## Cover

Federal Agency and Organization Element to Which Report is Submitted:

4900

Federal Grant or Other Identifying Number Assigned by Agency:

0949317

Project Title:

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

PD/PI Name:

* Melany C Fisk, Principal Investigator

Recipient Organization:

Miami University

Project/Grant Period:

07/01/2010 - 06/30/2015

Reporting Period:

07/01/2013 - 06/30/2014

Submitting Official (if other than PD\PI):

N/A

Submission Date:

N/A

Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)

N/A

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## Accomplishments

### \* What are the major goals of the project?

The goals of this project are to 1) test nutrient limitation of productivity in northern hardwood forests and whether it changes as forest age, 2) test species-specific differences in responses to nutrients to examine the possibility of community-level co-limitation, and 3) examine plant-soil feedbacks that potentially contribute to nutrient co-limitation or modify limitation, via processes that promote balance among available nutrients.  If we find evidence of co-limitation of forest productivity, we will learn the underlying mechanisms in our combination of work on ambient landscape-scale spatial patterns and responses over time to treatments.

### \* What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?

Major Activities:

Fertilization of 13 forest stands of 3 forest ages, distributed across different parent materials, continued.   Responses by soil nutrient availability, enzyme activities, and microbial respiration have been quantified in all stands.  We continue to process samples from an experiment testing the possibility of species-specific foraging by fine roots for different nutrients, and we continue to measure survivorship, growth, allocation, and nutrition of sugar maple and beech seedlings from a large 2012 cohort.  We established a field experiment that will, over the next two years, test fine root and fungal foraging for the mineral P source apatite.   An RET participant began analyzing materials from his litter decomposition experiment.

Specific Objectives:

We are examining mechanisms by which plants and soil organisms allocate effort to balance nutrient acquisition, over the long-term (across spatial variation in fertility), and in the shorter-term in response to nutrient manipulations.  Objectives of our specific measurements in 2013 were to 1) test fine root foraging responses by 4 dominant tree species to N, P, Ca , and water, 2) test responses by N-, P-, and C-mineralizing enzymes and N and P availability  to fertilization with N, P, and Ca, and 3) compare over time the leaf area, root system architecture and mycorrhizal colonization with above- and below-ground growth and survivorship of seedlings of two dominant tree species.

Significant Results:

Nutrient availability clearly responded to treatments.  In addition to predictable increases in availability of the added nutrient, we found that Ca addition reduced NO3- and especially P availability.  We were surprised to find that soil enzyme activities did not respond to treatments, and we did not detect any shifts in enzyme kinetics with treatment.  We will repeat these measurements periodically over time to learn more about changes in enzyme activities in relation to resource availability and other measures of biotic response to our treatments.  Microbial respiration in surface organic horizons increased in response to P addition but did not respond consistently to N addition.

In the first year after germination, seedlings allocated more to root growth where soil moisture was higher and the root system architecture of sugar maple differed significantly from that of beech; other results of the seedling studies are still in progress and will continue for several years.

Litter decomposition experiments show evidence for indirect food web interactions in these forests, with exclusion of mesoarthropods causing an increase in decomposition rates.

Key outcomes or Other achievements:

nothing to report

### \* What opportunities for training and professional development has the project provided?

Shinjini Goswami, a PhD student, is developing her research abilities in this project by designing her own research (studies of seedlings, fine-root foraging, and species-specific productivity responses), learning field methods and lab techniques in both chemistry and molecular biology, and mentoring undergraduate assistants.  This year Goswami mentored undergraduate student Erin Collin under Miami's DUOS (Doctorate-Undergraduate Opportunity scholarship) program.  Collin was awarded the DUOS scholarship based on a research proposal that she wrote with Goswami, and the project culminated in a poster presentation at Miami's undergraduate research symposium.

Shan Shan, a PhD student, is developing her research abilities in this project by designing her own research (rhizosphere processes and microbial responses to nutrients),  and learning appropriate field and lab techniques.  Shan will be mentoring an REU student and they will collaborate on rhizosphere work.

