

Preview of Award 0949324 - Annual Project Report

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Cover

Federal Agency and Organization Element to Which Report is Submitted: 4900

Federal Grant or Other Identifying Number Assigned by Agency: 0949324

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

PD/PI Name: Ruth D Yanai, Principal Investigator

Recipient Organization: SUNY College of Environmental Science and Forestry

Project/Grant Period: 07/01/2010 - 06/30/2015

Reporting Period: 07/01/2013 - 06/30/2014

Submitting Official (if other than PD\PI): Ruth D Yanai
Principal Investigator

Submission Date: 05/19/2014

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

Accomplishments

* What are the major goals of the project?

To test for co-limitation by N and P of aboveground production in young and old northern hardwood stands; to evaluate mechanisms for maintaining co-limitation of N and P; and to predict the long-term forest response to anticipated future conditions using a revised and improved Multiple Element Limitation (MEL) model.

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

Major Activities: Activities this year included maintaining fertilizer treatments; collecting foliar, litter and soil samples; incubating soils for carbon and nitrogen mineralization; collecting maple sap for sugar content; monitoring soil respiration, root turnover, and sap flow, and processing and analyzing samples and data.

Specific Objectives: We were excited to detect the first foliar response to nutrient addition. Sugar maple foliage shows the effect of N (see attached PDF, Fig 1) and P addition (Fig 2) at Jeffers Brook. The CaSiO₃ addition resulted in higher Si but not higher Ca in foliage at all sites. In addition, we have evidence that soil N content is driving foliar P resorption (Fig 3). Furthermore, N was associated with an increase in maple sap sweetness (Figure 4).

Significant Results:

Key outcomes or Other achievements:

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

Training and development continue to rely on active interactions among PIs and senior scientists, science teachers, post-docs, graduate students, undergraduates and technicians. Weekly conference calls allow PIs and students to discuss results and future plans, and frequent email on specific topics are used to monitor progress and solicit advice. Weekly Science Nights with visiting speakers, alternating between the dormitories at Bartlett and Hubbard Brook, remain a feature during the summer field season. Each undergraduate and graduate student has a mentor or a committee of mentors, who review proposals and consult on implementation of projects. Most of our students, including the summer crew, have presented talks at the annual HBES Cooperators' Meeting. They have also presented their final reports at a symposium in August, shared with REU students from Hubbard Brook.

Collaboration continues with the Crosby Middle School science department, as their students investigate the site during their academic year. The overlapping field seasons also provide opportunities for the middle school students to ask questions of the higher ed participants.

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

Journal publications, conferences, websites. (as detailed below)

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

Nutrient additions will continue along with monitoring plant and microbial responses to treatments. Several manuscripts are in preparation. At least one new graduate student will join the project.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
MELNHE annual 2014 figures.pdf	Figures to accompany "Significant Results"	Ruth Yanai	05/08/2014

***See next 2 pages! Thanx!

Products

Books

Book Chapters

Conference Papers and Presentations

Wild, A., and R. Yanai. (2014). *Do Nutrients Make Maple Sap Sweeter?*. New York Society of American Foresters Annual Winter Meeting. Syracuse NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Goswami, S., C. See, M. Fisk, M. Vadeboncoeur, and R. Yanai. (2012). *Evidence for species-specific nutrient limitation of growth efficiency in northern hardwoods..* Long Term Ecological Research All Scientists Meeting. Estes Park, CO. Status = OTHER; Acknowledgement of Federal Support = Yes

Fisk, Melany, Tera Ratliff, Shinjini Goswami, Craig See, Brendan Naples, Ruth Yanai, Matt Vadeboncoeur, Tim Fahey. (2012). *Examining nutrient co-limitation in northern hardwood forests..* Long Term Ecological Research All Scientists Meeting. Estes Park, CO. Status = OTHER; Acknowledgement of Federal Support = Yes

