

Award 1114804 **annual** Project Report

Project Title:

Long-Term Ecological Research at the Hubbard Brook Experimental Forest

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Recipient Organization: Cornell University Project/Grant Period: 02/01/2011 - 01/31/2017

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Accomplishments

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

The overall goal of Long-Term Ecological Research at Hubbard Brook Experimental Forest (HBR-LTER) is to advance the understanding of the response of northern forest ecosystems to natural and anthropogenic disturbances. The HBR serves as a hub for ongoing forest ecosystem research in the northeastern region where a suite of natural and anthropogenic disturbance agents causes unprecedented pace of change in ecosystem structure and function. We conduct an integrated suite of long-term monitoring, experimental manipulations, modeling and quantitative analysis, and public outreach and education activities. The HBR-LTER is

providing both fundamental insights about forest ecosystem dynamics and applications to help guide policy and management responses concerning human-accelerated environmental change. In our current LTER funding cycle we are evaluating landscape scale patterns and processes. New studies have been initiated to improve theoretical understanding of the dependence and interconnections of ecological, hydrologic, and biogeochemical phenomena within and across various landscape scales.

Long-term collection of precipitation and surface water for complete chemical characterization has been maintained continuously since the 1960s. Our biogeochemical monitoring program is designed to provide baseline measurements from which human-induced deviations can be resolved. Similarly, we quantify the hydrologic budget of a suite of small watersheds that allows us to detect global change effects on hydrologic fluxes with extremely high sensitivity. We also maintain a comprehensive, long-term monitoring program on forest vegetation composition, biomass, productivity and chemistry and the population trends of a suite of heterotrophic organisms, focused on passerine birds and their food web. These surveys indicate local and global phenomena shaping trends and a baseline for development of deeper theoretical understanding of ecological interactions.

Our most prominent ongoing watershed-scale experiments quantify ecosystem recovery from forest harvests and ecosystem responses to restoration of pristine conditions of soil base saturation. A variety of plot-scale experiments and manipulations also provides additional process-based understanding of ecosystem function in northern hardwood forest ecosystems. We synthesize the work at Hubbard Brook using simulation models, model-data fusion and uncertainty analysis to improve understanding of ecosystem dynamics at various spatial and temporal scales. Our dynamic hydrochemical models are useful tools for understanding and predicting the interactive effects of climate change, atmospheric CO₂, and atmospheric deposition on the hydrology and water quality of forested watersheds. Evaluation of uncertainty in ecosystem dynamics has been limited by the complexity of ecosystem data sets and processes, but new computational tools provide the means to improve this situation. A major ongoing activity in the HBR-LTER project has been to advance error analysis in biogeochemical budgets.

The HBR LTER project has an active program of outreach and education activities coordinated through the Hubbard Brook Research Foundation. Long-term research should play a crucial role in addressing grand challenges in environmental stewardship at local and national scales. The HBR LTER takes this responsibility very seriously. We attempt to inform policy decisions through our Science Links program. The project also takes very seriously its responsibilities for the training and development of scientists and educators. Most of these activities also are coordinated through the auspices of the Hubbard Brook Research Foundation, a "friends" group of the HBR-LTER.

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

Major Activities:

We organize this year's annual report around seven groups of activities for which significant new results have come to fruition in the past year.

SYNTHESIS OF LONG-TERM RESEARCH: The Hubbard Brook LTER provides synthesis of

research in a variety of ways including books, monographs, model and long-term data analyses. During the past year several new syntheses were completed including a popular-format overview book, an analysis of the strengths and limitations of site-level ecological research, a historical account on the discovery of acid rain, and a long-term analysis of recovery of surface water chemistry resulting from pollution control efforts.

CLIMATE CHANGE STUDIES: In addition to monitoring long-term changes in climate at the HBEF, we are conducting a variety of process-level research studies on climate change effects. We have utilized the elevation gradient in the HBEF watershed as a surrogate for roughly 2° C warming to study N cycle and bird population responses. We cooperate with the nearby Bartlett Experimental Forest to quantify climate change effects on phenology and forest physiology. We have employed simulation models that downscale future climate change projections to examine the sensitivity of predicted ecological responses to downscaling approaches. We also compare hydrologic responses to GCM projections across the northeastern region.

UNCERTAINTY ANALYSIS: A major research initiative in the Hubbard Brook LTER has been the application of uncertainty analysis to ecosystem budgets. This effort has been spearheaded by co-PI R. Yanai and organized through the QUEST program (Quantifying Uncertainty in Ecosystem Studies). Recent efforts in the QUEST program have focused on sources of uncertainty in stream solute export from headwater catchments, including both model uncertainty and natural spatiotemporal variability. A more specific analysis of this problem focusing on an experimental catchment manipulation also has been completed. Analysis of sources of uncertainty for quantifying element pools in forest vegetation, especially related to tissue chemistry, also was undertaken. These studies add to the rapidly growing published output from QUEST and our increasing understanding of this important deficiency in biogeochemical research.

EXPERIMENTAL MANIPULATION OF NUTRIENT AVAILABILITY: We have continued work on two ongoing, long-term experimental manipulations of soil nutrient availability. At the whole-catchment scale in 1999 we added calcium in the form of a calcium silicate mineral to experimental WS1 at the HBEF in an amount designed to gradually replace the Ca lost from the HBR ecosystem as a result of human activity during the 20th century. Responses of various ecosystem components have been monitored in treated and reference watersheds over the past 15 yr, with our most recent observations for soils, solution chemistry and fine root biomass summarized in the past year. At the plot scale we are manipulating the availability of N, P and Ca in a factorial experiment encompassing gradients in forest age (successional status) and natural soil fertility. To avoid artifacts we are very gradually increasing soil fertility with relatively low level additions that began in 2011. Observations regarding the interactive response to N, P and N+P of soil microbial activity and soil respiration have been summarized in the past year. These studies provide new insights into the mechanisms influencing forest ecosystem responses to changing inputs of N and acid deposition in temperate forests.

HETEROTROPH POPULATIONS - MIGRATORY SONGBIRDS: Study of neo-tropical migratory songbirds that dominate the bird community in northern hardwood forests has been greatly advanced by new techniques and approaches for quantifying activity in non-breeding winter habitat. Most recently we have evaluated the full-annual-cycle population demographic parameters for these birds by combining information on breeding success and migration and winter-season performance. This work is aided by the application of new techniques using GPS tags and light-level geolocators to identify non-breeding territories. New insights into key community assembly rules and density dependence are informed by better understanding non-breeding habitat. Understanding the contribution of these features to stability of populations of breeding birds at local and regional scales, as identified by long-term records,

may be facilitated.

FOREST HYDROLOGY. Long-term records from the gauged watersheds at the HBEF provide the basis for the application of new techniques to better understand hydrologic processes in forest ecosystems. Stable water isotopes have been applied to infer hydrologic processes that cause isotope fractionation in our headwater catchments. We have also combined experimental and modeling results to explore the link between water age and stream solute dynamics. We developed an integrated transport model to compute hydrochemical fluxes by estimating catchment water storage and dynamic travel time distributions. These studies are complemented by plot-scale research on hydrologic flowpaths during snowmelt under contrasting conditions of winter climate and soil frost. The effects of flowpaths and soil variation on the generation of DOC in headwater streams also were examined. Finally, we used our 43-yr record of precipitation isotope values (based on reanalysis of archived samples) to study the changing water cycle and sources of precipitation in the northeastern US.

INTERACTIONS OF NITROGEN AND CARBON: Remote sensing data have allowed us to derive maps of canopy nitrogen and forest production across the HBEF. We seek to identify the sources of discrepancies between growth rates of forests at the HBEF and nearby Bartlett Experimental Forest (BEF). Plot-level studies at HBEF and BEF evaluated the interactions among N availability, soil respiration and belowground C allocation in northeastern hardwood forest as well as the effects of soil fertility on foliar nutrient resorption.

Specific Objectives:

Our specific objectives include 1) maintaining long-term measurements of climate, hydrology, vegetation, soils, solution chemistry and heterotroph populations across the site; 2) exploring the interactions among hydrogeochemical templates, vegetation structure and microbial dynamics, and key heterotroph populations and habitats at the large landscape scale; 3) providing new discovery on the nature and mechanisms of nutrient limitation in forest ecosystems and its interaction with natural and human-accelerated environmental change; and 4) synthesizing biogeochemical and ecological knowledge using simulation models and regional surveys.

Significant Results:

SYNTHESIS OF LONG-TERM RESEARCH: A popular description of the Hubbard Brook Forest was recently completed for Yale University Press (Holmes and Likens, in press). We recently synthesized understanding of the process of surface water recovery from acidification over the past several decades (Fuss et al. 2015). Loss of base cations and mobilization of aluminum have gradually declined since the mid-1980s, and streamwater pH has increased at a rate of 0.01 units y^{-1} . The similarity of the whole-year and snowmelt trends demonstrates the consistency of recovery of baseflow stream chemistry and the abatement of snowmelt acidification with its consequences for many biotic populations. We have used long-term observations from the HBEF to evaluate how well local site-based research represents broader patterns (Fahey et al. 2015). In some respects the HBEF is representative of its region, including sensitivity and recovery of streams and forests from acid deposition (Figure 1). The difficulty of scaling up is greatest for ecological phenomena that are sensitive to historical legacies and that exhibit high spatio-temporal variability.

CLIMATE CHANGE STUDIES: The roughly 2° C gradient in air temperature across the northern hardwood forest is a surrogate for examining climate change effects on biogeochemical and heterotroph processes. Lower microbial activity during winter in colder soils at lower elevations is followed by higher summer activity. These effects appear to be more

pronounced for N cycling processes than for soil C processes, suggesting greater sensitivity of N cycle to climate warming. Climate change could affect the composition and dynamics of caterpillars, the principal food for many songbirds. Moreover, the timing of leaf phenology is climate sensitive whereas migrating songbird annual arrival dates are inflexible. However, our studies of plant phenology effects on bird reproductive success indicated comparable influence to caterpillar abundance (Lany et al. 2015); thus, the possible mismatch between the inflexible arrival dates and changing leaf phenology might not be crucial to songbird performance. Our results also suggest that local warming temperatures could have a positive effect on bird recruitment.

The sensitivity of plant phenology to climate change has obvious ramifications for ecosystem C balance. We observed that the timing of autumn senescence is correlated with the timing of spring budburst across the deciduous forest biome (Fig. 2; Keenan and Richardson 2015). We predict that climate effects on spring phenology may constrain the fall senescence response so that future increases in growing season length may be overpredicted by current models. Warmer future temperatures and longer growing seasons can be expected to increase AET across the region, but our work suggests that CO₂ effects on vegetation WUE could partly counteract this response.

NUTRIENT MANIPULATIONS IN WATERSHEDS AND PLOTS: Restoration of Ca on WS1 at the HBEF has been successful in returning the acid-base status of soils (Johnson et al. 2014) and surface water (Shao et al. 2015) to levels comparable to pristine, pre-industrial levels, and with consequent recovery of forest health (Battles et al. 2014). The concentrations and fluxes of inorganic Al in soil solution and streamwater have decreased significantly, decreasing the potential for aluminum toxicity. The increase in aboveground productivity of the forest on the treated watershed coincided with a significant decrease in fine root biomass (Fahey et al., in review).

We are evaluating the interactions of N and P, as co-limiting nutrients for forest production and microbial processes in northern hardwood forests. Across a soil fertility gradient we observed that P and N availability increase coincidentally (Fisk et al. 2014). The addition of low levels of N (but not P) decreased soil respiration on infertile sites but marginally increased it on fertile sites (Fig. 3; Kang et al. 2016). Added N reduced mineralization of soil C and increased microbial biomass. We suggest that N addition relieves N limitation of microbial biomass synthesis. Moreover, N mineralization activity affects soil phosphatase activity, suggesting that allocation to enzymes contributes to coupling of N and P availability (Ratliff and Fisk 2015).

