We are requesting a supplement for Research Experience for Undergraduates to support one REU student.    
  
**Form and Nature of Student’s Involvement**

The project on Multiple Element Limitation in Northern Hardwood Ecosystems (MELNHE) provides excellent opportunities for exposure to scientific research because it involves so many researchers and so many topic areas, with work centered in an attractive geographic location that promotes interaction.  In addition to the nine stands of three ages at Bartlett originally funded by NSF, we are working in young and mature stands at Jeffers Brook and Hubbard Brook, which provide a gradient in site fertility.  There were five PIs initially funded on collaborative proposals, and four more have written other proposals to fund their work in our sites. There are four graduate students currently associated with the project and at least two new students will join by the next field season.  There are undergraduates on the field crew, each with responsibility for a project area, and there is a constant flow of visiting scientists, foreign exchange students, and visitors from other projects.  The center of activity is the White House at Bartlett, with the nearby dorm and lab.  Sharing housing, meals, and cooking responsibilities contributes to the chances for interactions with scientists at all levels of development.  
  
Because of the large number of researchers involved, REU participants will have the opportunity to learn about and contribute to a wide variety of measurements at these sites, including tree inventory, herb and seedling inventory, soil respiration, nitrogen mineralization, leaf area, leaf litter production, and woody litter production.  There are opportunities for laboratory experiments, for example on nitrogen mineralization and microbial respiration, as well as field experiments.  They will also have access to reams of data collected during this project and the previous funding cycle at Bartlett ([http](http://macmillan.brown.edu/research/calcium/)://www.esf.edu/melnhe) and collected over decades at the Hubbard Brook Experimental Forest (http://www.hubbardbrook.org/data/dataset\_search.php).  
  
We hope to have additional REU students on our team at Bartlett, supported on the HBR LTER or by the REU Site at Plymouth State University. Regardless of how they are funded, we treat all our team members as researchers, not as grunt labor, and we give them the support they need to learn about experimental design, research planning, time management, project coordination, data analysis, and the scientific communication of results.  The integration of efforts across a range of backgrounds and experiences, from RAHSS, to REU, to RET, to visiting professors, provides everyone an opportunity to better understand the process of scientific research, and everyone gains exposure to a wide range of subjects within the fields of forest ecology and ecosystem nutrient cycling. Each student has primary responsibility for a research project, and each aspect of the research has a student with lead responsibility. We depend on REU supplements, volunteers, and interns to provide undergraduates to our summer crew, because our main grant does not include any undergraduate student salary in any year of the project.

**Possible projects**  
Participants in this year’s field operations will develop focused research projects in the context of the overall experimental design.  Some possible projects are listed here.

●    **Seed production**: A student could develop and implement a method for monitoring seed production, which could be expected to change with nutrient additions.  Red maple is heteroecious, and has been known to change sex with P addition, producing more female branches and thus more seed.  Traps must be designed such that animals don’t feed at them.

●    **Insect herbivores**: One of our stands, C9, has shown high rates of foliar herbivory, and we are scoring leaf litter collected in the fall.  A student could monitor frass production during the summer as another test for nutrient treatment effects on leaf herbivory.

●    **Soil respiration**: Soil respiration was measured in 2015 but not published, so data collection in 2016 could add enough information for a new analysis of response to treatment.  The early response to treatment (2011-2013) was modest and is currently in review.  This involves using a LI-COR 8100 in the field (all 13 sites).

●    **Phenology and leaf area development:**  The development of leaf area could be monitored using smart phones and the Gap Light Analysis Mobile Application (GLAMA).  We have been monitoring sap flow in some of our stands to test for an increased in transpiration in response to nutrient additions, as observed in the whole-watershed Ca addition at Hubbard Brook.  Differences in leaf area development with treatment could be important to explaining patterns of sap flow.  In addition, casual observations suggested that trees in the nutrient additions held their leaves longer in fall 2015.