Bae, K., and R.D. Yanai (2012). *Fertilization effects on soil respiration, root respiration, and microbial respiration in northern hardwoods of New Hampshire..* Rochester Academy of Science. Rochester, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Wild, A., and R. Yanai. (2014). *First Signs of a Foliar Treatment Response in the Multiple Element Limitation in Northern Hardwood Forest Ecosystem Study.* Hubbard Brook Committee of Scientist Spring Meeting. Millbrook NY. Status = OTHER; Acknowledgement of Federal Support = Yes

See, C.R., R.D. Yanai, M.C. Fisk. (2013). *Foliar N:P ratios and resorption efficiencies provide evidence of nutrient*

Figure 1. N treatment resulted in higher foliar N only at Jeffers Brook.

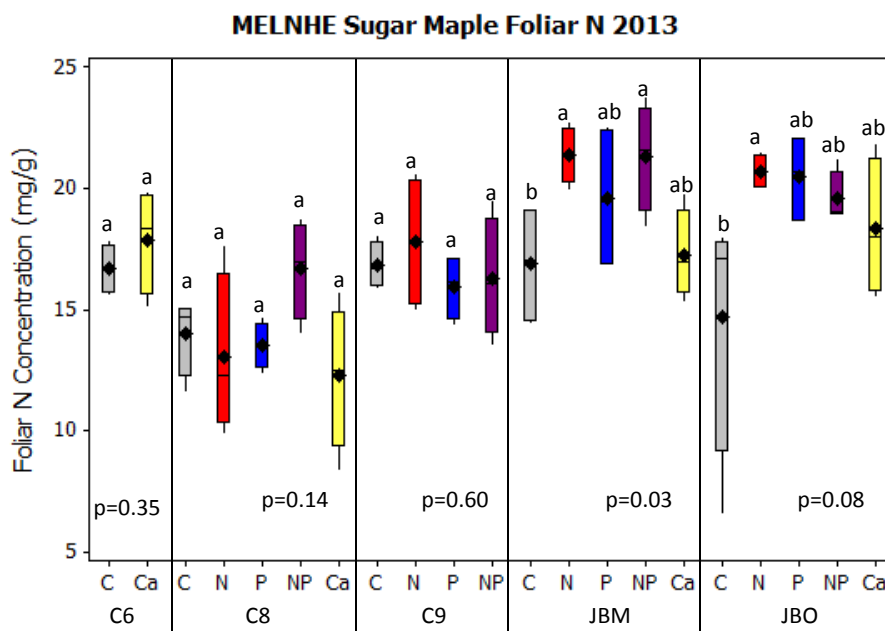


Figure 2. P treatment resulted in higher foliar P only at Jeffers Brook.

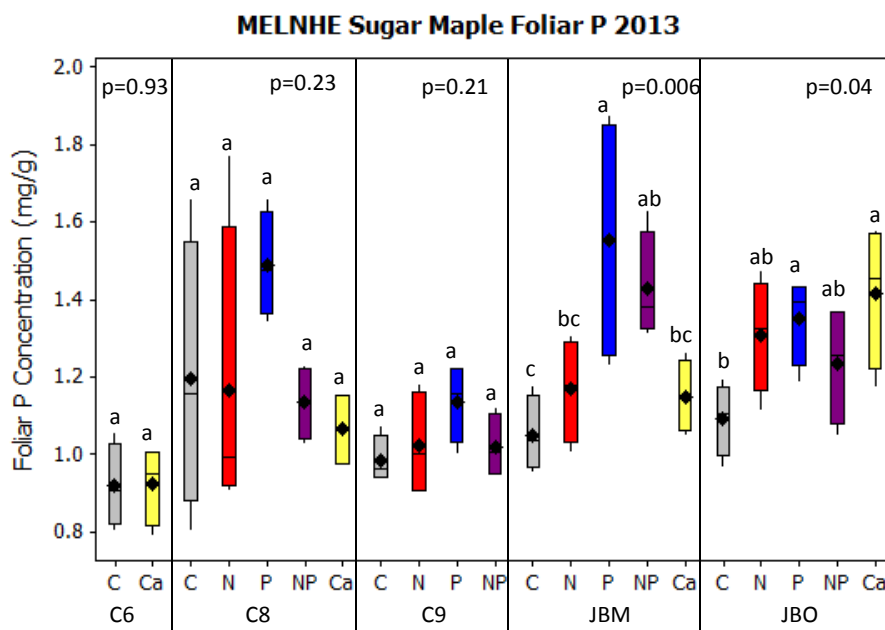


Figure 3. Soil N content drives foliar P resorption.