UNCERTAINTY ANALYSIS: We quantified the sources of uncertainty in the calculation of streamwater solute export in five highly contrasting headwater catchments. For solutes with strong concentration-discharge relations a composite method is most effective, whereas for solutes with weak concentration discharge relationships a period-weighted approach works best. We also analyzed sources of uncertainty in the response of input-output budgets of Ca following forest harvest of WS5 at the HBEF (Campbell et al. 2015). Initially, Ca loss from WS5 greatly exceeded pre-treatment, reference conditions. However, by 2009 the 95% confidence intervals for the annual budget estimates approach the 95% confidence intervals for pre-treatment regressions, indicating that in the future increased loss from the treated watershed will be undetectable. We quantified sources of uncertainty in nutrient pools in forest vegetation associated with plant tissue chemistry (Yang et al., in press) to guide the allocation of sampling effort depending upon the chemical element, tissue type of interest and study objectives.

HETEROTROPH POPULATIONS – MIGRATORY SONGBIRDS: Full-annual cycle models for migratory birds are particularly difficult to parameterize because of limited availability of

empirical data for all annual stages including migratory connectivity (Hostetler et al. 2015). We deployed miniaturized GPS tags and geolocators to identify and characterize winter territories and migratory connectivity for a small songbird, Ovenbird (Hallworth and Marra 2015). Ovenbirds exhibited strong migratory connectivity between breeding and non-breeding seasons (Hallworth et al. 2015). The contrasting effects of density-dependent and density-independent factors in adjacent overwintering habitats (Fig. 4) illustrate the complexity of processes governing the demography of migratory animals (Marra et al. 2015). Integrating these spatial and temporal components of community dynamics strengthens inferences regarding the processes that structure the overall bird community. These results depend upon long-term monitoring at large scales. In and around the HBEF abundance trends of most birds have been relatively stable in the intact forest but regionally species from higher elevation habitats are more likely to be declining and species from older forests to be increasing.

FOREST HYDROLOGY: Using stable water isotopes we observed the likely recycling of sub-canopy water vapor (i.e. re-condensation of evapotranspired water), a process that was most evident during the growing season (Green et al. 2015). We also used isotopic approaches to evaluate the time it takes water to travel through a catchment and the dynamic water age distribution (TTD, Fig. 5). A new integrated transport model was designed to reproduce water isotopes in streamflow and to simulate conservative, weathering-derived solutes (Benettin et al. 2015). These results highlight the key role played by sub-soil glacial material in solute circulation. The dynamics of geogenic solutes are controlled primarily by hydrologic drivers that determine contact time between water and mineral interfaces. Plot-scale flowpath analyses indicate the role of the development of granular soil frost which allows for the vertical infiltration of snowmelt water but either reduces lateral flow or prevents the solute exchange that would produce a chemical signature of shallow organic flowpaths.

Key outcomes or Other achievements:

HBR data collection: The HBR data catalog is available through both <http://hubbardbrook.org> and the LTER Network Information System Data Portal. Current status of the data catalog is as follows (1) *Upgrades/access to existing data packages:* Some work remains on a number of legacy datasets prior to their inclusion in the LTER-NIS, and we anticipate that this will be complete in January 2016. (2) *Development of new data packages:* We continue to incorporate earlier HBR-LTER datasets (from 1988 onward), and to add new datasets. Improvements in tracking and monitoring of data collections are being implemented through coordination with the HBR Research Approval Committee (RAC). This will provide the ability to track and monitor the completion of projects, publication of data, and to maintain timely submissions to the HBR data collection. (3) *Implementation of metadata database:* Work continues on the migration of HBR metadata content and project database to a PostgreSQL implementation of the metabase schema. Once complete, we will work with MCR/SCB LTER sites to adopt recently developed code that will generate metadata from the metabase database.

Website (<http://hubbardbrook.org>): The website for HBR is hosted on a server at the University of NH and managed by the HBR-Information Manager (HBR-IM). The physical location of this server is at the Research Computing and Instrumentation (RCI) Center, in a climate controlled environment, with emergency power. A service level agreement between the Earth Systems Research Center and RCI provides system administration, upgrades, backups, helpdesk support, and expertise for special projects as needed. A major revision to the Education virtual tour is nearly complete – content has been updated by HBRF staff, and Plymouth State University GIS specialists are developing a spatial storymap interface to a virtual

tour of HBR. This virtual tour consists of interactive maps, photographs, and links to existing HBR web/data resources. An open source photo management package (<http://piwigo.org>) is now used to manage the photo gallery for HBR. We are developing individual research project galleries, and are tagging the photo collection to provide a high quality 'public' view, and access to the complete photo archive for HBR researchers.

HBR Environmental Sensors: We maintain an environmental sensor network at the HBR site; the core sensor network monitors height/temperature/conductivity from 9 watersheds in the HBR, and meteorological data from 10+ stations. Maintenance and operation of these sensors is done by Forest Service staff. The GCEdata Toolbox (developed by GCE-LTER) workflow provides quality controlled data products for the research community. An extended project-level sensor network has been growing rapidly with the addition of the three new research projects at HBR: Climate Change Across Seasons Experiment, DroughtNet, and Ice Storm Experiment projects.

The analysis of overlapping chart/sensor data (~2008-2012) has established the baseline necessary for moving forward with core meteorological and hydrological, datasets derived now from digital sensors. We developed R code that is now in use to generate streamflow (instantaneous and daily) from the sensor data (replacing FORTRAN code in use since the 1970s).

Hubbard Brook Sample Archive: During the summer of 2015, there was a coordinated effort to improve the HBR sample archive, our unique storage system for physical samples. This effort was led by HBEF staff and HBR-IM, and included contributions from a number of research teams on-site. Highlights of the summer's accomplishment include (1) an inventory of uncatalogued samples and anticipated future archive contributions was completed, involving individual consultations with HBR investigators, (2) the development of a data entry station in the archive building that incorporates bar-code scanning and direct scale-to-computer entry of sample weights, (3) the development of a plan to link the database tables describing the physical samples to the analytical data tables. In a limited proof-of-concept, we demonstrate the ability to query a HBR data table to generate a list of physical samples that meet the given criteria. The report indicates sample bar-code, location in the archive (row/shelf), and the amount of sample available for further analysis, (4) extensive updates to the inventory, organization, and sample volume data archived streamwater and precipitation samples. Our efforts in the sample archive facility are all targeted at improving researcher interest and access in further resampling and analysis. The capacity for new scientific discovery afforded by the HBR archive has been demonstrated most recently by 1) analysis of precipitation samples for isotopes that showed the changing water cycle with climatic shifts in northeastern US (Puntsag et al., in review), and 2) Ca isotope analysis clarifying mechanisms maintaining soil exchangeable Ca pools in the face of changing losses and plant demand following forest disturbance.

Other information management:

Smart Forests for the 21st Century initiative: this US Forest Service effort extends sensor technology to sites within the USFS Experimental Forests and Ranges Network, and is led by the HBEF. In the past year, the Penobscot Experimental Forest has been added to this network (operational sites include HBEF, Marcell and Fernow Experimental Forests and Alley Pond Park in Queens NYC), and progress has been made in developing a SmartForest installation at the Milford Experimental Forest at Grey Towers. The LTER-funded GCE Toolbox provides both the quality control workflow for data from these site, and the centralized data portal for this environmental sensor network (<http://smartforests.org>).

Innovative data outreach: A water cycle visualization and sonification have been developed for

HBEF (<http://waterviz.org>). To support this collaborative between hydrological scientists, artists, musicians, and computer scientists, we have developed a real-time data workflow that combines data from multiple dataloggers, calculates variables on-the-fly (e.g. evapotranspiration), and stages an hourly custom datafile for access by this interdisciplinary team. In August 2015, an interdisciplinary team was funded by a NSF-EAGER grant to further this work. Funding for the grant, *Collaborative Research: The Confluence of Music, Art and Science at Long Term Ecological Research Sites* (\$300K), went to three institutions: UNH (lead institution with HBR-IM as PI), Dartmouth College and the Hubbard Brook Research Foundation. Both RET and REU supplemental proposals were recently submitted to fund additional work on this project at HBR.

Participation in LTER Network activities: The HBR-IM participates in monthly LTER-IM Virtual Watercooler teleconferences and the EnviroSensor telecons (an extension of the LTER Sensor Working Group).

The HBR IM also mentored both an RET from a local high school, and an Information Sciences intern from Syracuse University. The RET project involved the collection and analysis of sensor data on the DroughtNet plots (both RET and HBR-IM funded through NH-EPSCoR). The Syracuse intern worked on the development of a sensor data portal using the R-shiny package. This work is still under development, and will provide user-friendly access to sensor networks at Hubbard Brook, Smart Forests, and the Northeast Environmental Sensor Network.

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

The Hubbard Brook LTER project takes very seriously its responsibilities for the training and development of scientists and educators. Most of these activities are coordinated through the auspices of the Hubbard Brook Research Foundation, a non-profit, “friends” group associated with the HBR LTER.

During 2015 these activities included: 1) an undergraduate research program; 2) our Environmental Literacy Program (ELP), which is a cooperative effort with the USDA-Forest Service and the Schoolyard LTER aimed at supporting secondary science teachers through training events and the development of teaching resources; 3) posting of related educational-support material on our web pages (www.hubbardbrook.org and www.hubbardbrookfoundation.org); 4) cooperation with other regional groups engaged in secondary education teacher development; 5) conducting field trips at the site for visiting schools and the general public.

Undergraduate Research Program: 2015 marked the final year of our current REU site program, entitled “Investigating and Communicating Change in Ecosystems.” We hosted 10 undergraduates through a combination of the LTER-supported REU and the site REU, which we administer through Plymouth State University. The students were paired with researchers and developed and conducted independent research projects on topics representing the range of research at the HBR LTER, including hydrology, population ecology, biogeochemistry, and animal behavior. The students also participated in weekly science communications workshops which examined successful communications strategies aimed at policy, informal science education, and secondary science. The students interacted with graduate students, other undergraduates serving on field crews, and a spectrum of HBR scientists at weekly Science Night dinner/talks. In addition, REU students hosted two high school students for a 10-day

introduction to research experience. We submitted a renewal proposal for the site program in August.

Environmental Literacy Program (ELP): ELP is a joint project of the HBRF and the USDA Forest Service Northern Research Station to use ecological knowledge to promote informed decision-making for a sustainable future. It is funded through both the USDA-Forest Service and the LTER Schoolyard program. ELP has three main components, as follows:

1. **1. Teaching Resources:** *Seeking the Wolf Tree* was published as part of the LTER Schoolyard Series. We developed a teaching packet to supplement classroom use of the book that includes alignment with national standards, and existing HBRF lessons. The book and teaching packet were presented at two teacher conferences for NH teachers, and plans are in place to distribute the book to libraries and schools state-wide.

Data-based lessons: In partnership with teachers, we have continued to develop lessons and slideshows using HBR data that emphasize data representation and analysis and other science practices. These resources are leveraged by teacher workshops and on-going interactions with HBRF staff. Current offerings can be found at:

<http://hubbardbrookfoundation.org/middle-and-high-school-2/>.

1. **2. Teacher professional development:** We continue to present at teacher workshops and are active cooperators with the New Hampshire Science Teachers' Association (NHSTA) and the New Hampshire Environmental Educators Alliance (NHEEA). This year we presented sessions on our various resource offerings at the NHSTA and NHEEA conferences. We also partner with the New Hampshire Education and Environment Team (NHEET) to provide teacher workshops focusing on science process skills, including a state-wide Math-Science Partnership which works with 2 school districts in the state with the aim of integrating their science education from grades K-8. In addition, we hosted two teachers in our summer research experience program (RET), incorporating one new teacher and supporting one returning teacher.

