A Simple Pyrocosm for Controlled, Replicated Studies of Post-Fire Soil Microbial Communities

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Project Goals: Our goal is to produce an experimental system to study post-fire microbial communities that enables control and replication of key conditions.

Post-fire soil is a chemically distinct environment that is structured by depth in a predictable pattern due to the thermal properties of soil and the heat gradient that is produced by fire. The upper layers are rich in pyrolyzed organic material (PyrOM). These partially burned organic compounds include forms that are highly recalcitrant to degradation and effectively sequester carbon in the soil for decades [1, 2]. Volatilized waxes and lipids condense in the soil at shallow depths where the peak temperatures reach around 220^{o}C. This creates a hydrophobic zone that prevents water from percolating and facilitates surface runoff and erosion, which can reduce site productivity for decades [3-6].

Pyrophilous fungi are a specialized guild of post-fire saprobes that fruit exclusively on burned soil and appear in an ordered sequence following fire [7, 8]. These fungi are readily isolated into axenic culture and are known to grow rapidly in sterile or burnt soil [9, 10], but little is know about their function in post-fire soils. Recently it was found that some members of this guild dominate soil in the first months after forest fire (Bruns, unpublished results). We predict that pyrophilous fungi and other post-fire microbes are likely to interact with the unique post-fire soil chemistry in ways that impact carbon storage and long-term site productivity.

To test our predictions we developed a simple system the replicates the post-fire soil environment in controlled, repeatable ways and allows us to manipulate the key variables of heat, water, and inoculum. To that end we have developed a "pyrocosm," consisting of a metal bucket filled with 6.5 litters of unsterilized, dry forest soil, and topped with an organic/litter layer similar to intact forest soil. The bucket is buried in the ground to surface depth. A small fire is built on the surface of the soil, and heat at various depths is monitored with thermocouples for 12 hours. After soil has cooled to ambient soil temperature, it is wetted, covered, and incubated on site for three weeks.

By varying fuel loads and using amplicon metagenomics of the internal transcribed spacer region we have learned the following: 1) There is a lag time of several hours after the fire goes out before peak temperatures are achieved at a given depth. 2) Peak temperatures are predicted by the log10 of soil depth. 3) Controlling mass of coarse fuels yields repeatable temperature profiles, while flash fuels have almost no measurable effects. 4) *Pyronema spp*. are stimulated in uninoculated forest soil, and dominate the pyrocosm within one to two weeks.

The results are important for several reasons. First, the repeatability of the temperature profiles and the predicable depth gradient mimics the expected profile in forest fires [11]. Second, the stimulation and dominance of *Pyronema spp.* mimics closely what we see in real forest fire events. Thus, we have been able to recreate conditions that are biologically similar enough to forest fires that we can stimulate the major fungal dominant species seen in real fire events. Our next steps will be to verify that a soil chemical profile is also created that matches the profile expected of a real fire, and to test the way select soil microbes interact with it.

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