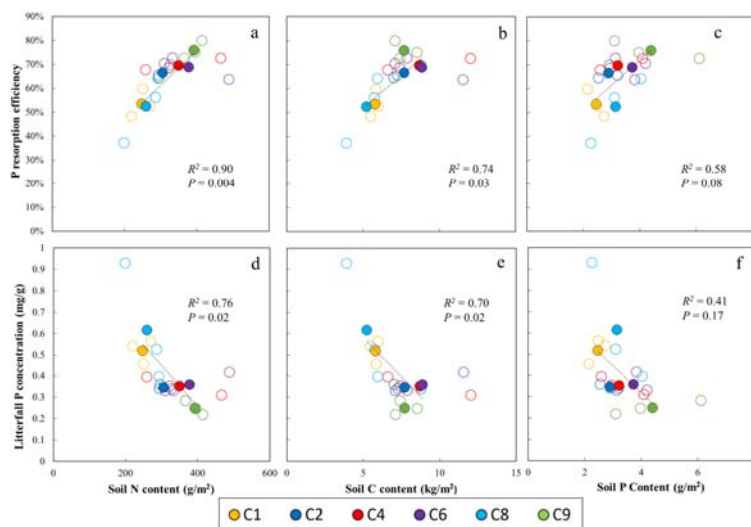
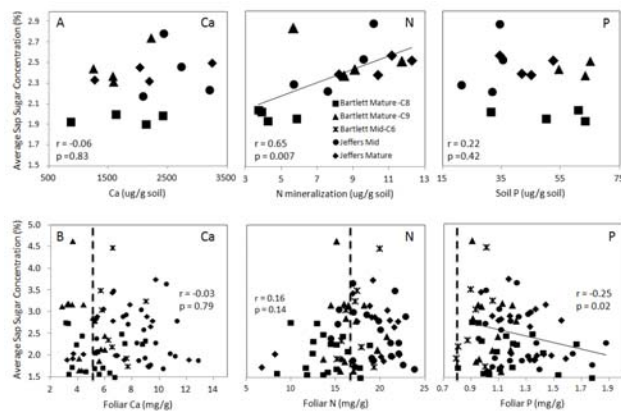


Figure 4. (A) Sap sweetness as a function of exchangeable soil Ca, potential N mineralization, and extractable P. Plots with higher potential N mineralization had trees with sweeter sap. (B) Sap sweetness as a function of foliar Ca, N, P, by tree. The vertical dashed line represents the threshold for nutrient deficiency (Kolb & McCormick 1993).



co-limitation in a northern hardwood forest. Northeastern Natural History Conference. Springfield, MA. Status = OTHER; Acknowledgement of Federal Support = Yes

Diggs, Franklin, R.D. Yanai, and Thomas Horton. (2013). *Mycorrhizal guilds decline similarly with depth in two northern hardwood forests.* Ecological Society of America Annual Meeting. Minneapolis, MN. Status = OTHER; Acknowledgement of Federal Support = Yes

Bae, Kikang, Ruth D. Yanai, Melany C. Fisk, and Timothy J. Fahey (2013). *N and P fertilization effects on soil respiration and microbial respiration in northern hardwood forests of New Hampshire.* Ecological Society of America Annual Meeting. Minneapolis, MN. Status = OTHER; Acknowledgement of Federal Support = Yes