1. **3. School partnerships:** We are active with a number of local schools and school districts. In addition to schools with RET teachers, we work closely with and give tours to Plymouth Elementary School, Bethlehem Elementary School, Lin-Wood Elementary School, Thornton Elementary School, Campton Elementary School, Littleton High School, (these represent the 5 school districts closest to Hubbard Brook), as well as Oyster River High School, St Thomas Aquinas High School, Winnesquam High School, Bishop Guertin High School, Pelham High School, and Londonderry High School. In partnership with the USDA-FS staff, we conduct tours of the HBEF for our partner schools.

Other K-12 support activities: As noted above, The HBRF is a member of the New Hampshire Education and Environment Team (NHEET), which is a collaboration of organizations working to support science education in the state. Additional members include the GLOBE Program, Project Learning Tree, Project WET at NH Department of Environmental Services, Projects WILD and Aquatic WILD at NH Fish and Game Department, and the USDA Forest Service. The focus of the group is to support the vertical alignment of science curriculum within districts and to assist teachers in the acquisition of content and development of science process skills. The main activity of the group in 2015 was the Math-Science Partnership program, described above.

On-site tours: The HBEF provides educational tours of the research site on a frequent basis throughout the academic year. Undergraduate partner schools bring at least one class per year to the site and provide the Hubbard Brook staff with syllabi and written statements describing how the site visit is incorporated into the course curriculum. These schools include: Yale

University, Plymouth State University, the University of New Hampshire, Colby-Sawyer College, Boston University, Cornell University, Skidmore College and Wellesley College. Secondary school tours are offered to our ELP partner schools (described above) and other schools where our teaching resources are being used in the classroom.

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

In 2014 the HBRF Foundation received an Advancing Informal STEM Learning grant from the National Science Foundation (Award #DRL 1322871) for a two-year pilot project called Forest Science Dialogues. The project is to develop and pilot a model for engaging ecosystem scientists and local citizens in action-oriented dialogue about social, economic, and policy-related issues and concerns in the rural regions of northern New England. Elements of the model are: 1) mechanisms and processes for rural community dialogue events that support multi-directional dialogue and mutual learning among nonscientists and scientists; 2) workshops with scientists to develop their comfort and skills with public engagement; and 3) infrastructure for recruitment, communication, and ongoing support for initiatives that arise from these dialogues. In 2015, highlights of the project include a Public Engagement with Science workshop for the HB Committee of Scientists meeting at the Cary Institute in New York and a two-day Hubbard Brook Roundtable with twenty-four participants representing region-wide leaders from diverse stakeholder groups and including five Hubbard Brook scientists.

Other specific products:

Product type: Website

Product description:

<http://hubbardbrookfoundation.org/education-programs-at-hubbard-brook-an-overview/>

Sharing information: The Hubbard Brook Research Foundation hosts a dynamic website with teaching resources developed with support of the LTER Schoolyard program and the USDA-Forest Service. It contains data activities developed by our RET teachers, mock-NECAP exams developed with our partner schools, and teaching guides on acid rain and migratory birds. Contents of the website are promoted at state-wide and regional science teacher conferences and through our various partnerships with teacher professional development organizations.

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

We plan to continue our long-term activities in ecosystem monitoring, biogeochemical experiments, landscape studies, modeling and quantitative analysis, data management, education and outreach during the next reporting period.

Supporting Files

	Filename	Description	Uploaded By	Uploaded On
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(Download)	2015 HBLTER REPORT NARRATIVE REFERENCES.pdf	2015 Reference List -- those cited within 2015 report narrative (Significant Results).	Timothy Fahey	01/13/2016
(Download)	2015 LTER ANNUAL REPORT FIGURES.pdf	2015 HBLTER REPORT FIGURE FILE (as cited in 2015 report narrative)	Timothy Fahey	01/13/2016

[Back to the top](#)

Products

Books

- Cleavitt, N.L. (2015). *Seeking the Wolf Tree* Illustrated by Marjorie Leggitt. Taylor Trade Publishing. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; OTHER:
- Holmes, R.T. and G. Likens. (2016). *Hubbard Brook, the Story of a Forest Ecosystem* Yale University Press.. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; OTHER:

Book Chapters

Inventions

Journals or Juried Conference Papers

- Bae, Kikang and Fahey, Timothy J. and Yanai, Ruth D. and Fisk, Melany (2015). Soil Nitrogen Availability Affects Belowground Carbon Allocation and Soil Respiration in Northern Hardwood Forests of New Hampshire. *Ecosystems*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s10021-015-9892-7
- Balaria, Ankit and Johnson, Chris E. and Groffman, Peter M. (2014). Effects of calcium treatment on forest floor organic matter composition along an elevation gradient. *Canadian Journal of Forest Research*. 44 (8), 969--976. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1139/cjfr-2014-0065
- Balaria, Ankit and Johnson, Chris E. and Groffman, Peter M. and Fisk, Melany C. (2014). Effects of calcium silicate treatment on the composition of forest floor organic matter in a northern hardwood forest stand. *Biogeochemistry*. 122 (2-3), 313--326. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s10533-014-0043-6

- Beier, Colin and Caputo, Jesse and Groffman, Peter M. (2015). Measuring ecosystem capacity to provide regulating services: forest removal and recovery at {Hubbard} {Brook} ({USA}). *Ecological Applications*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1890/14-1376.1
- Benettin, Paolo and Bailey, Scott W. and Campbell, John L. and Green, Mark B. and Rinaldo, Andrea and Likens, Gene E. and McGuire, Kevin J. and Botter, Gianluca (2015). Linking water age and solute dynamics in streamflow at the Hubbard Brook Experimental Forest, NH, USA. *Water Resources Research*. n/a--n/a. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1002/2015WR017552
- Burakowski, Elizabeth A. and Ollinger, Scott V. and Lepine, Lucie and Schaaf, Crystal B. and Wang, Zhuosen and Dibb, Jack E. and Hollinger, David Y. and Kim, JiHyun and Erb, Angel and Martin, Mary (2015). Spatial scaling of reflectance and surface albedo over a mixed-use, temperate forest landscape during snow-covered periods. *Remote Sensing of Environment*. 158 465--477. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1016/j.rse.2014.11.023
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Other Conference Presentations / Papers

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- Poirer, K. (2015). *Growing the way the wind blows.* 2015 REU conference. Thornton, NH. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Kaiser, S.A. T.S. Sillett, M.S. Webster. (2013). *Habitat-specific reproductive strategies in response to food supplementation increase male fitness in a songbird.* One Hundred and Thirty-first Meeting of the American Ornithologists' Union. Chicago, IL. Status = OTHER; Acknowledgement of Federal Support = Yes
- Driscoll, C.T. (2014). *Health Co-Benefits of Carbon Standards Air Quality and Health Benefits of the Carbon Standards Co-Benefits Stud.* Briefing: U.S. Environmental Protection Agency. Washington, DC. Status = OTHER; Acknowledgement of Federal Support = Yes
- Driscoll, C.T. (2014). *Health Co-Benefits of Carbon Standards Air Quality and Health Benefits of the Carbon Standards Co-Benefits Study.* Briefing given to the Office of Management and Budget. Washington, DC. Status = OTHER; Acknowledgement of Federal Support = Yes
- Driscoll, C.T. (2014). *Health Co-Benefits of Carbon Standards Air Quality and Health Benefits of the Carbon Standards Co-Benefits Study.* Briefing: Council on Environmental Quality (CEQ). Washington, DC. Status = OTHER; Acknowledgement of Federal Support = Yes
- Driscoll, C.T. (2014). *Health Co-Benefits of Carbon Standards Air Quality and Health Benefits of the Carbon Standards Co-Benefits Study.* Briefing: Senator Carper's

staff. Washington, DC. Status = OTHER; Acknowledgement of Federal Support = Yes

- Driscoll, C.T. (2014). *Health Co-Benefits of Carbon Standards Air Quality and Health Benefits of the Carbon Standards Co-Benefits Study*. briefing given to Senator Reid's staff. Washington, DC. Status = OTHER; Acknowledgement of Federal Support = Yes

- Berton, R., Shaw, S. B., Chandler, D. G., Driscoll, C. T. (2015). *Historical Climate Data Help Predict Future Water Availability*. 3-Minute Thesis Competition. Syracuse University, Syracuse, NY. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

- Rodenhouse, N. (2014). *How well do climate and ecosystem characteristics predict bird abundance at the landscape spatial scale?*. Annual Hubbard Brook Cooperators' Meeting. North Woodstock, NH. Status = OTHER; Acknowledgement of Federal Support = Yes

- Rodenhouse, N., Z. Zhou, M. Martin, S. Ollinger, and J. Battles. (2014). *How well do climate and ecosystem characteristics predict bird abundance at the landscape spatial scale?*. 2014 Annual Meeting of the Ecological Society of America. Sacramento, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

- Rodenhouse, N., Z. Zhou, M. Martin, S. Ollinger, and J. Battles. (2014). *How well do climate and ecosystem characteristics predict bird abundance at the landscape spatial scale?*. Northeastern Research Station, USDA Forest Service. Delaware, OH. Status = OTHER; Acknowledgement of Federal Support = Yes

- Rodenhouse, N., Z. Zhou, M. Martin, S. Ollinger, and J. Battles (2014). *How well do climate and ecosystem characteristics predict bird abundance at the landscape spatial scale?*. Department of Wildlife Biology, Ohio State University, Columbus, OH. Status = OTHER; Acknowledgement of Federal Support = Yes

- Rodenhouse, N., Z. Zhou, M. Martin, S. Ollinger, and J. Battles. (2014). *How well do climate and ecosystem characteristics predict bird abundance at the landscape spatial scale?*. 2014 Annual Meeting of the Ecological Society of America. Sacramento, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

- Miller, C. M., H. Merrill, N.L. Rodenhouse, S. Kaiser, L. Neitmann. (2013). *Humans vs. digital recorders: alternative methods for surveying birds*. Annual Cooperators' Meeting, Hubbard Brook Ecosystem Study. North Woodstock, NH.. Status = OTHER; Acknowledgement of Federal Support = Yes

- Berton, R., Driscoll, C. T., Chandler, D. G. (2014). *Hydrologic Response of the Merrimack Watershed (NH-MA) to Variations in Sea Surface Temperature and Sea Level Pressure*. Graduate Research Symposium. Syracuse University, Syracuse, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

- Berton, R., Driscoll, C. T., Chandler, D. G. (2014). *Hydrologic Response of the Merrimack Watershed (NH-MA) to Variations in Sea Surface Temperature and Sea Level Pressure*. Graduate Research Symposium. Syracuse University, Syracuse, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

- Yanai, R.D. (2014). *Improving Environmental Monitoring with Uncertainty Analysis*. Catskill Environmental Research and Monitoring Conference. Highmount, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

- Campbell, J.L., Mitchell, M.J., Mayer, B. and Groffman, P.M. (2015). *Isotopic evidence of over-winter nitrification in a northern hardwood forest floor*. 9th International Conference on Acid Deposition. Rochester, NY. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

