Microbial Community Succession and Metabolism in Post-Fire Environments

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Project Goals

- Determine the temporal responses of soil microbes in fire-effected soils and identify patterns of succession of bacterial communities.
- Characterize the extractable chemical fractions of pyrolyzed organic matter, their temporal patterns of degradation and their effects on soil organic carbon mineralization.
- Identify how the post-fire bacterial communities affect the fates of pyrolyzed carbon stocks and soil organic matter and drive degradation.

Over the past few decades, we have observed an increased frequency of high-severity wild-fires, a consequence of long-term fire suppression strategies and further exacerbated by climate change. These fires have a significant impact on soil carbon stocks: a direct, negative effect due to combustion and an indirect positive effect, via the production of pyrolyzed organic matter (PyOM). PyOM is chemically heterogeneous and while a small fraction of it can be mineralized by microbes, much of it is highly aromatic with slow decomposition rates, creating a long-term carbon sink. Reports suggest that PyOM may constitute up to 80% of total soil organic carbon (SOC) in fire-effected ecosystems. Thus, it is important to chemically characterize and study the constituents of PyOM and total SOC in these environments and elucidate the role microbial communities play in their fates.

Fire-fueled changes also dramatically alter soil microbial communities. There is a considerable decrease in total soil biomass. Rehabilitation of these fire-affected soil is acutely delayed - requiring decades to fully re-establish healthy and diverse communities. Studies suggest that this delay in recovery is due to changes in functional capabilities (i.e. metabolic potentials and rates of organic matter decomposition) of the organisms utilizing this transformed soil. While we know that fires have dramatic effects on soil communities, the fundamental mechanisms and key taxa involved in driving the recovery of these communities remain enigmatic.

Recent work by Dr. Thomas Bruns' lab, has identified a group of pyrophilous fungi as the first colonizers of these pyrolyzed soils. One of these fungi, *Pyronema omphalodes*, was found at 26 sample locations in Stanislaus National Forest within the first month following the Rim Fire in Northern California. The Bruns' lab continued sampling these sites over the course of a year and found a clear, temporal, pattern of succession which was dominated by known pyrophilous fungi. Much less is known about the bacterial communities in these environments. Preliminary experiments in Dr. Thea Whitmans' lab have shown that bacterial communities can be selectively enriched by the addition of PyOM, some of these pyrophilous bacteria have been identified. Further the Whitman lab has shown that the dominant responders are members of the phyla Actinobacteria, Proteobacteria and Bacteroidetes. However, environmental studies have yet to be done to complement this work.

In order to close the gap and gain a clearer picture of the affects of fire on soil and microbial community recovery, we are conducting a year-long field study at Blodgett Forest Research Station in Georgetown, CA. We will use 16S rDNA bacterial community profiling and hope to observe a successional pattern, similar to the pyrophilous fungi observed by the Bruns' lab. Additionally, we will us LC/MS analysis to understand the pre- to post-fire soil chemistry and further understand how this changes over time. Together these data have the power to unveil the temporal patterns of PyOM degradation and the microbial powerhouses associated with these actions. Finally, we aim to recapitulate these observations in pyrocosms, which are experimentally tractable systems we use to mimic wild-fire conditions. We hope this work will further scientists' knowledge, insight and expertise of these blistered ecosystems and the community of organisms associated with them. Understanding microbial community re-establishment is essential for the secondary succession of plant communities, thus elucidating the initial stages of succession will greatly aide in the recovery of our forest ecosystems.

References

1. Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam, Warming and earlier spring increase western US forest wildfire activity. Science, 2006.313(5789): p. 940-943.
2. Gonzalez-Perez, J.A., F.J. Gonzalez-Vila, G. Almendros, and H. Knicker, The effect of fire on soil organic matter - a review. Environment International, 2004.30(6): p. 855-870.
3. Lehmann, J., J. Skjemstad, S. Sohi, J. Carter, M. Barson, P. Falloon, K. Coleman, P. Woodbury, and E. Krull, Australian climate-carbon cycle feedback reduced by soil black carbon. Nature Geoscience, 2008. 1(12): p. 832-835.
4. Köster, K., F. Berninger, A. Lindén, E. Köster, and J. Pumpanen, Recovery in fungal biomass is related to decrease in soil organic matter turnover time in a boreal fire chronosequence, in Geoderma2014, Elsevier B.V. p. 74-82.
5. Fontúrbel, M.T., A. Barreiro, J.A. Vega, A. Martín, E. Jiménez, T. Carballas, C. Fernández, and M. Díaz-Raviña, Effects of an experimental fire and post-fire stabilization treatments on soil microbial communities, in Geoderma2012, Elsevier B.V. p. 51-60.
6. Seaver, F.T., Studies in Pyrophilous Fungi: I. The Occurrence and Cultivation of Pyronema. Mycologia, 1909. 1(4): p. 131-139.
7. Whitman, T., Z. Zhu, and J. Lehmann, Carbon Mineralizability Determines Interactive Effects on Mineralization of Pyrogenic Organic Matter and Soil Organic Carbon, in Environmental Science & Technology2014. p. 13727-13734.