Annual Report for Period: 07/2011 - 06/2012

Submitted on: 05/21/2012

Principal Investigator: Fisk, Melany C.

Award ID: 0949317

Organization: Miami Univ

Submitted By:

Fisk, Melany - Principal Investigator

Title:

Collaborative Research: Nutrient co-limitation in young and mature northern hardwood forests

Project Participants

Senior Personnel

Name: Fisk, Melany

Worked for more than 160 Hours: Yes

Contribution to Project:

Post-doc

Graduate Student

Name: Ratliff, Tera

Worked for more than 160 Hours: Yes

Contribution to Project:

Tera Ratliff has coordinated sample processing and lab analyses as a lab technician for the past several years. She has analyzed soil P fractions, enzyme activities, and nutrient availability. Tera is now a graduate student on the project studying processes mediating nutrient availability and microbial stoichiometry and will defend her MS thesis this summer.

Name: Goswami, Shinjini

Worked for more than 160 Hours: Yes

Contribution to Project:

Shinjini Goswami is a PhD student studying plant species-specific above- and below-ground responses to nutrients

Undergraduate Student

Name: Geyser, Zach

Worked for more than 160 Hours: Yes

Contribution to Project:

Zach Geyser has collected and processed samples from field sites and assisted with soil nutrient and enzyme assays.

Name: Mikolaj, Zack

Worked for more than 160 Hours: Yes

Contribution to Project:

Zack Mikolaj is carrying out pre-treatment fungal community analysis for the project.

Name: Reidy, Matt

Worked for more than 160 Hours: No

Contribution to Project:

Matt Reidy has assisted with soil nutrient and enzyme assays.

Name: Ulm, Ashley

Worked for more than 160 Hours: No

Contribution to Project:

Ashley Ulm has assisted with fungal community analyses and soil nutrient and enzyme assays.

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Name: Dair, Ben

Worked for more than 160 Hours: Yes

Contribution to Project:

Ben Dair conducted an REU study testing limitation of microbial activity by nitrogen and phosphorus.

Organizational Partners

Cornell University

State University of New York - ESF

University of Michigan

Marine Biological Laboratory

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Findings: (See PDF version submitted by PI at the end of the report)

Training and Development:

Tera Ratliff (technician and MS student) has gained extensive lab experience by overseeing all laboratory work and training undergraduates to assist with and carry out analyses. She has been responsible for all soil chemical and biological analyses and presented work on patterns of nutrient availability and enzyme activity at the Ecological Society of America meetings in summer 2011. Tera is also learning the writing process while completing her MS thesis and preparing it for publication.

Shinjini Goswami (PhD student) was a member of our field crew in summer, 2011, and learned project and personnel management skills as well as field approaches for forest inventory. She has also learned data analysis and management by working with the large forest inventory data sets for the project, and has become proficient at soil nutrient analyses.

Zach Geyser, Zack Mikolaj, Matt Reidy, and Ashley Ulm (undergraduates) have learned soil and fungal community analyses. Ben Dair (undergraduate, REU) designed and carried out an independent project testing the influence of available C resources on the effects of N vs P on microbial activity and presented his work at ESA in summer 2011.

Outreach Activities:

Journal Publications

Naples, BK; Fisk, MC, "Belowground insights into nutrient limitation in northern hardwood forests", BIOGEOCHEMISTRY, p. 109, vol. 97, (2010). Published, 10.1007/s10533-009-9354-

Books or Other One-time Publications

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Conference Proceedings

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Activities and Findings: Any Outreach Activities
Any Book
Any Web/Internet Site
Any Product
Contributions: To Any within Discipline
Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering
Any Conference

Findings:

One of our goals in this study is to examine plant-soil feedbacks that potentially contribute to nutrient colimitation, via processes that promote balance among available nutrients. Our pre-treatment work in the Bartlett Experimental Forest has shown that plant roots forage primarily for P or Ca in forest stands where N availability is high. We have also found that allocation to phosphatase tends to increase P availability where N availability is high. These results suggest important mechanisms by which plants and soil organisms allocate effort to balance nutrient acquisition. Our results help us to understand spatial variation in biotic processes at the forest-stand level and provide an important background for testing responses by these processes to changes over time in nutrient availability, as we begin our treatments.