- Burakowski, E.A., S.V. Ollinger, A. Ouimette, L. Lepine, S. Fogarty, G. Bonan. (2015). *Land Surface Modeling of a Flux Tower Cluster in the Northeastern US with CLM4.5.* Community Earth System Model annual conference. Breckenridge, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Puntsag, T., Welker, J.M., Mitchell, M.J., Klein, E.S., Campbell, J.L. and Likens, E. (2014). *Long-term precipitation isotope ratios ($\delta^{18}O$, δ^2H , d -excess) in the northeast US reflect Atlantic Ocean warming and shifts in moisture sources.* American Geophysical Union, Fall Meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Vadeboncoeur, M., Asbjornsen, H., Green, M., and Campbell, J. (2014). *Long-term trends in evapotranspiration in forested small catchments in the northeastern USA.* 2014 American Society of Agricultural and Biological Engineers Meeting, Evapotranspiration: Challenges in Measurement and Modeling from Leaf to the Landscape Scale and Beyond. Raleigh, NC. Status = OTHER; Acknowledgement of Federal Support = Yes
- Goswami S, Fisk MC, Babel H., Forlini D., Ratliff TJ, Yanai RD. (2015). *Microbes mineralize N but accumulate P in response to N and P fertilization in northern hardwood forests.* Annual meetings of the Ecological Society of America. Baltimore MD. Baltimore MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Goswami, Shinjini, Melany C. Fisk, Tera J. Ratliff, and Ruth D. Yanai. (2015). *Microbial biomass accumulates P but not N in response to N and P fertilization in northern hardwood forests.* Ecological Society of America Annual Meeting. Baltimore MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Hallworth, M. T., T. S. Sillett, S. Van Wilgenburg, K. A. Hobson and P.P. Marra. (2014). *Migratory connectivity of a Neotropical migratory songbird revealed using archival light-level geolocators.* Symposium of Animal Movement and the Environment. Raleigh, NC. Status = OTHER; Acknowledgement of Federal Support = Yes
- Hallworth, M. T., T. S. Sillett, S. Van Wilgenburg, K. A. Hobson and P.P. Marra. (2014). *Migratory connectivity of a Neotropical migratory songbird revealed using archival light-level geolocators.* North America Congress for Conservation Biology. Missoula, MT. Status = OTHER; Acknowledgement of Federal Support = Yes
- Benettin, P., Queloz, P., Bailey, S.W., McGuire, K.J., Rinaldo, A., Botter, G. (2015). *Modeling Hydrologic Transport through the Critical Zone: Lessons from Catchment-Scale and Lysimeter Studies.* AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Pourmokhtarian, A., Driscoll, C. T., Campbell, J. L., Hayhoe, K. (2015). *Modeling climate change effects on forests.* Hubbard Brook Committee of Scientists Meeting. N. Woodstock, NH. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Bailey, S.W., McGuire, K.J., Ross, D.S. (2015). *Moving the Watershed Ecosystem Approach Beyond the Black Box with Sensor Technologies and New Conceptual Models.* AGU Fall Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Goodale, C.L. (2014). *Nitrogen and Climate Change.* BIOGEMON 2014 Conference. Bayreuth, Germany. Status = OTHER; Acknowledgement of Federal Support = Yes
- See, C.R., M.C. Fisk, R.D. Yanai. (2014). *Nitrogen and phosphorus co-limitation in northern hardwood forests.* Ecological Society of America Annual Meeting. Sacramento, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

- See, C.R., M.C. Fisk, R.D. Yanai. (2014). *Nitrogen and phosphorus co-limitation in northern hardwood forests.*. Ecological Society of America Annual Meeting. Sacramento, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Eimers, C., Crossman, J., Casson, N., Burns, D., Campbell, J., Likens, G., Mitchell, M.J., Nelson, S. and Shanley, J. (2015). *Nitrogen dynamics in the dormant season: an inter-watershed comparison.*. Crossman at the 9th International Conference on Acid Deposition. Rochester, NY. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Asbjornsen H, L Rustad, PH Templer. (2014). *Northern Forest DroughtNet: A new framework to understand impacts of precipitation change on the Northern forest ecosystem.*. American Geophysical Union. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Driscoll, C.T. (2015). *Nutrient Loss From Soil and Stream Water in a Wollastonite Treated Watershed.* Hubbard Brook Ecosystem Study 52nd Annual Cooperators' Meeting. Thornton, NH. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Betts, M.G. (2012). *On species distributions.* Invited seminar, Portland State University Dept. of Biology. Portland, WA. Status = OTHER; Acknowledgement of Federal Support = No
- Illan, J.G, Thomas C.D, Betts M.G. (2012). *On the influence of climate change on bird distributions: Will the predictions come true?.* Department of Biology Workshop. The University of York. York, United Kingdom. Status = OTHER; Acknowledgement of Federal Support = No
- Yanai, R. (2014). *P-recycling and P-efficiency of ecosystems.* German Research Foundation's (DRG) Priority Research Programme SPP 1685 workshop "Ecosystem Nutrition: Forest Strategies for limited phosphorus resources". Freising, Munich, Germany. Status = OTHER; Acknowledgement of Federal Support = Yes
- Dong, Y., R.D. Yanai, M.C. Fisk, R. Briggs, M. Johnston (2014). *Parent material, N cycling, and foliar chemistry in northern hardwood forests.*. Ecological Society of America Annual Meeting. Sacramento, CA. Status = OTHER; Acknowledgement of Federal Support = No
- Driscoll, C.T. (2015). *PnET-BGC Applications to Hubbard Brook and Beyond.* Hubbard Brook Committee of Scientists Meeting. Thornton, NH. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Goswami S, Vadeboncoeur M, Collin E, Yanai R, Fisk M. (2014). *Poster: Contrasting root systems of two coexisting tree species in northern hardwood forest ecosystems.*. Annual meetings of the Ecological Society of America. Sacramento, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Hallworth, M. T., T. S. Sillett, S. Van Wilgenburg, K. Hobson and P. P. Marra. (2013). *Range-wide migratory connectivity revealed by archival light-level geolocators.* Annual Cooperators' Meeting, Hubbard Brook Ecosystem Study. North Woodstock, NH. Status = OTHER; Acknowledgement of Federal Support = Yes
- Driscoll, C. T. (2014). *Recovery of Acid Lakes in the Adirondack Region of New York: Model Projections under Different Scenarios of Emissions Controls.* LTER Mini-symposium. National Science Foundation, Arlington, VA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Sorensen P, PH Templer, A Finzi, P Groffman, M Fisk, L Christensen, and T Fahey. (2014). *Roots alter microbial response to winter climate change.*. Hubbard Brook

Annual Cooperators Meeting. North Woodstock, NH. Status = OTHER;

Acknowledgement of Federal Support = Yes

- Yang, Yang, Ruth D. Yanai, Craig R. See, Mary A. Arthur. (2015). *Sampling intensity and uncertainty in litterfall mass and nutrient flux in northern hardwoods..* Rochester Academy of Science Fall Paper Session. Canandaigua, NY. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Berton, R., Shaw, S. B., Chandler, D. G., Driscoll, C. T. (2015). *Seasonal Discharge Predictions in regards to Temporal Variations of AMO and NAO in the Northeastern United States.* 52th Annual Hubbard Brook Cooperators' Meeting. Thornton, NH. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Hallworth, M. T., T. S. Sillett, L. Rockwood, and P. P. Marra. (2014). *Seasonal interactions influence individuals and the population growth rate of a long distance migratory songbird..* Seasonal interactions influence individuals and the population growth rate of a long distance migratory songbird.. Estes Park, CO. Status = OTHER; Acknowledgement of Federal Support = Yes
- Cleavitt, N.L. (2015). *Seeking the Wolf Tree: Hubbard Brook in the schoolyard..* 2015 HB Cooperators meeting.. Thornton, NH. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Valipour, M., Driscoll, C.T. (2015). *Simulation of the Response of Soil and Streamwater Chemistry to the Effects of Whole –Tree Clear-Cutting Using PnET-BGC.* Hubbard Brook Annual Cooperators Meeting. N. Woodstock, NH. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Johnson, C.E. (2015). *Soil Carbon Stocks in a Temperate Hardwood Forest: Climate Change Effects and Recovery from Chronic Acidification.* International Symposium on Forest Soils. Fuzhou, China. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Johnson, C.E. (2015). *Soil chemistry on Watershed 1: 1998-2014.* Hubbard Brook Ecosystem Study 52nd Annual Cooperators' Meeting. Thornton, NH. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Shan S., Grentzer M, Fisk MC. (2015). *Soil nutrient availability influences rhizosphere effect on soil microbial properties..* Annual meetings of the Ecological Society of America. Baltimore MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Sorensen PO, PH Templer and AC Finzi. (2014). *Soil temperature manipulation in winter vs. summer leads to different effects on growing season soil microbial activity in temperate hardwood forests..* American Geophysical Union. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Yang Yang (2014). *Source of variability in tissue chemistry in northern hardwood species..* New York Society of American Foresters. Syracuse, NY. Status = OTHER; Acknowledgement of Federal Support = Yes
- Muniz, A., and S.A. Kaiser. (2013). *Spatial and temporal variation in nest predation rates of a migratory songbird across an elevation gradient.* 20th Annual Conference of The Wildlife Society. Milwaukee, WI. Status = OTHER; Acknowledgement of Federal Support = Yes
- Lany, N.K., M.P. Ayres, E. Stange, T.S. Sillett, N.L. Rodenhouse, R.T. Holmes (2013). *Spring leaf phenology, insect abundance, and the timing of breeding by the Black-throated Blue Warbler.* New England Natural History Conference. Springfield, MA. Status = OTHER; Acknowledgement of Federal Support = Yes

- Yanai, R.D., Steven Hamburg, Matt Vadeboncoeur; Joel Blum, Mary Arthur, Paul Lilly (2014). *Sustainable Forest Harvest Requires Nutrient Supply from Soil Pools: Ecosystem Budgets for Second-Growth Northern Hardwoods in New Hampshire, USA.* 24th IUFRO World Congress. Salt Lake City, UT. Status = OTHER; Acknowledgement of Federal Support = Yes
- Lany, N.K., M.P. Ayres. (2013). *Temperature and the balance of top-down and bottom-up interactions in a temperate hardwood forest.* Seminar, Swedish University of Agricultural Sciences. Uppsala, Sweden. Status = OTHER; Acknowledgement of Federal Support = No
- Berton, R., Driscoll, C. T., Chandler, D. G (2014). *The Assessment of Climate and Anthropogenic Impacts on Watershed Hydrology: A Case Study of the Merrimack Watershed, NH-MA.* 3-Minute Thesis Competition. Syracuse University, Syracuse, NY. Status = OTHER; Acknowledgement of Federal Support = Yes
- Yang, Y. and R.D. Yanai. (2014). *The Importance of Measuring Mercury in Wood.* American Geophysical Union Fall Meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Yanai, R.D. (2014). *The Importance of quantifying uncertainty in managing forests.* 24th IUFRO World Congress. Salt Lake City, UT. Status = OTHER; Acknowledgement of Federal Support = Yes
- Pourmokhtarian, A. (Invited Speaker), C.T. Driscoll, J.L. Campbell, K. Hayhoe, A.M.K. Stoner (2014). *The Influence of Downscaling Models and Observations on Future Hydrochemistry Responses of Forest Watersheds.* American Geophysical Union (AGU) 2014 Fall Meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Berton, R., Shaw, S. B., Chandler, D. G., Driscoll, C. T. (2014). *The Prediction of Annual Discharge Due to Oceanic Indices Variations in the Northeastern United State.* New England Graduate Student Water Symposium. University of Massachusetts Amherst, Amherst, MA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Berton, R., Driscoll, C. T., Shaw, S. B., Chandler, D. G. (2014). *The Teleconnection of Merrimack Hydrology to AMO and NAO Oceanic Indices.* 51st Annual Hubbard Brook Cooperators' Meeting. Hubbard Brook, NH. Status = OTHER; Acknowledgement of Federal Support = Yes
- Berton, R., Driscoll, C. T., Chandler, D. G. (2014). *The Teleconnection of Streamflow Variations with Large-Scale Oceanic Variables in the Merrimack Watershed, NH-MA.* NUNAN Lecture & Research Day. Syracuse University, Syracuse, NY. Status = OTHER; Acknowledgement of Federal Support = Yes
- Berton, R., Shaw, S. B., Chandler, D. G., Driscoll, C. T. (2014). *The Use of Oceanic Indices Variations Due to Climate Change to Predict Annual Discharge Variations in Northeastern United States.* American Geophysical Union Fall Meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Pourmokhtarian, A., Driscoll, C.T., Campbell, J.L., Hayhoe, K., Stoner, A. (2014). *The influence of downscaling models and observations on future hydrochemistry responses of forest watersheds.* American Geophysical Union, Fall Meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Battles, J.J. (2015). *The non-steady state of vegetation dynamics in the Hubbard Brook Valley.* 2015 HB Cooperators meeting.. Thornton, NH. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Lany, N.K., M. P. Ayres, and J. M. Scriber. (2014). *Top-down vs. bottom-up is a*

function of temperature for forest Lepidoptera.. 2014 Annual Meeting of the Ecological Society of America. Sacramento, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

