Pulse-Press Project – Jeb Barrett

Climate warming in polar regions is associated with thawing of permafrost, resulting in significant changes in soil hydrology, biogeochemical cycling, and in the activity and composition of soil communities. While ongoing, directional climate warming can elicit such responses over decadal time scales, their manifestation typically occurs as discrete thawing pulses. Indeed, in the McMurdo Dry Valleys of Antarctica abrupt changes in community structure and biogeochemical cycling in terrestrial and aquatic ecosystems following a summer warming event (Jan. 2002) exceeded the influences of a decadal cooling trend in both magnitude and rate of response (Foreman et al. 2004, Barrett et al. 2008). Thus, we anticipate that climate-mediated permafrost changes and their associated impacts on soil communities and biogeochemical cycles may occur over seasonal time scales. **Our objective is to simulate different frequencies of permafrost thawing events in Antarctic permafrost soils**. Since the top horizons of most Antarctic soils are dry permafrost (*i.e*., there is insufficient water content to generate ice-cement), with ice-cement or massive ice typically below 30 cm, permafrost thawing events are likely to result in subsurface movements of water that may manifest as groundwater seeps down gradient.

The south-facing hillslope of Many Glaciers Pond showing the location of the Pulse-Press Project. The large black structure on the ridge is a 1000 gallon holding tank. White boxes are insulated instrument power arrays and data storage modules (Photo: MCM LTER).

We designed a long-term study to address these objectives using a water diversion experiment introducing two frequencies of water additions from a natural pond to trenches excavated to the depth of ice-cement. In Dec. 2011 we established three sets of permanent plots (7.5 X 15m) on the south-facing hillslope above Many Glaciers Pond in Taylor Valley. High-resolution LIDAR imaging, instrumentation, and comprehensive pre-treatment sampling of all plots was conducted in Dec. of 2011, and in Jan. 2013, prior to an additional round of pre-treatment sampling and then initiation of the experiment anticipated in Jan. 2014. Instrumentation consists of thermocouples, delta-T moisture probes and water activity probes buried at multiple active-layer depths every 2 m down-gradient from the water-addition trenches. The three different plots will receive the following different treatments:

> PRESS Treatment: Annual water additions sufficient to raise soil water to 10% water content (as observed during the melt event in Jan. 2002). This is achieved by pumping water from Many Glaciers Pond to a holding tank above the experimental plots, from which we will apply water by gravity feed to a trench during the warmest week of the year (typically the 1st or 2nd week of Jan.).
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> PULSE Treatment: Same as above, but water diversions added only in alternate years to simulate a lower frequency of thawing permafrost
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> Positive Control: Trenched and instrumented, but no water additions

Sampling campaigns consist of 84 soil samples (28 per treatment) collected from permanent plots for quantification of soil biota (invertebrates determined by microscopy and bacteria by 16S rRNA sequencing) and intensive geochemical analyses.

This experiment will address the overarching hypothesis: *Climate warming in the McMurdo Dry Valleys will amplify connectivity among landscape units leading to enhanced coupling of nutrient cycles across landscapes, and increased biodiversity and productivity*. Specifically, this experiment was designed with H2 & H3 of the MCM4 proposal in mind. Simulated permafrost thaw is expected to mobilize solutes and nutrients within the active layer of treated plots, resulting in homogenization of the fine scale variation in surface geochemistry typically observed in this region (e.g. Barrett et al. 2006 & 2009). In contrast, responses of biotic communities to enhanced water availability and connectivity are expected to be complex. For example, wet sediments in stream channels and on lake margins typically have larger populations and more diverse invertebrate communities than dry environments (Treonis et al. 1999; Ayres et al. 2007), but lower diversity of bacteria (Takacs-Vesbach et al. 2010, Zeglin et al. 2011, Sokol et al. 2013). Most of our understanding of the response of soil biota to increased water availability comes from studies of spatial gradients (*e.g.*, Simmons et al. 2009, Takacs-Vesbach et al. 2010, Geyer et al. 2013). Fewer examples demonstrate temporal community responses to changes in soil resource availability (Barrett et al. 2008b), and little is known about the response of soil bacterial communities to environmental change in this region, though a recent study examining the activity of soil bacterial communities following addition of isotopically labeled water and organic matter showed that certain taxa of the phylum *Proteobaceria* were enriched during *in situ* incubations (Schwartz et al. in review).

Prediction

- Greater solute mobility and lower coefficient of variation in surface geochemistry in manipulated plots vs control plots
- Decreases in the dominant, arid-soil adapted species of invertebrate (*Scottnema lindsayae*) and increases in subordinate species adapted to wet sediments
- Changes in bacterial community composition between manipulated and control plots
- Changes in soil communities will be most significant in PRESS treatment and intermediate in PULSE plots, with greater compositional similarity between PULSE and control plots, relative to PRESS plots