We tested the nutrient availability response to fertilizing during the first growing season of treatment (prior to plant litterfall), in an effort to separate the direct effect of nutrients from the possible plant-mediated feedbacks via changes in litter chemistry. We expected that fertilizing forests with a limiting nutrient (either N or P) would have the direct effect of promoting uptake of the other nutrient to maintain balanced nutrition in plants or decomposer organisms. Our results did not support this; in fact we found the opposite, that N and P together have a synergistic effect that appears to either reduce the uptake of N or to increase its mineralization.

One possible explanation for our results is that N+P together alleviate N limitation of enzyme production at the same time as they alleviate the demand for phosphatase enzymes, and that this creates excess N availability relative to the addition of N or P alone. Support for this idea would complement pre-treatment work in our study sites to suggest N use for P-mineralizing enzymes as a belowground mechanism for resource optimization. We plan to examine this question further this summer.

Research and Education Activities:

We are studying 13 replicate forest stands in central New Hampshire: 5 each of mature (>100 years) and young (30-35 yrs) age and 3 of very young (15-20 yrs) age. Four 50 x 50 m plots are delineated in each stand. The young and very young stands originated following clearcut harvest and forest composition is typical of early-successional hardwood forests of the region, with pin cherry, white birch, yellow birch, red maple, and beech common in the overstory. Mature forest overstory is dominated by beech, yellow birch, and sugar maple, with some white ash.

In our pretreatment work we analyzed patterns of net N mineralization, resin-available P, soil P fractions, soil microbial respiration and microbial N:P ratios across all stands in organic and mineral soil horizons. We found a clear positive relationship between N mineralization and resin-P availability that was somewhat surprising given the variation in forest age, species composition, and site characteristics that were encompassed by our study sites. Stoichiometry of the decomposer microbial community might be expected to mediate this process; however, we found no relationships between microbial N:P and nutrient availability. We did find a strong positive relationship between N mineralization and acid phosphatase activity (Figure 1) that suggests a mechanism by which organisms use available N to maintain balance with P availability. The relative abundance of organic P in these forests suggests that this resource is potentially available in response to further N enrichment, and we are in the process of analyzing soil P fractions to test whether slowly recycling fractions are depleted in forest stands with higher N availability. We are also in the process of pre-treatment analysis of soil fungal communities in a subset of our forest stands in order to identify potential functional groups of interest for future studies of hyphal foraging for different nutrient resources.

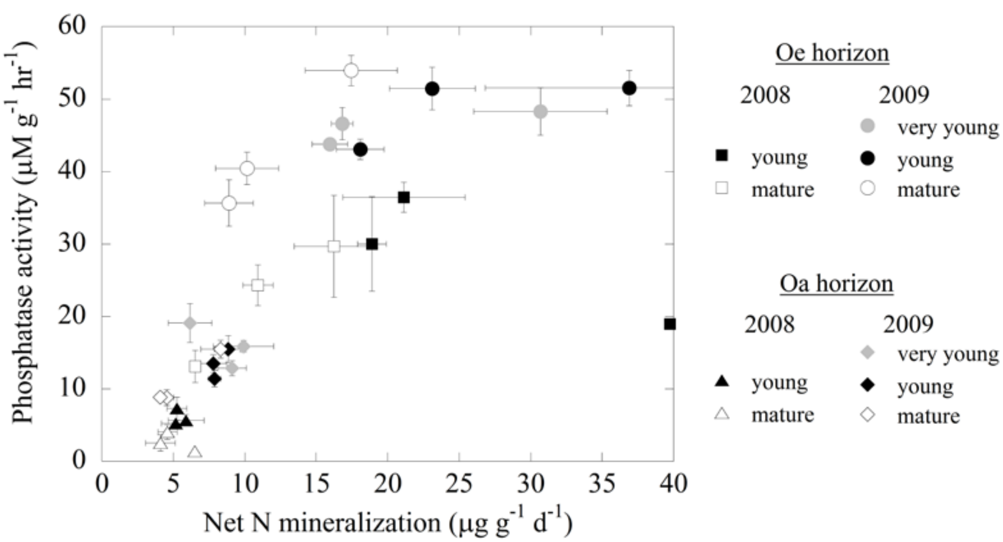

Figure 1. Relationship between phosphatase activity and net N mineralization potential in surface organic horizons of 9 forest stands (3 each of very young, young, and mature) in the Bartlett Experimental Forest, NH. Each data point represents a single stand; error bars are standard errors of the mean for 4 plots within each stand.