See, C., B.A. Quinero, and R.D. Yanai (2012). *Nitrogen and phosphorus resorption efficiency ratios vary with stand age in northern hardwoods.* Ecological Society of America Annual Meeting. Portland, OR. Status = OTHER; Acknowledgement of Federal Support = Yes

Bae, K., R. Yanai, and T. Fahey (2012). *No fertilization effects on soil respiration and root respiration in northern hardwoods of New Hampshire.* Long Term Ecological Research All Scientists Meeting. Estes Park, CO. Status = OTHER; Acknowledgement of Federal Support = Yes

Wild, A., and R. Yanai. (2013). *Project Sweeter Sap: Do Soil Nutrient Make Maple Sap Sweeter?.* Rochester Academy of Science Fall Paper Session. Rochester NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Wild, A., and R. Yanai. (2013). *Project Sweeter Sap: Increasing the Sugar Concentration of Sugar Maple Sap Through Nutrient Additions.* Syracuse University Life Sciences Research Showcase. Syracuse, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

See, C.R., and R.D. Yanai. (2013). *Soil nitrogen drives community-level phosphorus resorption in a co-limited system: evidence from a northern hardwood forest.* American Geophysical Union Fall Meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Yanai, Ruth D., Kikang Bae, Carrie R. Levine, Craig R. See, Matthew A. Vadeboncoeur, Steven P. Hamburg, Joel D. Blum, and Mary A. Arthur. (2013). *Sustainable forest harvest requires calcium supply from soil pools: Ecosystem budgets for second-growth northern hardwoods in New Hampshire.* Ecological Society of America Annual Meeting. Minneapolis, MN. Status = OTHER; Acknowledgement of Federal Support = Yes

Bae, K., Yanai, R.D., S.P. Hamburg, J.D. Blum, M.A. Arthur, M.A. Vadeboncoeur, C.R. See, and C.R. Levine. (2012). *Sustainable harvest requires calcium supply from soil pools: Ecosystem budgets for second-growth northern hardwoods in New Hampshire.* Ecological Society of America Annual Meeting. Portland, OR. Status = OTHER; Acknowledgement of Federal Support = Yes

Wild, A., and R. Yanai (2013). *Sweet Times in the MELNHE Plots: Do Soil Nutrients Make Maple Sap Sweeter.* Hubbard Brook Cooperators Meeting. North Woodstock, NH. Status = OTHER; Acknowledgement of Federal Support = Yes

Goswami, Shinjini, Melany C. Fisk, Tera J. Ratliff, and Ruth D. Yanai. (2013). *Synergistic soil response to nitrogen plus phosphorus fertilization in hardwood forests.* Ecological Society of America Annual Meeting. Minneapolis, MN. Status = OTHER; Acknowledgement of Federal Support = Yes

See, C.R., H.A. Tremblay, R.D. Yanai (2012). *The Grass is always greener: nitrogen processes in lawns and adjacent forest land in the White Mountains.* 10th Annual Symposium in Plant Biology. Amherst, MA. Status = OTHER; Acknowledgement of Federal Support = Yes

Diggs, F.D., R.D. Yanai, T.R. Horton (2012). *Variance in mycorrhizal colonization in stands of mixed hosts.* Rochester Academy of Science. November 10, 2012. Rochester, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Inventions

Journals

Fahey, T.J., R.D. Yanai, M.C. Fisk (2014). Nitrogen availability reduces soil respiration and belowground carbon allocation

in northern hardwood forests of New Hampshire. *Ecosystems*. tbd tbd. Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Fisk, Melany C., Tera J. Ratliff, Shinjini Goswami, and Ruth D. Yanai. (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: 10.1007/s10533-013-9918-1

See, Craig R., R.D. Yanai, and M.A. Vadeboncoeur (). Foliar phosphorus resorption increases with soil nitrogen: evidence of nutrient co-limitation in northern hardwoods. *Ecology*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes

Vadeboncoeur, MA, Hamburg SP, Yanai RD, Blum JD. (2014). Rates of sustainable forest harvest depend on rotation length and weathering of soil minerals.. *Forest Ecology and Management*. 318 194. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.foreco.2014.01.012

Yanai, R.D., C.A. Blodgett, K. Bae, and B.B. Park. (). Nutrient concentrations of roots vary with diameter, depth, and site in New Hampshire northern hardwoods.. *Journal of Forest Research*. . Status = SUBMITTED; Acknowledgment of Federal Support = Yes

Yanai, R.D., M.A. Vadeboncoeur, S.P. Hamburg, M.A. Arthur, M.A. Fuss, P.M.Groffman, T.G. Siccama, and C.T. Driscoll (2013). From Missing Source to Missing Sink: Long-Term Changes in a Forest Nitrogen Budget.. *Environmental Science & Technology*. 47 (20), 11440. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1021/es4025723

Licenses

Other Products

Physical Collections.

Physical collection. Many samples with long-term value are stored at SUNY-ESF and tracked through a system developed by the Soil Fertility Laboratory. Samples in active use are at many locations. Samples are tracked on a googledoc. Resultant data is shared among cooperators via <http://www.esf.edu/melnhe>

Other Publications

Patents

Technologies or Techniques

Thesis/Dissertations

Bae, Kikang. *Belowground Carbon Fluxes in Response to Nutrient Availability in a Northern Hardwood Forest*. (2013). SUNY College of Environmental Science and Forestry. Acknowledgement of Federal Support = Yes

See, Craig R.. *Foliar resorption in a northern hardwood forest*. (2013). SUNY College of Environmental Science and Forestry. Acknowledgement of Federal Support = Yes

Vadeboncoeur, Matthew A. *Mechanisms of nutrient limitation and nutrient acquisition in managed and unmanaged forest ecosystems*. (2013). University of New Hampshire. Acknowledgement of Federal Support = Yes

Wild, Adam D.. *Soil Nutrients Affect Sweetness of Sugar Maple Sap*. (2014). SUNY College of Environmental Science and Forestry. Acknowledgement of Federal Support = Yes

Websites

Multiple Element Limitation in Northern Hardwood Ecosystems

<http://www.esf.edu/MELNHE>

We use the MELNHE website to provide news blurbs about the project to any interested party, and also use a password protected section to share data, photos, and documentation among collaborators.

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? 40

How many REU applicants were selected and agreed to participate during this reporting period? 4

REU Comments:

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Yanai, Ruth	PD/PI	1
Garrison-Johnston, Mariann	Faculty	1
Wang, Haiyan	Faculty	2
Engelman, Heather	Technician	1
See, Craig	Technician	2
Wild, Adam	Technician	2
Barr, Brannon	Graduate Student (research assistant)	1
Kendrick, Joseph	Research Experience for Undergraduates (REU) Participant	1
MacPherson, Eric	Research Experience for Undergraduates (REU) Participant	1
McLin, Megan	Research Experience for Undergraduates (REU) Participant	1
Warner, Cleo	Research Experience for Undergraduates (REU) Participant	1

Full details of individuals who have worked on the project:

Ruth D Yanai

Email: rdyanai@syr.edu

Most Senior Project Role: PD/PI

Nearest Person Month Worked: 1

Contribution to the Project: Dr. Yanai coordinates the project, oversees study design, staff and students, and coordinates communication among collaborators.

Funding Support: State of New York, SUNY College of Environmental Science and Forestry

International Collaboration: No

International Travel: No

Mariann Garrison-Johnston

Email: mjohnston@esf.edu

Most Senior Project Role: Faculty

Nearest Person Month Worked: 1

Contribution to the Project: Dr. Johnston has been involved in a study of beech bark disease and has a “satellite” fertilization study in Wanakena, NY.

