Determination of the Roles of Pyrophilous Microbes in the Breakdown and Sequestration of Pyrolyzed Forms of SOM

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Project Goals:

The frequency of large, high severity wild fires is increasing in the western US and in regions around the world due to long-term fire suppression strategies and climate change [1]. These fires have direct, negative effects on soil carbon stocks through combustion, but they have indirect and potentially positive effects on soil carbon stocks through the production of pyrolyzed organic matter (PyOM) [2]. **We are dissecting the effects of microbes on post-fire soil carbon dynamics by using a systems biology approach that couples small experimental "pyrocosms", highly controlled production of ^{13}C-labeled pyrolyzed substrates, genomics, transcriptomics, stable isotope techniques, and mass spectrometry.**

Post-fire soil systems are important to understand, because they have significant direct and indirect effects on global carbon storage. For example, fires result in a large amount of carbon that remains resident on the site as dead and partially pyrolyzed (*i.e.*, burnt under low oxygen) material that has long residence times and constitutes a major pool of C in fire-prone ecosystems [3],[4]. In addition, fire-induced hydrophobic soil layers, caused by condensation of pyrolyzed waxes and lipids, increase post-fire erosion and lead to long-term productivity losses [5]. Soil microbes are likely to be involved with the degradation of all of these compounds, yet little is currently known about the organisms or metabolic processes involved. We are using the following objectives and hypotheses to address our goal of understanding how the post-fire microbial community affects the fates of pyrolyzed carbon and soil carbon in post-fire soil environments:

Objectives:

1. Develop improved genomic and other -omic resources for the dominant microbes of fire-affected soils

2. Determine the temporal response of soil microbes to fire and to PyOM additions

3. Characterize the temporal patterns of degradation of different sub-fractions of PyOM

Hypotheses:

1. Specific microbes will colonize post-fire and PyOM-amended soils in a predictable sequence.

2.1. The earliest microbial colonizers will primarily target easily-mineralizable carbon sources.

2.2. Early microbial colonizers will be able to at least partially degrade the hydrophobic layer produced from fire.

2.3. The second stage microbial colonizers will target partially pyrolyzed lignocellulose and non-water-soluble PyOM.

3.1. PyOM additions will stimulate a subset of pyrophilous microbes independent of heat.

3.2. PyOM additions will result in changes in SOC mineralization rates.

We propose a physicochemical gradient model that evokes the steep heat gradient produced in soils by forest fires to predict the soil chemical environment and patterns of microbial recolonization. This model predicts that the post-fire soil environment is likely to be much simpler and more experimentally tractable than undisturbed soil systems. Preliminary work shows that the fungal community and at least a part of the bacterial community fit this model and are indeed simplified following fire. We further simplify this system by moving it into experimental "pyrocosms" that allow us to control and replicate the physiochemical gradient, and by using a "charcoalator" to create highly reproducible, ^{13}C-labeled forms of pyrolyzed carbon. In addition, we study the response of individual dominant organisms to these environments as well as the response of intact communities, and by deconstructing the community in this way, we expect to maximize the power of genomics and simplify the problem of interpreting metatranscriptomes and metabolomes. The combination of these relatively simple communities in the context of this heat structured, chemically complex, yet manipulable environment will give us unprecedented ability to dissect carbon storage in this pivotal system.

References

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