●    **Aboveground predictors of belowground processes:**  By mapping the location of tree stems, a student could investigate the effect of aboveground biomass and species composition on many of our field measurements, which are taken in known locations in the plots, such as soil respiration, N mineralization, and root biomass and turnover.  We mapped stems in the old stands in 2014, and **Stem mapping:**  We may have only the measurement area in the old stands.  Add the buffers in the older stands, map the mid-aged stands, and think about what to do in the young ones (see below).

**Other program elements**  
We have developed a culture for mentoring students and developing skills essential to the conduct of scientific research and a spirit of cooperation in the field crew.  Some of the program elements are listed below.

* Identify research interests in advance of the field season, then pair graduate student mentors with REU students, and provide them with relevant background reading.
* Proposals for each research project will be developed by the leading student and reviewed by the team within the first two weeks.  Approved proposals are posted on our web site. Formal review of proposals can prevent many misunderstandings and errors in implementation.
* Data documentation: We train students to follow our protocols for data documentation, including providing peer review of data sets and the accompanying metadata.
* Presentations at the annual Hubbard Brook Cooperators meeting in July (many of our undergraduates have made presentations at this meeting, including four associated with this collaboration just in the last year).
* Field crew blog: We post photos, results, and stories. Our ongoing blog is available at [http://shoestringproject.wordpress.com/](https://bl2prd0103.outlook.com/owa/redir.aspx?C=085f8a38d1d2480687e45171b8be8bb5&URL=http%3a%2f%2fshoestringproject.wordpress.com%2f)
* Wednesday night discussions series.  Scientists who have presented their work and interacted with our students include Tony Federer, Tim Fahey, Chris Costello, Melany Fisk, and Mark Green. Many prominent researchers work at Bartlett in addition to those associated with our project (e.g., Andrew Richardson, Dave Hollinger, Bill Leak, Heidi Abjornsen), so it is not difficult to find speakers.  In addition to scheduling seminars on scientific topics, we discuss the impacts of scientific research on society.

**Results from Previous REU Supplements**

Since 2011, we have had four REU supplements on this project. REU students have conducted research projects on tree height, sap flow, decomposition, beech bark disease, arthropod communities, germination, mycorrizal types, and responses to nutrient additions , and have made presentations at the summer Hubbard Brook Cooperators meetings. Slides from 2012, 2013 and 2014 meetings are linked from [www.esf.edu/melnhe](http://www.esf.edu/melnhe). Some projects were also presented at REU meetings or at home colleges, one of which won an award. Projects are still ongoing and will contribute to future publications.

**Diversity**  
Half of the 6 PIs are women, including two in leadership positions. Thus the male and female students on the crew will be exposed to both female and male role models. We have benefited from broad cultural diversity, with students hailing from India, China, and Korea, as well as Hawaii and the mainland US. We also have had African-Americans among our college students, one in each of the last two years.   
  
**Participant selection**  
We announce summer opportunities on the listserv of the Ecological Society of America, Ecolog-L. We screen applicants with a committee of current graduate students. We will select students based on academic and career interests, previous academic course work and field experience, and aptitude for research.  We have contact with many potential students through teaching and academic year lab employment; where we don’t have first-hand knowledge of student ability and interests, we will interview their referees, rather than relying solely on written references.

**The desired start date and duration of supplement**: June 1 to August 15, 2016.

**Expiration Date of the Parent Award:** We will request a no-cost extension to June 30, 2017.

**An assessment plan to measure the impact of the research experience on the student**

The PI and management team always write reviews of the summer students at the end of the field season, for use in preparing letters of recommendation. We have a new procedure for entrance and exit interviews, following up after one year, including impact on understanding of the research process, including the proposal and peer review process, and ability to design and deliver presentations. We have a web page for former graduate students in our Syracuse projects called “Where are they now?” (<http://www.esf.edu/for/yanai/Students/index.htm>). We will create a similar page for former members of the MELNHE team. This will be inspiring to future participants, I believe, and will help our alumni with networking.