress, as well as low productivity, patchy distributions of biotic resources (microhabitats) and atypical sources of nutrient inputs. Given these unique characteristics, we hypothesized that responses seen in mesic forests and grasslands will apply in drylands. We conducted a meta-analysis of 15 recently N deposition studies in arid lands, and calculated N-effects from soil microbial biomass and metabolic responses. In contrast to our expectations, the critical N concentrations separating positive from negative treatment effects were comparable to microbial biomass, decomposition rates and respiration reported in broader meta-analyses of N amendment effects in mesic ecosystems. However, the large effect sizes at low N addition rates indicate that arid lands are sensitive to modest increments in anthropogenic N deposition.

References

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Funding statement: The information in this poster was supported by the U.S. Department of

Energy Biological System Science Division, through a Science Focus Area Grant (2016LANLF260).