- Lany, N.K. and M. P. Ayres (2014). *Top-down vs. bottom-up is a function of temperature for forest Lepidoptera.*. International Union of Forest Research Organizations 2014 World Congress. Salt Lake City, UT. Status = OTHER; Acknowledgement of Federal Support = Yes
- Yanai, R.D, P.J. Lilly, M.A. Arthur, K. Bae, S.P. Hamburg, C.R. Levine, M.A. Vadeboncoeur. (2014). *Uncertainty in accounting for carbon accumulation following forest harvesting.*. American Geophysical Union Fall Meeting. San Francisco, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Yanai, Ruth D., Paul J. Lilly, Matthew A. Vadeboncoeur, Steven P. Hamburg, Joel D. Blum, Mary A. Arthur, Carrie R. Levine, Kikang Bae, Farrah Fatemi R., Byung Bae Park. (2015). *Uncertainty in nutrient budgets in northern hardwood forests: Natural variation exceeds measurement error.*. Ecological Society of America Annual Meeting. Baltimore MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Frey, S.J.K, Rodenhouse, N.L., Sillett, S., Holmes, R.T., and Betts, M.G. (2012). *Ups and downs: Long-term songbird population trends across an elevational gradient in the Hubbard Brook Experimental Forest, NH.* Ecological Society of America Conference. Portland Oregon. Status = OTHER; Acknowledgement of Federal Support = Yes
- Frey, S.J.K, Rodenhouse, N.L., Sillett, S., Holmes, R.T., and Betts, M.G. (2012). *Ups and downs: Long-term songbird population trends across an elevational gradient in the Hubbard Brook Experimental Forest, NH.* North American Ornithological Congress. Vancouver, British Columbia. Status = OTHER; Acknowledgement of Federal Support = Yes
- Holmes, R.T. (2013). *Ups and downs: bird population trends across the Hubbard Brook valley.* Annual Cooperators' Meeting, Hubbard Brook Ecosystem Study. North Woodstock, NH. Status = OTHER; Acknowledgement of Federal Support = Yes
- Driscoll, C.T. (2015). *Using Science-policy Integration to Improve Ecosystem Science and Inform Decision-making: Lessons from U.S. LTERs.* 100th Ecological Society of America Meeting (ESA). Baltimore, MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Pardo, L.H., Green, M.B., Bailey, S.W., McGuire, K.J., Goodale, C. L., Groffman, P.M. (2015). *Using a hydrogeological framework to identify carbon and nitrogen cycling hotspots in a northern hardwood forest.* Ecological Society of America Annual Meeting. Baltimore MD. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Bailey, S.W. (2015). *Where do forests end and streams begin?*. New Hampshire Association of Natural Resource Scientists. Concord, NH. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Bailey, S.W. (2015). *Where do forests end and streams begin?*. Northeastern Ecosystem Research Cooperative (NERC). Saratoga Springs, NY. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

- *Databases.*

Hubbard Brook Database sets: http://www.hubbardbrook.org/data/dataset_search.php

- *Databases.*

The LTER grant partially supports the eddy covariance measurements made at the Bartlett Experimental Forest AmeriFlux site. Data through the beginning of 2014 have been contributed to the AmeriFlux database for processing and public distribution: <http://ameriflux.ornl.gov/fullsiteinfo.php?sid=75>

- *Models.*

A daily version of the PnET-CN model, PnET-Daily, was developed and released online (<http://www.pnet.sr.unh.edu/download.html>). The model was developed by downscaling the monthly time step model, PnET-CN with several improvements. It uses daily weather data, such as daily temperature and precipitation, to predict daily dynamics of carbon, nitrogen, and water fluxes in forests. The model was validated at the plot scale for GPP and NEE estimates with eddy flux tower data from Bartlett Experimental Forest (BEF), Litterfall and wood growth at BEF and Hubbard Brook Experimental Forest (HBEF), and runoff and N leaching at HB. It is being applied to link with an aquatic biogeochemistry model, FRAMES, to study the effect of future land use and climate projections on ecosystem functions and tradeoffs in New Hampshire. It is also applied by researchers from other institutions, such as Boston University.

Other Publications

- Botter, G., Benettin, P., McGuire, K., Kirchner, J.W., Rinaldo (2015). *Modeling river hydrochemistry through dynamic travel time distributions*. European Geophysical Union, Geophysical Research Abstracts Vol. 17, EGU2015-5838.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Harper, Caroline (2015). *Within season movement of songbirds at the landscape scale in the Hubbard Brook Experimental Forest..* Undergraduate honors thesis.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Patents

Technologies or Techniques

Thesis/Dissertations

- Gannon, J.P.. *A Hydropedological Approach to Describing Runoff Generation, Lateral Podzolization, and Spatial and Temporal Patterns of {DOC} in a Headwater Catchment..* (2014). Virginia Tech. Acknowledgement of Federal Support = Yes
- Diggs, Franklin M.. *Contrasting mycorrhizal guilds through the soil profile..* (2014). SUNY College of Environmental Science and Forestry. Acknowledgement of Federal

Support = Yes

- Yang, Yang.. *Detecting changes in tree tissue chemistry over time in Northern Hardwood Stands..* (2015). SUNY College of Environmental Science and Forestry. Acknowledgement of Federal Support = Yes
- Frey, Sarah J. K.. *Effects of Spatial Scale and Heterogeneity on Avian Occupancy Dynamics and Population Trends in Forested Mountain Landscapes..* (2014). Oregon State University. Acknowledgement of Federal Support = Yes
- Dong, Yi. *Effects of rock-derived nutrients on N cycling in northern hardwood forest.* (2014). {SUNY} College of Environmental Science and Forestry. Acknowledgement of Federal Support = Yes
- Lany, Nina. *Effects of temperature on species interactions in northern hardwood forests.* (2014). Dartmouth College. Acknowledgement of Federal Support = Yes
- Reinmann, Andrew. *Effects of winter climate change on carbon and nitrogen losses from temperate forest ecosystems.* (2014). Boston University. Acknowledgement of Federal Support = Yes
- Fuss, Colin. *Hydrochemical Dynamics Under Differing Winter Climate Regimes at the Hubbard Brook Experiment Forest.* (2014). Syracuse. Acknowledgement of Federal Support = Yes
- Bourgault, R.. *Hydropedology of podzols at Hubbard Brook, New Hampshire.* (2014). University of Vermont. Acknowledgement of Federal Support = Yes
- Lee, M. *Impact of Diffuse Radiation Measurements on Modeling Carbon Budgets: A Model-Data Fusion Experiment at Bartlett Experimental Forest.* (2013). Department of Organismic and Evolutionary Biology, Harvard U. Acknowledgement of Federal Support = Yes
- van Doorn, Natalie S.. *Patterns and Process of Forest Growth: the Role of Neighborhood Dynamics and Tree Demography in a Northern Hardwood Forest.* (2014). University of California, Berkeley. Acknowledgement of Federal Support = Yes
- Pellissier, P.A.. *Remote Sensing Foliar Nitrogen of Cultivated Grasslands in Human Dominated Landscapes..* (2015). University of New Hampshire. Acknowledgement of Federal Support = Yes
- Hallworth, Michael. *The influence of migratory connectivity and seasonal interactions on individual- and population-level dynamics of a long distance migratory songbird..* (2014). George Mason University. Acknowledgement of Federal Support = Yes
- Burakowski, Elizabeth. *Winter climate impacts of historical deforestation in New England.* (2014). University of New Hampshire. Acknowledgement of Federal Support = Yes

Websites

- *HBR Research Climate Change by Templer*
<http://www.hubbardbrook.org/research/climate/templer.shtml>

This web-site provides a summary of our Climate Change Across Seasons Experiment (CCASE) at Hubbard Brook.

- *Hubbard Brook hydropedology project*
<http://hydro.vwrrc.vt.edu/research/projects/hubbard-brook-hydropedology-project/>

documents project description, publications and data associated with Hubbard Brook hydrogeology

- *Light-Level geolocator analysis using the GeoLight package*
https://github.com/SCBI-MigBirds/scbi-migbirds.github.io/blob/master/Geolocator_GeoLight.Rmd

Document outlines the steps for analyzing data from archival light-level geolocators.

- *Modeling abundance and occupancy using point count data*
https://github.com/SCBI-MigBirds/scbi-migbirds.github.io/blob/master/Abundance_Occupancy.Rmd

Point count data are a cost effective way of surveying large areas to answer ecological questions.

- *Multiple Element Limitation in Northern Hardwood Ecosystems*
<http://www.esf.edu/MELNHE>

Stands at this site are among those under observation in MELNHE's nutrient manipulation studies.

- *Network Streamwater Chemistry Project*
<http://hydro.vwrrc.vt.edu/research/projects/network-stream-water-chemistry-project/>

document project description and publications associated with the Hubbard Brook Network Stream Chemistry project

- *Online teaching module: Analyze bird migration data*
http://nationalzoo.si.edu/ConservationAndScience/MigratoryBirds/Research/Climate_Change/

This module teaches students how to analyze bird migration data collected from light-level geolocators. Data for ovenbirds, collected at Hubbard Brook, are used.

- *Quantifying Uncertainty in Ecosystem Studies*
<http://quantifyinguncertainty.org>

Some of our work appears on the QUEST website as case studies, and as input in developing best practices.

- *Teaching Module: analyze abundance and occupancy data*
<http://www.hubbardbrook.org/research/animals/bird/holmes-intro03.htm>

Online teaching module: This module teaches students how to analyze abundance and occupancy data, using the Hubbard Brook valley-wide bird survey dataset.

[Back to the top](#)

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? 108 How many REU applicants were selected and agreed to participate during this reporting period? 10 REU Comments:

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Lovett, Gary	PD/PI	2
Driscoll, Charles	Co PD/PI	2
Fahey, Timothy	Co PD/PI	1
Bailey, Scott	Co-Investigator	3
Battles, John	Co-Investigator	2
Blum, Joel	Co-Investigator	1
Campbell, John	Co-Investigator	3
Fisk, Melany	Co-Investigator	3
Goodale, Christine	Co-Investigator	1
Groffman, Peter	Co-Investigator	1
Johnson, Chris	Co-Investigator	2
Likens, Gene	Co-Investigator	2
McGuire, Kevin	Co-Investigator	2
Mitchell, Myron	Co-Investigator	2
Ollinger, Scott	Co-Investigator	1
Pruyn, Michele	Co-Investigator	2
Richardson, Andrew	Co-Investigator	1
Rodenhouse, Nicholas	Co-Investigator	2
Yanai, Ruth	Co-Investigator	1
Dumont, Peter	K-12 Teacher	1
Sheehan, Kerry	K-12 Teacher	1
Aubrecht, Donald	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Burakowski, Elizabeth	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Fuss, Colin	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Hallworth, Michael	Postdoctoral (scholar, fellow or other postdoctoral position)	3
Keenan, Trevor	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Roco, Constance	Postdoctoral (scholar, fellow or	2

	other postdoctoral position)	
Cleavitt, Natalie	Other Professional	8
Garlick, Sarah	Other Professional	8
Lepine, Lucie	Other Professional	1
Martin, Mary	Other Professional	11
Pardo, Linda	Other Professional	3
Templer, Pamela	Other Professional	1
Wilson, Geoff	Other Professional	10
Wilson, Jackie	Other Professional	8
Ard, Gabrielle	Technician	1
Berton, Rouzbeh	Technician	6
Burns, Margaret	Technician	2
Buso, Donald	Technician	0
Engelman, Heather	Technician	1
Fakhraei, Habibollah	Technician	2
Gillen, Jennifer	Technician	3
Glick, Nicholas	Technician	12
Heinz, Alexis	Technician	1
Irish, Amanda	Technician	2
Koppers, Mary Margaret	Technician	6
Lang, Ashley	Technician	12
Martel, Lisa	Technician	3
Moler, Erin	Technician	1
Montesdeoca, Mario	Technician	2
O'Neill, William	Technician	1
Simmons, Wade	Technician	2
Soften, Laura	Technician	4
Thorne, Trischa	Technician	4
Valipour, Mahnaz	Technician	3
Weeks, Josiah	Technician	3
Zhou, Zaixing	Staff Scientist (doctoral level)	1
Barner, Jerome	Graduate Student (research assistant)	1
Bayer, Clarice`	Graduate Student (research assistant)	4
Blumstein, Megan	Graduate Student (research assistant)	1
Goswami, Shinjini	Graduate Student (research assistant)	6
Jensen, Carrie	Graduate Student (research assistant)	3
Jiang, Pamela	Graduate Student (research assistant)	1
Quimette, Andrew	Graduate Student (research assistant)	2