Funding Support: State of New York, SUNY College of Environmental Science and Forestry

International Collaboration: No

International Travel: No

Haiyan Wang

Email: haiyanwang72@aliyun.com

Most Senior Project Role: Faculty

Nearest Person Month Worked: 2

Contribution to the Project: Dr. Wang gained field experience at our site in Bartlett, NH, by assisting with fertilization; litter sorting; soil respiration and minirhizotron measurements; soil sampling and subsequent lab incubations and extractions; and collected green foliage from standing trees.

Funding Support: China Scholarship Council supported her sabbatical from Beijing Forestry University’s department of Soil Science.

International Collaboration: Yes, China

International Travel: No

Heather Engelman

Email: forestecology@esf.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 1

Contribution to the Project: Heather provides administrative support for the project, including preparation of reports and maintenance of www.esf.edu/melnhe

Funding Support: Heather also worked part-time on another NSF project, and was supported by it. She also has a small FTE state position.

International Collaboration: No

International Travel: No

Craig R See

Email: craigrsee@gmail.com

Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Craig was a Research Support Specialist at SUNY-ESF, and is continuing as a Research Analyst. He served as the summer field crew chief, and has prepared and analyzed many samples.

Funding Support: Craig also worked part-time on another NSF project, and was supported by it.

International Collaboration: No

International Travel: No

Adam D Wild

Email: adamdwild@gmail.com

Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Adam started with MELNHE as "Other" and continued as a grad student, heavily supporting field work and the REU participants. He continued with the project as crew chief in 2014.

Funding Support: Time as a student also supported by NSRC, a coaching position, and teaching assistships.

International Collaboration: No

International Travel: No

Brannon Barr

Email: barrbrannon@gmail.com

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 1

Contribution to the Project: Brannon assisted with statistical analyses, apatite core insertion, and soil sampling. On the field crew, he was involved with site maintenance, fertilization, and sample collection and sorting.

Funding Support: Brannon also had a TA.

International Collaboration: No

International Travel: No

Joseph Kendrick

Email: joseph.alexander.kendrick@gmail.com

Most Senior Project Role: Research Experience for Undergraduates (REU) Participant

Nearest Person Month Worked: 1

Contribution to the Project: Joe joined us between his junior and senior years at Bennington College, where he is working toward a BA with concentration in ecology. His project was entitled: Measuring leaf area index above locust seedlings. He also compared soil moisture in Ca addition and control plots by monitoring the soil moisture sensors he had repaired. On the field crew, he was involved with site maintenance, fertilization, sample collection and sorting, and tree canopy assessment.

Funding Support: limited to REU

International Collaboration: No

International Travel: No

Year of schooling completed: Junior

Home Institution: Bennington College

Government fiscal year(s) was this REU participant supported: 2013

Eric MacPherson**Email:** emacpherson@mail.smcvt.edu**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant**Nearest Person Month Worked:** 1

Contribution to the Project: Eric joined us between his junior and senior years at St. Michael's College, where he is a biology major. His project: Does addition of Ca increase the growth of sugar maples trees or seedlings? He measured all sugar maple trees in the Ca addition plots and control plots and measured saplings and seedlings in subplots. He found that Ca significantly increased the growth of sugar maple trees. Eric also participated on the field crew, as described above

Funding Support: limited to REU**International Collaboration:** No**International Travel:** No**Year of schooling completed:** Junior**Home Institution:** St. Michael's College**Government fiscal year(s) was this REU participant supported:** 2013**Megan McLin****Email:** meganmclin1@gmail.com**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant**Nearest Person Month Worked:** 1

Contribution to the Project: Megan McLin joined us between her junior and senior years at the historically black Tougaloo College, where she majors in biology. Her project was entitled: Arbuscular mycorrhizal fungi and ectomycorrhizal fungi colonization on Populus roots after a nitrogen addition. She found that N decreased colonization. A presentation on this work earned second place in Tougaloo College's scientific research spotlight. On the field crew, Megan was involved with site maintenance, fertilization, sample collection and sorting, and tree canopy assessment.