We completed our pre-treatment forest inventory in each stand in 2011. Inventory data were reduced and summarized and are available on our project website. Graduate student Shinjini Goswami analyzed this and a previous inventory dataset to test whether diameter growth rates of individual tree species vary in relation to N or P availability across stands, and found no patterns. Ms Goswami and SUNY-ESF student Craig See are currently analyzing production efficiency by species in relation to nutrient availability.

We began fertilizing in summer, 2011. In each of our 13 stands we randomly assigned control, nitrogen (N) addition, phosphorus (P) addition, and N+P addition treatments to the 4 plots. In mid-May and early July 2011 we fertilized all plots, adding in each dose 15 kg/ha of N as NH_4NO_3 and (or) 5 kg/ha of P as NaH_2PO_4 for a total of 30 kg/ha/yr of N and 10 kg/ha/yr of P. The level of P was high relative to N to account for potential fixation in soil. Fertilizer was spread by hand evenly over sub-plots delimited by strings. We imitated our fertilizer spreading procedure (without fertilizer) in control plots to ensure similarities among plots of any short-term disruption of the forest floor.

We quantified resin-available PO_4^-, NO_3^-, and NH_4^+ in soils of 9 of our forest stands (3 of each age, at Bartlett Experimental Forest) to test treatment effects on nutrient availability. We incubated anion and cation-exchange resin strips in the Oa horizon for 2 weeks, beginning in late July, 2 weeks after the second treatment application. Our treatments successfully raised N and P availability. Forest age had no consistent effect on the nutrient response to fertilization nutrient addition, and addition of one nutrient did not affect the availability of the other nutrient. The most surprising result was a substantial interactive effect of N+P on N availability (Figure 2).

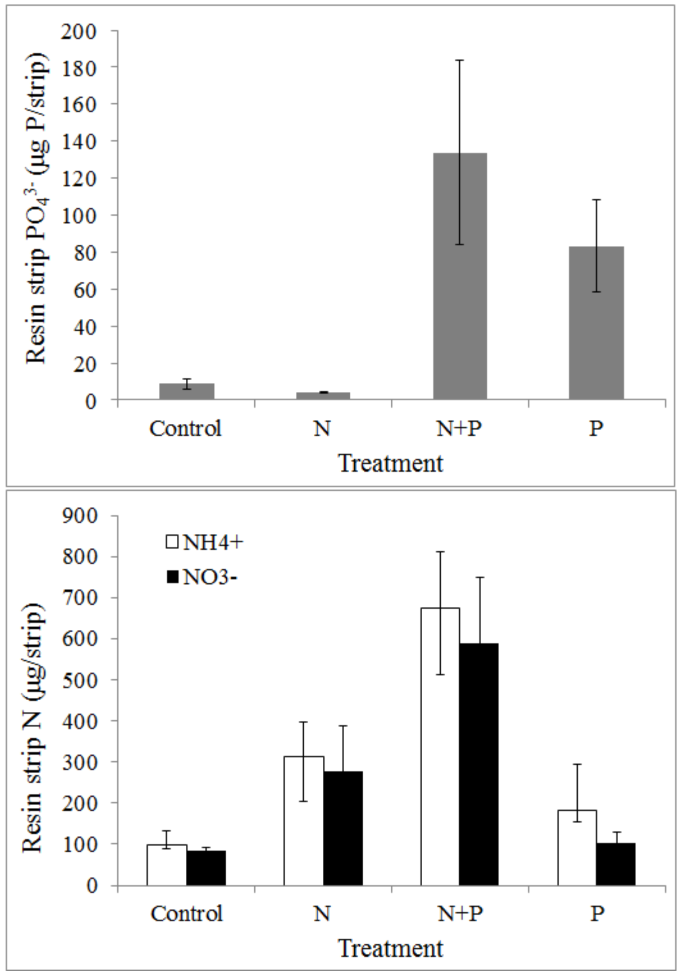

Figure 2 Resin-available P (top panel) or N (lower panel) in fertilized forest stands at the Bartlett Experimental Forest, NH. Error bars are standard errors of the mean; n = 9 stands (3 each of very young, young, and mature).