Patterson, Owen	Graduate Student (research assistant)	2
Puntsag, Tamir	Graduate Student (research assistant)	9
Shan, Shan	Graduate Student (research assistant)	4
Yang, Yang	Graduate Student (research assistant)	1
Clyne, Ailis	Undergraduate Student	3
Devens, Hannah	Undergraduate Student	2
Forlini, Dominic	Undergraduate Student	1
Harband, Matthew	Undergraduate Student	2
Jardine, Kelsey	Undergraduate Student	1
Montague, Madeline	Undergraduate Student	3
Schiera, James	Undergraduate Student	1
Suttenberg, Stephanie	Undergraduate Student	1
Tamargo, Katelyn	Undergraduate Student	1
Tiller, Jenna	Undergraduate Student	4
Washburn, Brittany	Undergraduate Student	1
Coco, Angela	Research Experience for Undergraduates (REU) Participant	3
Corcoran, Kyle	Research Experience for Undergraduates (REU) Participant	3
Geyman, Benjamin	Research Experience for Undergraduates (REU) Participant	3
Hampton, Tyler	Research Experience for Undergraduates (REU) Participant	3
Leonardi, Brendan	Research Experience for Undergraduates (REU) Participant	3
MacMillan, Ashley	Research Experience for Undergraduates (REU) Participant	3
Poirier, Kate	Research Experience for Undergraduates (REU) Participant	3
Sapnas, Christen	Research Experience for Undergraduates (REU) Participant	3
Spina, Paloma	Research Experience for Undergraduates (REU) Participant	3

Wiggins, Lauren	Research Experience for Undergraduates (REU) Participant	3
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Full details of individuals who have worked on the project:

<p>Gary M Lovett Email: lovettg@caryinstitute.org Most Senior Project Role: PD/PI Nearest Person Month Worked: 2 Contribution to the Project: Research on forest nutrient cycling; supervision of students, postdocs and technician. Funding Support: This grant and other NSF grants. International Collaboration: No International Travel: No</p>
<p>Charles T Driscoll Email: ctdrisco@syr.edu Most Senior Project Role: Co PD/PI Nearest Person Month Worked: 2 Contribution to the Project: Designs and coordinates project, works with students and technicians. Funding Support: Home institution International Collaboration: Yes, korea, democratic people's republic of International Travel: Yes, israel - 0 years, 0 months, 15 days; korea, democratic people's republic of - 0 years, 0 months, 10 days</p>
<p>Timothy J Fahey Email: tjf5@cornell.edu Most Senior Project Role: Co PD/PI Nearest Person Month Worked: 1 Contribution to the Project: Principal Investigator of the project. Funding Support: Home Institution. International Collaboration: No International Travel: No</p>
<p>Scott W Bailey Email: swbailey@plymouth.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 3 Contribution to the Project: Dr. Bailey is the lead researcher and field coordinator on the hydrogeology study, which examines feedbacks between hydrology, soil characteristics, and catchment biogeochemistry in the reference watershed. He has been responsible for soil and geochemical characterization in the reference watershed. Funding Support: USFS-Northern Research Station and this grant. International Collaboration: No International Travel: No</p>
<p>John J Battles Email: jbattles@berkeley.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2</p>

Contribution to the Project: Co-lead scientist for long-term monitoring of primary productivity, forest composition, and tree demography.

Funding Support: this award.

International Collaboration: No

International Travel: No

Joel D Blum

Email: jdblum@umich.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Analyses of vegetation and stream water, data interpretation and publication.

Funding Support: LTER

International Collaboration: No

International Travel: No

John L Campbell

Email: jlcampbell@fs.fed.us

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 3

Contribution to the Project: Campbell conducts research on biogeochemistry and hydrology. Help maintain the long-term hydrometeorological record.

Funding Support: US Forest Service

International Collaboration: No

International Travel: No

Melany Fisk

Email: fiskmc@miamioh.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 3

Contribution to the Project: Melany Fisk's research focuses on nutrient cycling and soil organisms. She is involved in studies of winter climate and snowpack controls of carbon and nitrogen processing, and of plant-microbe processes that mediate interactions among different nutrients (calcium, nitrogen, phosphorus).

Funding Support: partial support from this grant towards research.

International Collaboration: No

International Travel: No

Christine Goodale

Email: clg33@cornell.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: I supported part of C. Armanda Roco's time as a postdoc to work on analyzing & writing up a HB soil microbiome project conducted jointly w/my part of the HB award. I spent some of my time as well, overseeing an undergrad honors student (a former REU on another award) revising her research on dendrochemistry, working with Armanda, and facilitating collection of additional HB & nearby soils.

Funding Support: home institution.

International Collaboration: No

International Travel: No

Peter Mark Groffman

Email: groffmanP@caryinstitute.org
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1
Contribution to the Project: Peter leads long-term monitoring of soil microbial biomass and activity, winter climate change and nitrogen gas flux research.
Funding Support: NSF Hubbard Brook LTER
International Collaboration: No
International Travel: No

Chris Johnson
Email: cejohns@syr.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2
Contribution to the Project: Research on soil biogeochemistry; supervision of students and technician.
Funding Support: this grant.
International Collaboration: Yes, china
International Travel: Yes, china - 0 years, 0 months, 5 days

Gene E Likens
Email: LikensG@ecostudies.org
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2
Contribution to the Project: Overall project supervision, ecosystem and biogeochemical research on forest, stream and lake ecosystems of the Hubbard Brook Valley.
Funding Support: salary from home institution
International Collaboration: No
International Travel: No

Kevin J McGuire
Email: kevin.mcguire@vt.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2
Contribution to the Project: Dr. McGuire is the main researcher on the process hydrology portion of the project that relates to the hydrogeology study, which examines feedbacks between hydrology, soil characteristics, and catchment biogeochemistry in the reference watershed, WS3. McGuire has also been working to understand chemical variation in the stream network at the valley-wide scale. Manages a subaward and was the primary advisor to 1 graduate student on the project in 2015. • Manages a subaward and was the primary advisor to 1 graduate student on the project in 2014.
Funding Support: This grant.
International Collaboration: No
International Travel: No

Myron James Mitchell
Email: Mitchell@syr.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2
Contribution to the Project: Developed analyses of stable water isotopes from archives at the HBEF and manuscript preparation.
Funding Support: This grant and home institution.

<p>International Collaboration: No International Travel: No</p>
<p>Scott Ollinger Email: scott.ollinger@unh.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1 Contribution to the Project: Carbon and nitrogen cycling, remote sensing and ecosystem modeling and regionalization. Funding Support: Home institution and other grants. International Collaboration: Yes, netherlands International Travel: No</p>
<p>Michele Lynn Pruyn Email: mlpruyn@plymouth.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2 Contribution to the Project: Serves as PI for the HBEF REU project. Mentor to undergraduate participants. Work with the co-PIs, to run the programming, review submissions, etc. Conduct research with undergrads and graduate student. Funding Support: home institution support. International Collaboration: No International Travel: No</p>
<p>Andrew Richardson Email: arichardson@oeb.harvard.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1 Contribution to the Project: Dr. Richardson managed CO2 flux measurements at Bartlett Experimental Forest; supervised undergraduates and postdocs conducting empirical and model-data fusion analyses of Bartlett Data. Funding Support: Funded through Harvard faculty position. International Collaboration: No International Travel: No</p>
<p>Nicholas Rodenhouse Email: nrodenho@wellesley.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2 Contribution to the Project: Nick leads/manages the study of heterotrophs: sampling of birds, salamander, insects, mammals to produce the data and models needed develop a landscape demography for heterotrophs. Funding Support: Home institution. International Collaboration: Yes, poland International Travel: No</p>
<p>Ruth Yanai Email: rdyanai@syr.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1 Contribution to the Project: Ruth coordinates the MELNHE project (Multiple Element Limitation in Northern Hardwood Ecosystems), which was proposed as an activity of the</p>

Hubbard Brook LTER. 2014 was the fourth year of treatment of N, P, and Ca in stands of different ages at Hubbard Brook, Jeffers Brook, and Bartlett Experimental Forests. Uncertainty analysis was another theme of the HBR LTER. This effort has since been funded as a Research Coordination Network called QUEST (Quantifying Uncertainty in Ecosystem Studies), led by Yanai and other HBR researchers (Mark Green and John Campbell) as well as researchers at other institutions.

Funding Support: State University of New York, MELNHE and QUEST grants from NSF.

International Collaboration: No

International Travel: No

Peter Dumont

Email: pdumont@sau4.org

Most Senior Project Role: K-12 Teacher

Nearest Person Month Worked: 1

Contribution to the Project: Peter is a high-school science teacher and participated in our Research Experience for Teachers program. He worked on a project estimating fish populations in Mirror Lake and the effects of pumpkinseed introduction on other fish species in the lake.

Funding Support: RET

International Collaboration: No

International Travel: No

Kerry Sheehan

Email: kerile@profile.k12.nh.us

Most Senior Project Role: K-12 Teacher

Nearest Person Month Worked: 1

Contribution to the Project: Kerry is a high school science teacher and participated in our Research Experience for Teachers program. She worked on a biogeochemical model project seeking to evaluate the role that soil plays in storing and serving as a sink for nitrogen. Kerry's project also had an educational component as well, and she developed a model-based lesson that can be used to teach about modeling and N cycle concepts.

Funding Support: RET

International Collaboration: No

International Travel: No

Donald Aubrecht

Email: aubrecht@oeb.harvard.edu

Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)

Nearest Person Month Worked: 1

Contribution to the Project: Donald assisted with field maintenance of instruments and CO2 flux system at Bartlett.

Funding Support: Also funded through other NSF support.

International Collaboration: No

International Travel: No

Elizabeth Burakowski

Email: elizabeth.burakowski@gmail.com

Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)

Nearest Person Month Worked: 1

Contribution to the Project: Remote sensing, albedo, ecosystem-climate interactions.

Funding Support: This grant and other.

International Collaboration: No

<p>International Travel: No</p> <p>Colin Fuss Email: cfuss@syr.edu Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position) Nearest Person Month Worked: 12 Contribution to the Project: Biogeochemical research on forest ecosystems. Funding Support: This grant and other NSF grants. International Collaboration: No International Travel: No</p>
<p>Michael Hallworth Email: mhallwor@masonlive.gmu.edu Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position) Nearest Person Month Worked: 3 Contribution to the Project: Spatial and temporal components of community dynamics identify assembly rules, Smithsonian Institution, Washington, DC. Funding Support: this grant. International Collaboration: No International Travel: No</p>
<p>Trevor Keenan Email: trevor.keenan@mq.edu.au Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position) Nearest Person Month Worked: 1 Contribution to the Project: Analyzed long-term phenology data from Hubbard Brook. Funding Support: Funded through Australian fellowship. International Collaboration: Yes, australia International Travel: No</p>
<p>Constance Armanda Roco Email: car94@cornell.edu Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position) Nearest Person Month Worked: 2 Contribution to the Project: Armanda led the microbiome analyses, interpretation, and manuscript portion of a project examining microbial community composition and genomics of our Hubbard Brook soils. Funding Support: Home institution. International Collaboration: No International Travel: No</p>
<p>Natalie L Cleavitt Email: nlc4@cornell.edu Most Senior Project Role: Other Professional Nearest Person Month Worked: 8 Contribution to the Project: Dr. Cleavitt oversees the tree survey crew and runs several other long-term plant ecology projects. She conducts the collection of fine litter, coarse woody debris and leaves for foliar chemistry. This season she mentored one REU student. She curates the long-term vegetation data sets. She takes full part in data analysis and paper writing. She is also author of "Seeking the Wolf Tree", the schoolyard book for Hubbard Brook, published in October 2015. Funding Support: this award and Cornell University.</p>

International Collaboration: No

International Travel: No

Sarah Garlick

Email: sarahgarlick@gmail.com

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 8

Contribution to the Project: Sarah is the Director of Science Policy and Outreach for the Hubbard Brook Research Foundation and directs the site's Forest Science Dialogs project.

