Characterizing Soil Microbial Community Response to Prescribed Fire Along a High-Resolution Soil Depth Profile

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Abstract

The aim of this project was to assess the impact of soil depth on fungal and bacterial community composition in response to two discrete disturbances: (1) a pulse of precipitation after a dry season and (2) a low-intensity prescribed fire in a Sierra Nevada mixed conifer forest. While final results are forthcoming, initial data suggest an effect of the organic matter layer on deeper soil microbial communities, as well as the seasonality of disturbance.

Introduction

Prescribed fire is an emerging tool in wildland resource management to counteract more than a century of fire suppression (1). The effect of prescribed fire on soils, and soil microbial communities, however, has received relatively little attention, despite the critical role of these bacteria and fungi in global biogeochemical cycles, maintenance of forest health, and stable watershed dynamics (2). Within microbial ecology, prescribed fire may also help elucidate fundamental questions regarding disturbance, succession, and novel metabolic pathways.

The majority of soil microbial ecology studies perform analysis with minimal regard to gradients of depth, yet we believe that the most pronounced post-fire changes to microbial community composition will occur in the top few centimeters, and decline with depth, given the insulating properties of the soil matrix (see Fig. 1) (3, 4).

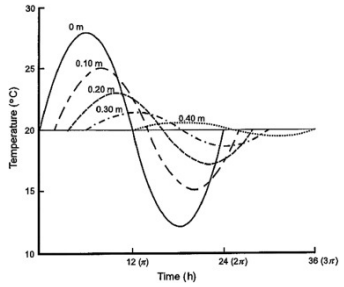

Fig. 1. Diurnal soil temperature fluctuations are dampened by depth (from Al-Kaisi et al. 2017)

Methods

A. Sampling and DNA Extraction

- Soil samples were collected from UC Blodgett Experimental Forest in Georgetown, CA at three time points: October 2019 (pre-rain, pre-fire); December 2019 (post-rain, pre-fire); and February 2020 (post-rain, post-fire)
- pH measurement taken for each sample
- Soil microbial DNA was extracted using Qiagen DNeasy PowerSoil Kit, and amplified 16S (bacteria) or ITS (fungi) DNA sequences were prepared for sequencing on the Illumina HiSeq platform

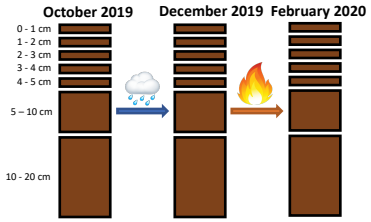

Fig. 2. Soil sampling scheme

Fig. 3. Sampling soil at Blodgett Experimental Forest, Georgetown, CA

B. Organic Soil Horizon

- The organic "O" horizon of soil (litter, decomposing organic matter) was measured at all three time points

C. Prescribed Fire and Thermocouples

- A low-intensity prescribed fire burned the experimental plot in Feb. 2020
- Thermocouple probes measured soil temperatures at 1-5, 10, and 20 cm

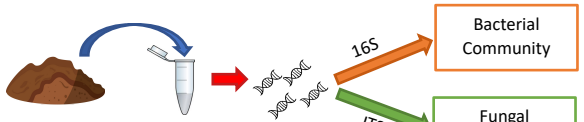

Fig. 4. Soil DNA extraction and bioinformatic pipeline

Fig. 5. Measuring the O Horizon

Fig. 6a-b. Experimental plot during prescribed burn (left) and 3 days later (right)

Results

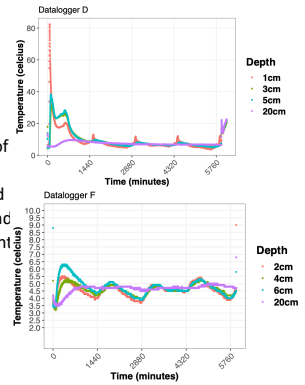

Fig. 7a-b. Soil temperatures over a range of depths during the prescribed burn (t = 0) and the subsequent 3 days

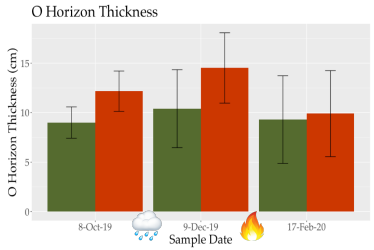

Fig. 8. Organic soil horizon thickness over time. Error bars = ± 1 SD, n = 6

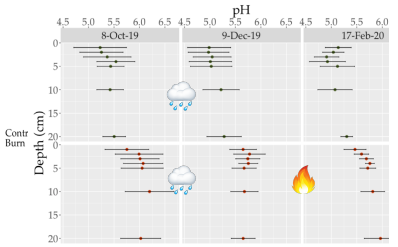

Fig. 9. Soil pH as a function of depth and treatment. Error bars = ± 1 SD, n = 6

Discussion and Future Directions

- From these early results, it is not apparent whether soil microbial community composition will change dramatically
- Prescribed fire may result in a heterogeneous pattern of disturbance, whereas a rain pulse may represent a more homogeneous disturbance
  - Soil temperatures varied significantly within a scale of a few meters (see Fig. 7a-b) perhaps due to seasonality of the burn
  - Soil pH did not change significantly after the fire, but did change significantly after the rain pulse (slight acidification)
- The O horizon may provide a "buffer" to excessive heating from prescribed fire, since much of the organic material remained post-fire (see Fig. 8)
- When lab operations resume, a detailed picture of microbial community dynamics will be revealed from sequencing results, and interesting patterns may emerge worthy of further study
  - E.g. correlations between community dynamics and other variables, such as pH, C or N concentrations, etc.

References

(1) Stephens, Scott L., Brandon M. Collins, et al. "U.S. Federal Fire and Forest Policy: Emphasizing Resilience in Dry Forests." *Ecosphere*, vol. 7, no. 11, 2016, p. e01584.

(2) Neary, Daniel G., et al. *Wildland Fire in Ecosystems: Effects of Fire on Soils and Water*. RMRS-GTR-42-V4, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 2005.

(3) Fontúrbel, M. T., et al. "Effects of an Experimental Fire and Post-Fire Stabilization Treatments on Soil Microbial Communities." *Geoderma*, , Dec. 2012, pp. 51–60.

(4) Al-Kaisi, M. M. et al. "Chapter 1:Fundamentals and Functions of Soil Environment." *Soil Health and Intensification of Agroecosystems*, Apr. 2017, pp 1-23.

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