Owen Patterson, an MS student, is learning molecular analysis of microbial communities and the data processing and statistical approaches that he will be using with high-throughput approaches.

Rick Biche and Joe Yahna are teachers in the NH public schools who were involved in our work through the RET program.   They have learned about the general scientific process by participating in our summer field crew (fertilizing, root foraging experiments, seedling surveys and collections, canopy measurements) and associated activities (weekly "science night" talks by Hubbard Brook scientists, preparation of a brief research proposal and sharing for review proposals among different field crew members and lead scientists).  Yahna brought high school volunteers into the field to assist, one of whom subsequently designed his own project testing effects of snow depth on sugar maple sap.  Yahna also used his experience to design work for his students; his 7th grade classes compare sap sugar content among several tree species, and his 8th grade classes develop and carry out a project testing health of different sugar bush trees based on their sap.   Biche initiated his own litter decomposition study testing N x P effects and their interactions with different size classes of invertebrates.  His middle school classes carried out much of this work, processing litter and learning about about methods of studying decomposition, retrieving litterbags from the field, quantifying decay, and extracting invertebrates.  Biche mentored an undergraduate student who was analyzing invertebrates, and developed invertebrate-based studies for use in his classroom.   He has used this project as a basis for developing an analysis of soil biodiversity that will be implemented throughout the school district every year.

### \* How have the results been disseminated to communities of interest?

A paper was published in Biogeochemistry in 2013.

Shinjini Goswami presented a poster at the ESA meetings in August, 2013.

Miami University undergraduate student Erin Collin presented a poster at the annual Miami Undergraduate Research Symposium, spring 2014.

Yahna and Biche have used experiences with our research group to develop science projects for middle and high school students and to involve other teachers in these efforts.

### \* What do you plan to do during the next reporting period to accomplish the goals?

We will continue quantifying nutrient availability, enzyme activities, microbial respiration, and microbial biomass C:N:P to assess microbial feedbacks to nutrient availability.  Total soil respiration is gradually declining in response to N and N+P treatments, in a pattern dependent on pre-treatment nutrient availability, and we will initiate rhizosphere work this summer to begin dissecting the specific mechanisms of this decline.   We will begin testing fertilizer effects on plant-root or mycorrhizal mediated weathering of apatite, a Ca-P mineral, and will continue work on ongoing projects by identifing fine roots to species in the foraging experiment and quantifying mycorrhizal responses to treatments on seedlings.  We will quantify forest productivity response to treatments next year (5th year of treatment).

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## Products

### Books

### Book Chapters

### Conference Papers and Presentations

### Inventions

### Journals

* Fisk MC, Ratliff TJ, Goswami S, Yanai RD (2014). Synergistic soil response to nitrogen plus phosphorus fertilization in hardwood forests.  Biogeochemistry. 118 (1-3),  195. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: DOI 10.1007/s10533-013-9918-1
* Rastetter EB, Yanai RD, Thomas RQ, Vadeboncoeur MA, Fahey TJ, Fisk MC, Kwiatkowski BL, Hamburg SP (2013). Recovery from disturbance requires resynchronization of ecosystem nutrient cycles..  Ecological Applications. 23  621. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

### Licenses

### Other Products

### Other Publications

### Patents

### Technologies or Techniques

### Thesis/Dissertations

### Websites

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## Participants/Organizations

### Research Experience for Undergraduates (REU) funding

Form of REU funding support:

REU supplement

How many REU applications were received during this reporting period?

0

How many REU applicants were selected and agreed to participate during this reporting period?