Funding Support: NSF Award #DRL 1322871

International Collaboration: No

International Travel: No

Lucie Lepine

Email: lucie.lepine@unh.edu

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 1

Contribution to the Project: Remote sensing using high spectral resolution aircraft data. Preparation of spatial data layers for modeling.

Funding Support: this grant and home institution.

International Collaboration: No

International Travel: No

Mary Martin

Email: mary.martin@unh.edu

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 11

Contribution to the Project: Information management

Funding Support: this grant, USDA, NSF NH-EPSCOR, NSF-EAGER

International Collaboration: No

International Travel: No

Linda H Pardo

Email: lpardo@fs.fed.us

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 3

Contribution to the Project: technician supervision, study design, methods development, data qa/qc and analysis.

Funding Support: US Forest Service.

International Collaboration: No

International Travel: No

Pamela Templer

Email: ptempler@bu.edu

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 1

Contribution to the Project: I am an ecosystem ecologist and forest ecologist. I manage projects related to plant nutrient uptake, canopy and soil carbon fluxes, as well as soil nitrogen cycling measurements in the laboratory and field. I am an elected member of the Scientific Coordinating Committee and am on the Board of Trustees for the Hubbard Brook Research Foundation. I support graduate students working at Hubbard Brook.

Funding Support: NSF LTER grant, along with funds from a NSF CAREER grant.

International Collaboration: No

International Travel: No

Geoff Wilson

Email: gwilson@hbresearchfoundation.org

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 10

Contribution to the Project: Geoff is the Director of Facilities and Programs for the Hubbard Brook Research Foundation. His primary responsibilities include the REU program for this NSF award) and the management of the facilities. He also participates in other education and outreach activities on behalf of the site as needed.

Funding Support: sLTER.

International Collaboration: No

International Travel: No

Jackie Wilson

Email: jwilson@hbresearchfoundation.org

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 8

Contribution to the Project: Jackie is the Education Director for the Hubbard Brook Research Foundation and directs the K-12 education initiatives for the site, including lesson development, participation in a state-wide teacher professional development team and outreach to schools.

Funding Support: sLTER

International Collaboration: No

International Travel: No

Gabrielle Ard

Email: gard@syr.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 1

Contribution to the Project: Gabrielle is analyzing patterns of phosphorus in soil water and stream water.

Funding Support: this grant.

International Collaboration: No

International Travel: No

Rouzbeh Berton

Email: rberton@syr.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 6

Contribution to the Project: Hydrologic analysis of Merrimack River

Funding Support: this grant and home institution.

International Collaboration: No

International Travel: No

Margaret Burns

Email: burnsm@caryinstitute.org

Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Field, laboratory and data analysis.

Funding Support: NSF Hubbard Brook LTER.

International Collaboration: No

<p>International Travel: No</p> <p>Donald C Buso Email: dbuso@worldpath.net Most Senior Project Role: Technician Nearest Person Month Worked: 0 Contribution to the Project: Manager of Field Studies and Data Management at Hubbard Brook Experimental Forest under supervision of Gene E. Likens. Funding Support: partial support from grant and support from home institution. International Collaboration: No International Travel: No</p>
<p>Heather Engelman Email: forestecology@esf.edu Most Senior Project Role: Technician Nearest Person Month Worked: 1 Contribution to the Project: Heather takes care of the bulk of the lab paperwork and maintains project information on the ESF websites. She also supports manuscript, poster and grant preparation. Funding Support: this project. International Collaboration: No International Travel: No</p>
<p>Habibollah Fakhraei Email: hfakhrae@syr.edu Most Senior Project Role: Technician Nearest Person Month Worked: 2 Contribution to the Project: Conduct model simulations and field research on experimental ice storm. Funding Support: home institution. International Collaboration: No International Travel: No</p>
<p>Jennifer L Gillen Email: jg4259@gmail.com Most Senior Project Role: Technician Nearest Person Month Worked: 3 Contribution to the Project: Assisted with salamander sampling, maintained experimental stream pools. Funding Support: this grant. International Collaboration: No International Travel: No</p>
<p>Nicholas Glick Email: nbglick@syr.edu Most Senior Project Role: Technician Nearest Person Month Worked: 12 Contribution to the Project: Sampling and analysis of soil solution and stream samples. Funding Support: this grant and home institution. International Collaboration: No International Travel: No</p>
<p>Alexis Kristan Heinz</p>

Email: akh24@cornell.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 1
Contribution to the Project: Alexis is the lab manager for Fahey's lab at Cornell University; she provides laboratory assistance for this project performing data management and field sampling.
Funding Support: this award.
International Collaboration: No
International Travel: No

Amanda Irish
Email: irishA@caryinstitute.org
Most Senior Project Role: Technician
Nearest Person Month Worked: 2
Contribution to the Project: Role: Field, laboratory and data analysis.
Funding Support: NSF Hubbard Brook LTER.
International Collaboration: No
International Travel: No

Mary Margaret Koppers
Email: mmkoppers@syr.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 6
Contribution to the Project: Mary Margaret Koppers is a technician examining soil chemistry at Syracuse University.
Funding Support: this grant.
International Collaboration: No
International Travel: No

Ashley Lang
Email: ashley504@gmail.com
Most Senior Project Role: Technician
Nearest Person Month Worked: 12
Contribution to the Project: Field and laboratory work in forest nutrient cycling.
Funding Support: this grant and other NSF grants.
International Collaboration: No
International Travel: No

Lisa Martel
Email: martelL@caryinstitute.org
Most Senior Project Role: Technician
Nearest Person Month Worked: 3
Contribution to the Project: Role: Field, laboratory and data analysis.
Funding Support: NSF Hubbard Brook LTER.
International Collaboration: No
International Travel: No

Erin Moler
Email: ermoler@syr.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 1
Contribution to the Project: Ehren performed field work.

<p>Funding Support: this project. International Collaboration: No International Travel: No</p>
<p>Mario Montesdeoca Email: mmontesd@syr.edu Most Senior Project Role: Technician Nearest Person Month Worked: 2 Contribution to the Project: Mario Montesdeoca supervises laboratory activities at Syracuse University, Department of Civil Engineering. Funding Support: paid by employer. International Collaboration: No International Travel: No</p>
<p>William O'Neill Email: wfoneill160@msn.com Most Senior Project Role: Technician Nearest Person Month Worked: 1 Contribution to the Project: Bill contributed to manuscript support this year, preparing graphics, and also serve as resource for sample organization. Funding Support: this project. International Collaboration: No International Travel: No</p>
<p>Wade Simmons Email: simmonsW@caryinstitute.org Most Senior Project Role: Technician Nearest Person Month Worked: 2 Contribution to the Project: Field, laboratory and data analysis. Funding Support: NSF Hubbard Brook LTER. International Collaboration: No International Travel: No</p>
<p>Laura Soften Email: laura.sofen@gmail.com Most Senior Project Role: Technician Nearest Person Month Worked: 4 Contribution to the Project: Laura was responsible for assisting with field and laboratory work at Hubbard Brook and Boston University, respectively. Funding Support: this grant, along with funds from a NSF CAREER grant to Pamela Templer. International Collaboration: No International Travel: No</p>
<p>Trischa B Thorne Email: trischa.b.thorne@gmail.com Most Senior Project Role: Technician Nearest Person Month Worked: 4 Contribution to the Project: Crew leader; assisted plot teams with data collection; organized data entry and proofing, etc. Funding Support: this grant. International Collaboration: No International Travel: No</p>

Mahnaz Valipour**Email:** mvalipou@syr.edu**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 3**Contribution to the Project:** Model simulations of clear-cutting disturbance.**Funding Support:** this grant.**International Collaboration:** No**International Travel:** No**Josiah Weeks****Email:** jdw.weeks@gmail.com**Most Senior Project Role:** Technician**Nearest Person Month Worked:** 3**Contribution to the Project:** Conducted point-counts of birds and assisted with arthropod and vegetation sampling.**Funding Support:** this grant.**International Collaboration:** No**International Travel:** No**Zaixing Zhou****Email:** zaixingzhou@gmail.com**Most Senior Project Role:** Staff Scientist (doctoral level)**Nearest Person Month Worked:** 1**Contribution to the Project:** Enhancements to PnET ecosystem models model, simulation of NPP for the HB valley and validation against valley-wide plot measurements.**Funding Support:** this grant and other.**International Collaboration:** No**International Travel:** No**Jerome Barner****Email:** jcbarner@syr.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 1**Contribution to the Project:** Jerome worked on characterizing the mycorrhizal fungi on beech seedlings collected during the 2014 mast year. He led the MELNHE summer field crew, including student projects on soil respiration, woody debris, N mineralization, and sap flow.**Funding Support:** Jerome was a graduate teaching assistant (soils), and was also supported partially by the MELNHE project.**International Collaboration:** No**International Travel:** No**Clarice` S Bayer****Email:** clarice.bayer@umontana.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 4**Contribution to the Project:** Claire Bayer is a Ph.D. candidate, University of Montana. Food Web Complexity and Retentiveness in Low Productivity Environments. Ph.D. Dissertation in progress, University of Montana, Missoula, MT**Funding Support:** this grant.**International Collaboration:** No**International Travel:** No

Megan Blumstein**Email:** blumstein@fas.harvard.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 1**Contribution to the Project:** Worked on improvements to the FöBAAR model, which is being used for model-data fusion analysis of Bartlett data.**Funding Support:** Funded by NSF Doctoral Fellowship.**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 graduate student at Miami University studying nitrogen and phosphorus limitation in forests.**Funding Support:** Partially supported by this project.**International Collaboration:** No**International Travel:** No**Carrie K Jensen****Email:** ckjensen@vt.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 3**Contribution to the Project:** Ms. Jensen was in her first year of a PhD project and Hubbard Brook is one out of four sites where she is investigating stream channel wetting and drying behavior. This project is related to valley-wide stream chemistry.**Funding Support:** This grant and the Virginia Tech Graduate School.**International Collaboration:** No**International Travel:** No**Pamela Jiang****Email:** becky2014jiang@gmail.com**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 1**Contribution to the Project:** Panmei acclimated to northern forests by assisting with field measurements. She took responsibility for weighing leaf litter samples collected in 2013.**Funding Support:** none**International Collaboration:** No**International Travel:** No**Andrew Ouimette****Email:** Andrew.Ouimette@unh.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 2**Contribution to the Project:** Carbon balances and sequestration estimates**Funding Support:** This grant and other.**International Collaboration:** No**International Travel:** No**Owen Patterson****Email:** patteroe@miamioh.edu