Funding Support: limited to REU**International Collaboration:** No**International Travel:** No**Year of schooling completed:** Junior**Home Institution:** Tougaloo College**Government fiscal year(s) was this REU participant supported:** 2013**Cleo Warner****Email:** ccwarner@eckerd.edu**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant**Nearest Person Month Worked:** 1

Contribution to the Project: Cleo joined us between her sophomore and junior years at Eckerd Collge, where she majors in Environmental Studies and Literature. She completed a project entitled: Do arthropod communities change after an addition of N, P, N and P? She collected samples from the litter layer in each plot and used Tullgren Funnels to extract arthropods. She sub-sampled arthropods, and worked with a local middle school science class teaching students about arthropods communities and scientific research along with having them identify arthropods under a microscope. She also participated on the field crew.

Funding Support: limited to REU**International Collaboration:** No

International Travel: No

Year of schooling completed: Sophomore

Home Institution: Eckerd Collge

Government fiscal year(s) was this REU participant supported: 2013

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
A. Crosby Kennett Middle School	Academic Institution	Conway, NH
Cornell University	Academic Institution	Ithaca, NY
Hubbard Brook Research Foundation	Other Nonprofits	North Woodstock, NH
Marine Biological Laboratory	Academic Institution	Woods Hole, MA
Miami University	Academic Institution	Oxford, OH
USDA Forest Service - Northeastern Forest Experiment Station	Other Organizations (foreign or domestic)	Bartlett, NH
University of Michigan	Academic Institution	Ann Arbor, MI

Full details of organizations that have been involved as partners:

A. Crosby Kennett Middle School

Organization Type: Academic Institution

Organization Location: Conway, NH

Partner's Contribution to the Project:

Collaborative Research

More Detail on Partner and Contribution: teachers have been working with collaborators to incorporate age-appropriate investigations of the sites in their middle school science classrooms.

Cornell University

Organization Type: Academic Institution

Organization Location: Ithaca, NY

Partner's Contribution to the Project:

Financial support

In-Kind Support

Facilities

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution: This project was established as, and continues to be, Collaborative Research with Principal Investigators housed at each institution.

Have other collaborators or contacts been involved? No

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

Ecosystem theory tested by the MEL model. Also see Journal publications, above.

What is the impact on other disciplines?

Nothing to report.

What is the impact on the development of human resources?

See Training and Development, above.

What is the impact on physical resources that form infrastructure?

The continuing treatment (control, N, P, N&P, and Ca), and monitoring of plots in thirteen stands distributed over three sites represents a huge investment in research infrastructure.

What is the impact on institutional resources that form infrastructure?

The project contributes to the HBR LTER.

What is the impact on information resources that form infrastructure?

We contribute data sets to the HBR LTER. We have a mailing list of 30 active researchers, including graduate and undergraduate students, and 37 other interested parties. We invite participation from any potential collaborators with the ideas and the motivation to join us, and the team continues to grow.

What is the impact on technology transfer?

Nothing to report.

What is the impact on society beyond science and technology?

Nothing to report.

Changes/Problems**Changes in approach and reason for change**

Two of our sites (Jeffers Brook and Hubbard Brook) were not mentioned in the grant proposal. We added stands of two age classes at these two sites to complement the nine stands (three replicates of three age classes) at Bartlett Experimental Forest. One of our treatments (Ca addition) was not in the original proposal but was the subject of an ROA Supplement. The additional sites and treatments have enabled us to test a broader suite of hypotheses than originally envisioned.

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

One of our fertilizers (ammonium nitrate) may become more difficult to obtain and store following the West, TX plant explosion. If necessary, ESF will become a 'registered' user. We hope not to have to substitute urea for ammonium nitrate.

Changes that have a significant impact on expenditures

Our first technician left the program, and has not been replaced in the same capacity. Instead, we have hired current or recent graduate students to manage the summer field crew, paying them at the rate of a technician rather than at the graduate student rate. This strategy takes advantage of personnel already familiar with the project and saves money in fringe benefits.

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.