0

REU Comments:

### What individuals have worked on the project?

| **Name** | **Most Senior Project Role** | **Nearest Person Month Worked** |
| --- | --- | --- |
| [Fisk, Melany](https://reporting.research.gov/rppr-web/rppr?execution=e1s51#participant_0) | PD/PI | 2 |
| [Biche, Rick](https://reporting.research.gov/rppr-web/rppr?execution=e1s51#participant_1) | K-12 Teacher | 2 |
| [Yahna, Joe](https://reporting.research.gov/rppr-web/rppr?execution=e1s51#participant_2) | K-12 Teacher | 2 |
| [Goswami, Shinjini](https://reporting.research.gov/rppr-web/rppr?execution=e1s51#participant_3) | Graduate Student (research assistant) | 6 |
| [Patterson, Owen](https://reporting.research.gov/rppr-web/rppr?execution=e1s51#participant_4) | Graduate Student (research assistant) | 2 |
| [Shan, Shan](https://reporting.research.gov/rppr-web/rppr?execution=e1s51#participant_5) | Graduate Student (research assistant) | 1 |
| [Babel, Hannah](https://reporting.research.gov/rppr-web/rppr?execution=e1s51#participant_6) | Undergraduate Student | 1 |
| [Collin, Erin](https://reporting.research.gov/rppr-web/rppr?execution=e1s51#participant_7) | Undergraduate Student | 2 |

### Full details of individuals who have worked on the project:

|  |
| --- |
| **Melany C Fisk****Email:** fiskmc@miamioh.edu**Most Senior Project Role:** PD/PI**Nearest Person Month Worked:** 2 **Contribution to the Project:** Fisk supervised students and technicians working on the project, managed project data, carried out field and lab work, and wrote a manuscript.**Funding Support:** this project and Hubbard Brook LTER grant**International Collaboration:**  No **International Travel:**  No  |
| **Rick Biche****Email:** r\_biche@sau9.org**Most Senior Project Role:** K-12 Teacher**Nearest Person Month Worked:** 2 **Contribution to the Project:** Rick Biche is an RET participant who studied litter decomposition and designed a study of soil biodiversity for middle school students in his school district.**Funding Support:** this award**International Collaboration:**  No **International Travel:**  No  |
| **Joe Yahna****Email:** jyahna13@gmail.com**Most Senior Project Role:** K-12 Teacher**Nearest Person Month Worked:** 2 **Contribution to the Project:** Joe Yahna is an RET participant who assisted with all aspects of field work, especially seedling surveys and collection, and designed projects for his middle and high school students to study sugar maple sap.**Funding Support:** this award**International Collaboration:**  No **International Travel:**  No  |
| **Shinjini Goswami****Email:** goswams@miamioh.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 6 **Contribution to the Project:** Shinjini Goswami is a PhD student studying plant species-specific above- and below-ground responses to nutrients**Funding Support:** this award, NSF Hubbard Brook LTER grant**International Collaboration:**  No **International Travel:**  No  |
| **Owen Patterson****Email:** patteroe@miamoh.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 2 **Contribution to the Project:** Owen Patterson is a masters student characterizing spatial distribution of soil fungal communities.**Funding Support:** this award, NSF Hubbard Brook LTER grant**International Collaboration:**  No **International Travel:**  No  |
| **Shan Shan****Email:** shans@miamioh.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 1 **Contribution to the Project:** Shan is a PhD student studying plant-microbial interactions in the rhizosphere.**Funding Support:** this award, NSF Hubbard Brook LTER grant**International Collaboration:**  No **International Travel:**  No  |
| **Hannah Babel****Email:** babelhr@miamioh.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 1 **Contribution to the Project:** Hannah Babel is an undergraduate who carried out soil analyses.**Funding Support:** this award, Miami University Department of Biology**International Collaboration:**  No **International Travel:**  No  |
| **Erin Collin****Email:** collineg@miamioh.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 2 **Contribution to the Project:** Erin Collin is an undergraduate student who characterized seedling allometry.**Funding Support:** this award, Miami University Department of Biology**International Collaboration:**  No **International Travel:**  No  |

