Dominic A. Forlini

June 20, 2014

MELNHE

Bartlett Experimental Forest

**‘Microbial Respiration in response to N and P fertilizers treatments’**

**Hypothesis:**

In accordance to biological stoichiometry theory, we expect microbial respiration rates to be directly correlated to total inorganic P availability per unit of biomass within a northern hardwood forest soil system.

**Introduction / Background:**

Climatic changes in regard to current atmospheric CO2 emission rates and net N deposition values are primary factors towards the modifying nutrient influx of C and N, which soil systems are experiencing today (van Groenigen et al. 2006; Hyvonen et al 2007). Experimental evidence suggests that these global changes of C and N have transformed soil systems into a state of imbalance (van Groenigen et al. 2006). There are still many unknowns as to the response effect of environmental earth systems when exposed to modern day climactic conditions.

Our research observing microbial activity will be stationed at the Bartlett experimental forest in Bartlett, NH. In association with the Multiple Element Limitation in Northern Hardwood Ecosystems (MELNHE) project, we will be studying the retainment and limitations of N and P through soil nutrient additions of northern hardwood forest systems, and the response which this particular system exerts. The MELNHE project has been regularly adding N:P, N, and P treatments to determine post-treatment long-term response effects. The fertilizer treatment has been annually applied to the MELNHE stands since the spring of 2011.

There is a plethora of C and N cycling functions that occur within a northern hardwood forest biological system. When specifically observing total nutrient availability in soil systems, microbial cycling plays a pivotal role. Microbial enzymes released by process of metabolism offer essential nutrients that are used for a fertile soil chemistry. The production of these enzymes is dependent on the relative abundance of C, N, and P within the soil system. In response to alterations of nutrient availability ratios in part to human impact, changing climatic conditions, and land usage, microbial activity is a difficult to understand, yet essential, biological processes that contributes to overall system nutrient cycling (Hartman & Richardson 2013). It is suggested that microbial activity, both growth and respiration, is based on the fixed use of available nutrients ratios (Hartman & Richardson 2013). Total microbial biomass is attributed to the total N content available, whereas microbial respiration per amount of biomass seems to be associated with total P content availability (Hartman & Richardson 2013).

Based on the notion that microbial respiration is dependent on the relative availability of P in soils, it would be ideal to have a sense of the typical fixed ratios at which microbes function on. A relative study done on microbial biomass element ratios, indicates that there is an average C: N: P distribution of (60:7:1) for biomass and a distribution of (186:13:1) accounted for the soil system in which those microbes thrive in (Cleveland & Liptzin 2007). Although there were noticeable variances in total P abundance of biomass in regard to different vegetation habitats, the soil system C: N: P ratios held fairly consistent between grasslands and forested regions (Cleveland & Liptzin 2007). This leads us to believe that microbes in grassland ecosystems are more efficient users of P rather than that of microbes existing within a forested ecosystem. Possible explanations for the P usage efficiency of microbes may be attributed to total microbial biomass, on a population size driven factor (Hartman & Richardson 2013, Cotner et al 2010), or the complexity of organic matter associated with a particular ecosystem and the required energy for microbes to break down thus organic matter. Forested ecosystems are known to have complex organic matter within the system. As forest microbes breakdown leaf litter and fallen trees, they will have to use more energy in comparison to the energy they would be using to break down grassland organic matter. While we study microbial activity in a northern hardwood forest habitat, we can predict to see increased rates of respiration from P treated plots. Inorganic P availability in a northern hardwood forest should be directly related to microbial respiration potential.

When observing microbial processes in reference to stoichiometry, we can gather information on which nutrients are inevitably are entering a biological system, which nutrients leave that system, and how the overall concentrations of nutrients may affect the biological community associated with that particular soil makeup. (Mooshammer 2014). By studying the effects N and P fertilizers have on microbial respiration we can determine net C flux to and from the soil system via microbial activity, determine which fertilizer treatments either hinder or promote microbial activity, and associate whether the soil content may be nutrient limited in any aspect. As our knowledge of microbial activity grows, we can draw connections to possible applicable benefits which the soil system may hold.

**Field Methods:**

- Soil Cores

There are 13 total stands from which data will be gathered from. These stands are located within the Bartlett Experimental Forest, the Hubbard Brook Experimental Forest (HBEF), and the Jeffers Brook Experimental Forest (JBEF). Bartlett stands are labeled C1, C2, C3, C4, C5, C6, C7, C8, and C9. HBEF stands are labeled HBO, and HBM. JBEF stands are labeled JBO, and JBM.

Each stand holds 4 treatment plots. The 4 treatment plots associated with each stand are Control, N:P, N, and P. These four plots will be fertilized separately, and each trampled to simulate mirror miscellaneous damage due to the human impact of walking in the plots.

Within these 4 treatment plots, there are four 5m x 5m soil sub-plots. Our soil cores will come from these sub-plots. From each 5m x 5m sub-plot, 3 soil cores will be extracted. Those 3 soil cores will be complied with the other 9 soil cores gathered from the other three sub-plots in the respective treatment plot. Together, these will be divided into an Oe, Oa, and a B (Mineral) Horizon. There will be 3 soil samples per 1 treatment plot.

Samples will be taken from each horizon to serve for both timed incubation trial data to observe different microbial processes over timed intervals, and horizon comparison of microbial respiration activity from the differing soil compositions.

**Lab Methods:**

- Soil Dry Mass / Moisture Content Percentage

After retrieving our soil samples, we will first record soil dry mass and moisture content percentage values. Moisture content will affect the soil sample size, since they are based on a fixed mass. When higher moisture content is calculated, this will overall affect the total amount of microbes within the soil sample and thus total respiration values. By calculating soil dry mass and moisture content, we can manipulate calculations to compensate for these mass differences after field collection.

- Incubation

Incubation methodology will be conducted with base traps and done on 3 separate timed intervals. This will allow us to determine CO2 respiration values attributed solely from microbial activity. There will be a T1, T2, and T3 incubation time period, so that we can get sense of the microbial activity over a set amount of time.

- Titration

After incubation, we will take our base traps and titrate them in order to quantify net CO2 respiration by means of microbial activity. For each timed interval set (i.e. T1, T2, and T3) there will be 8 blank base traps so that we can account for CO2 particulates, not from microbial respiration, which may have seeped into our sample base traps.

**Future Implications:**

The results from this research would allow us to dig deeper into microbial processes within a northern hardwood forest ecosystem setting and how they can be manipulated to serve applicable purposes, while still maintaining a healthy environment.

- We will be able to determine net CO2 respiration of microbes and how that translates after they have been exposed to long-term applications of N:P, N, and P.

- We will be able to determine the susceptibility for C to be sequestered within, or emitted from the soil system solely by means of microbial activity.

- We will be able to determine microbial activity responses associated with N deposition by analysis of the N treatment plot data

- We will be able to determine a threshold among soil horizons as to where microbial activity is limited versus predominant.

-The microbial respiration data gathered will be a useful resource to forest management objectives, including the effects of climate change on the ecosystem and nutrient imbalances that may exist within the soil profile.

- When observing data from the separate fertilizer treatments, we should be able support the biological stoichimometry notion that microbial respiration per amount of biomass seems to be associated with total P content availability.

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