### What other organizations have been involved as partners?

| **Name** | **Type of Partner Organization** | **Location** |
| --- | --- | --- |
| [Cornell University](https://reporting.research.gov/rppr-web/rppr?execution=e1s51#organization_0) | Academic Institution | Ithaca, NY |
| [Marine Biological Laboratory](https://reporting.research.gov/rppr-web/rppr?execution=e1s51#organization_1) | Other Nonprofits | Woods Hole, MA |
| [SUNY-Environmental Science and Forestry](https://reporting.research.gov/rppr-web/rppr?execution=e1s51#organization_2) | Academic Institution | Syracuse NY |
| [University of Michigan](https://reporting.research.gov/rppr-web/rppr?execution=e1s51#organization_3) | Academic Institution | Ann Arbor, MI |

### Full details of organizations that have been involved as partners:

|  |
| --- |
| **Cornell University****Organization Type:** Academic Institution**Organization Location:** Ithaca, NY **Partner's Contribution to the Project:**Collaborative Research **More Detail on Partner and Contribution:**  |
| **Marine Biological Laboratory****Organization Type:** Other Nonprofits**Organization Location:** Woods Hole, MA **Partner's Contribution to the Project:**Collaborative Research **More Detail on Partner and Contribution:**  |
| **SUNY-Environmental Science and Forestry****Organization Type:** Academic Institution**Organization Location:** Syracuse NY **Partner's Contribution to the Project:**Collaborative Research **More Detail on Partner and Contribution:**  |
| **University of Michigan****Organization Type:** Academic Institution**Organization Location:** Ann Arbor, MI **Partner's Contribution to the Project:**Collaborative Research **More Detail on Partner and Contribution:**  |

### Have other collaborators or contacts been involved? No

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## Impacts

### What is the impact on the development of the principal discipline(s) of the project?

The interactive effects of different nutrients that we are finding contribute to the growing recognition that it can be difficult to understand ecosystem processes based on study of individual nutrients alone.  We hope that this will help us to learn why, in some cases, results are not generalizable across ecosystems.

### What is the impact on other disciplines?

Nothing to report.

### What is the impact on the development of human resources?

Nothing to report.

### What is the impact on physical resources that form infrastructure?

Nothing to report.

### What is the impact on institutional resources that form infrastructure?

Nothing to report.

### What is the impact on information resources that form infrastructure?

Nothing to report.

### What is the impact on technology transfer?

Nothing to report.

### What is the impact on society beyond science and technology?

Our RET participants have translated their experiences in our project into engaging field and classroom experiences  for their students and other teachers and students in their school district.  This will likely improve the appreciation and understanding of science by some of these students, including those who do not pursue careers in science.

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## Changes/Problems

### Changes in approach and reason for change

Nothing to report.

### Actual or Anticipated problems or delays and actions or plans to resolve them

Nothing to report.

### Changes that have a significant impact on expenditures

Nothing to report.

### Significant changes in use or care of human subjects

Nothing to report.

### Significant changes in use or care of vertebrate animals

Nothing to report.

### Significant changes in use or care of biohazards

Nothing to report.

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* [Privacy Policy](https://identity.research.gov/sso/idpssoinit?NameIDFormat=urn:oasis:names:tc:SAML:2.0:nameid-format:transient&metaAlias=/research/idp&spEntityID=https://www.research.gov/sso/sp&binding=urn:oasis:names:tc:SAML:2.0:bindings:HTTP-POST&RelayState=https%3A%2F%2Fwww.research.gov%2Fresearch-portal%2Fredirect.jsp%3FTARGET%3Dhttps%253A%252F%252Fwww.research.gov%252Fresearch-portal%252Fappmanager%252Fbase%252Fdesktop%253F_nfpb%253Dtrue%2526_pageLabel%253Dresearch_privacypolicy)
* [FOIA](http://www.nsf.gov/policies/foia.jsp)
* [No Fear Act Data](http://www.nsf.gov/od/odi/notice.jsp)
* [USA.gov](https://reporting.research.gov/rppr-web/exit.jsp?link=http%3a%2f%2fwww.usa.gov)
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