<p>Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 2 Contribution to the Project: Owen Patterson is a graduate student at Miami University studying nutrient limitation of microbial activity. Funding Support: Partially supported by this project International Collaboration: No International Travel: No</p>
<p>Tamir Puntsag Email: tpuntsag@syr.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 9 Contribution to the Project: Working with Myron Mitchell at SNY ESF, Tamir did the actual isotopic analyses, data analyses, statistical analysis and manuscript writing. Funding Support: Fulbright Fellowship and NSF LTER project. International Collaboration: No International Travel: No</p>
<p>Shan Shan Email: shans@miamioh.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 4 Contribution to the Project: Shan Shan is a graduate student at Miami University studying interactions of nutrient limitation and rhizosphere microbial processes. Funding Support: Partially supported by this project. International Collaboration: No International Travel: No</p>
<p>Yang Yang Email: yyang100@syr.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 1 Contribution to the Project: Yang Yang continued with litter sample processing and data analysis. He completed his MS degree with a thesis using data from Hubbard Brook, MELNHE, and other sites; this paper was just accepted by CJFR. He is preparing a paper on litterfall uncertainty, using data from Hubbard Brook and MELNHE. Funding Support: graduate teaching assistant (chemistry) through Syracuse University. International Collaboration: No International Travel: No</p>
<p>Ailis Clyne Email: abc237@cornell.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 3 Contribution to the Project: Ailis served as one of our field crew members for tree measurements including the 20-yr re-measure of the first 200 Valleywide plots, and 2-yr tree health checks on the long-term demography transects. She plans to return next season as an REU and began work on a senior thesis examining effects of gastropod grazing on health and diversity of epiphytic lichens in the spruce-fir zone. Funding Support: this grant. International Collaboration: No</p>

<p>International Travel: No</p> <p>Hannah Devens Email: devenshr@miamioh.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 2 Contribution to the Project: Hannah Devens is an undergraduate at Miami University studying fine root responses to nutrient additions. Funding Support: Partially supported by this project. International Collaboration: No International Travel: No</p>
<p>Dominic Forlini Email: forlinda@miamioh.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1 Contribution to the Project: Dominic Forlini is an undergraduate at Miami University studying controls of soil microbial respiration. Funding Support: partially supported by this project. International Collaboration: No International Travel: No</p>
<p>Matthew Harband Email: mph225@cornell.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 2 Contribution to the Project: Matt served as one of our field crew members for tree measurements including the 20-yr re-measure of the first 200 Valleywide plots, and 2-yr tree health checks on the long-term demography transects. Funding Support: this grant. International Collaboration: No International Travel: No</p>
<p>Kelsey Jardine Email: krjardin@syr.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1 Contribution to the Project: laboratory analyses of soils. Funding Support: this grant. International Collaboration: No International Travel: No</p>
<p>Madeline Montague Email: msm297@cornell.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 3 Contribution to the Project: Maddie served as a key returning field crew members for tree measurements including the 20-yr re-measure of the first 200 Valleywide plots, and 2-yr tree health checks on the long-term demography transects. She also started work for her senior thesis on patterns of beech bark disease across the Hubbard Brook valley landscape. Funding Support: this grant. International Collaboration: No</p>

<p>International Travel: No</p> <p>James Schiera Email: jtschier@syr.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1 Contribution to the Project: Field sampling of soils. Funding Support: this grant. International Collaboration: No International Travel: No</p>
<p>Stephanie Suttentberg Email: slsuttent@syr.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1 Contribution to the Project: Leaf and root sorting, supervising high school students and beginning undergraduates in the lab, and other activities in support of operations in Syracuse. Funding Support: Federal work study. International Collaboration: No International Travel: No</p>
<p>Katelyn Tamargo Email: kmtamarg@syr.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1 Contribution to the Project: laboratory analyses of soils. Funding Support: this grant. International Collaboration: No International Travel: No</p>
<p>Jenna Tiller Email: tillerjr@miamioh.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 4 Contribution to the Project: Jenna Tiller is an undergraduate at Miami University studying the recycling of litter-driven N. Funding Support: Partially supported by this project. International Collaboration: No International Travel: No</p>
<p>Brittany Washburn Email: bawashbu@syr.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1 Contribution to the Project: Leaf and root sorting, supervising high school students and beginning undergraduates in the lab, and other activities in support of operations in Syracuse. Funding Support: Federal work study International Collaboration: No International Travel: No</p>
<p>Angela Coco Email: angelacoco@kings.edu Most Senior Project Role: Research Experience for Undergraduates (REU) Participant</p>

Nearest Person Month Worked: 3
Contribution to the Project: REU project entitled: Influences of canopy cover and the presence of Brook Trout on macroinvertebrate communities in Kineo Brook at Hubbard Brook Experimental Forest.
Funding Support: REU site grant DEB # 1156844.
International Collaboration: No
International Travel: No
Year of schooling completed: Junior
Home Institution: King's College
Government fiscal year(s) was this REU participant supported: 2015

Kyle Corcoran
Email: kbcorcoran1@catamount.wcu.edu
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 3
Contribution to the Project: REU project entitled: Biogeochemical hotspots in shallow bedrock zones. Worked on stream network chemical dynamics; focus was on sources of dissolved organic carbon; continuing project as part of senior research at home institution.
Funding Support: REU site grant DEB # 1156844.
International Collaboration: No
International Travel: No
Year of schooling completed: Junior
Home Institution: West Carolina University
Government fiscal year(s) was this REU participant supported: 2015

Benjamin Geyman
Email: bgeyman@bowdoin.edu
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 3
Contribution to the Project: REU project entitled: Searching for a Signature: relationships between surface roughness and soil depth in the shallow-to-bedrock zone.
Funding Support: REU site grant DEB # 1156844
International Collaboration: No
International Travel: No
Year of schooling completed: Junior
Home Institution: Bowdoin College
Government fiscal year(s) was this REU participant supported: 2015

Tyler Hampton
Email: tyler.hampton@wildcats.unh.edu
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 3
Contribution to the Project: REU project entitled: Near stream groundwater table dynamics in two distinct hydro-pedologic units.
Funding Support: REU site grant DEB # 1156844.
International Collaboration: No
International Travel: No
Year of schooling completed: Junior
Home Institution: University of New Hampshire
Government fiscal year(s) was this REU participant supported: 2015

Brendan Leonardi**Email:** bmleonardi@mail.plymouth.edu**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant**Nearest Person Month Worked:** 3**Contribution to the Project:** REU project entitled: Comparison of sap flow rates among three northern hardwood tree species.**Funding Support:** REU funding; this award.**International Collaboration:** No**International Travel:** No**Year of schooling completed:** Junior**Home Institution:** Plymouth State University**Government fiscal year(s) was this REU participant supported:** 2015**Ashley MacMillan****Email:** anmacmillan@mail.plymouth.edu**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant**Nearest Person Month Worked:** 3**Contribution to the Project:** REU project entitled: An Evaluation of the Correspondence Among Outdoor Recreation, Environmental Values, and Ecosystem Services.**Funding Support:** This award.**International Collaboration:** No**International Travel:** No**Year of schooling completed:** Junior**Home Institution:** Plymouth State University**Government fiscal year(s) was this REU participant supported:** 2015**Kate Poirier****Email:** kmpoirier@mail.plymouth.edu**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant**Nearest Person Month Worked:** 3**Contribution to the Project:** Kate was an REU under the Hubbard Brook site REU program. She examined patterns of tree height across the first 200 Valleywide plots, and served as an important member of our crew. REU project entitled: Refining Allometric Equations for Trees at Hubbard Brook in a Changing Forest,**Funding Support:** REU site grant DEB # 1156844.**International Collaboration:** No**International Travel:** No**Year of schooling completed:** Sophomore**Home Institution:** Plymouth State University**Government fiscal year(s) was this REU participant supported:** 2015**Christen Sapnas****Email:** christensapnas@u.boisestate.edu**Most Senior Project Role:** Research Experience for Undergraduates (REU) Participant**Nearest Person Month Worked:** 3**Contribution to the Project:** REU project entitled: Wetland contributions to streamwater chemistry**Funding Support:** REU site grant DEB # 1156844**International Collaboration:** No**International Travel:** No

Year of schooling completed: Other
Home Institution: Boise State University
Government fiscal year(s) was this REU participant supported: 2015

Paloma Spina
Email: pgs72@cornell.edu
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 3
Contribution to the Project: REU project entitled: Investigating nitrogen and carbon adsorption dynamics in the mineral soils of the White Mountains.
Funding Support: REU site grant DEB # 1156844.
International Collaboration: No
International Travel: No
Year of schooling completed: Junior
Home Institution: Cornell University
Government fiscal year(s) was this REU participant supported: 2015

Lauren Wiggins
Email: lwiggin1@tnstate.edu
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 3
Contribution to the Project: REU project entitled: Environmental Attitude and Sustainable Behavior: An Evaluation of Perceived Ecological Literacy and Landscape Value in the Pemigewasset Watershed in New Hampshire.
Funding Support: REU site grant DEB # 1156844
International Collaboration: No
International Travel: No
Year of schooling completed: Other
Home Institution: Tennessee State University
Government fiscal year(s) was this REU participant supported: 2015

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
Hubbard Brook Research Foundation	Other Organizations (foreign or domestic)	Woodstock, NY
Plymouth State University	School or School Systems	New Hampshire

Full details of organizations that have been involved as partners:

Hubbard Brook Research Foundation
Organization Type: Other Organizations (foreign or domestic)
Organization Location: Woodstock, NY
Partner's Contribution to the Project:
 Facilities
 Collaborative Research
More Detail on Partner and Contribution:

Plymouth State University
Organization Type: School or School Systems
Organization Location: New Hampshire
Partner's Contribution to the Project:

Facilities

Collaborative Research

More Detail on Partner and Contribution:

What other collaborators or contacts have been involved?

Hubbard Brook Research Foundation; U.S. Forest Service
Dr. Matthew Ayres, Dartmouth College; Dr. Steven Matthews, Ohio State University; Dr. Winsor Lowe, University of Montana; Dr. T. Scott Sillett, Smithsonian Institution; Dr. Michael Webster, Cornell University; Dr. Richard Holmes, Dartmouth College; Dr. Alan Strong, University of Vermont; Dr. Peter Marra, Smithsonian Institution; Dr. Matthew Betts, Oregon State University; Dr. Lynn Christenson, Vassar College; Dr. Dorata Czeszczewik, Siedlce Univerity, Poland; Dr. Wieslaw Walankiewicz, Siedlce Univerity, Poland; Dr. John Battles, University of California at Berkeley; Dr. Sara Kaiser, Cornell University; Dr. Renate Gebauer, Keene State College; Dr. Zaixing Zhou, University of New Hampshire; Dr. Louis Iverson, United States Forest Service; Jeffrey Welker, University of Alaska Anchorage; Dr. David Conley, Lund University (Sweden); Dr. Lars Hedin, Princeton University;

[Back to the top](#)

Impacts

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

Research in the Hubbard Brook LTER program seeks a better basic understanding of the discipline of ecosystem biology, especially biogeochemistry and energy flow. Our long-term measurements of a suite of large-scale experiments has contributed to refined understanding of the interactions between ecological processes and biogeochemical cycles. A suite of simulation modeling studies allows us to synthesize understanding at regional scales and in future scenarios of environmental change. Our studies of energy flow through the complex herbivore and detrital food webs integrates knowledge across sub-disciplinary lines including vegetation dynamics, microbial ecology and heterotrophy population dynamics

What is the impact on other disciplines?

Beyond the core disciplines of ecosystem biology and biogeochemistry, the HBR LTER Program contributes to allied research disciplines in the physical and biological sciences. Our work attracts the interest of geochemists and physical hydrologists as well as that of molecular

and cell biologists. The continuity of standardized and well-documented data collection is a hallmark of the HBR LTER; this aspect of the long-term studies at our site provides an internationally recognized benchmark for many disciplines of field-oriented research.

What is the impact on the development of human resources?

The Hubbard Brook LTER Project makes an active effort to develop human resources at many stages of development, from K-12 through post-doctoral. Through our educational and research activities numerous students and technicians have advanced their capacity for addressing the environmental problems that face 21st Century society. A continuous stream of researchers has been nurtured in the HBR LTER, eventually to reach prominent positions in academic, governmental and private sector institutions. We have encouraged the participation of females and minorities in our project through recruitment at our participating Universities and throughout the world.

What is the impact on physical resources that form infrastructure?

During the past year we continued to improve the physical infrastructure at HBR in two ways: 1) we refined our realtime environmental sensor network and completed cross-checking with historic analog data sets, and 2) we expanded the capacity of our physical sample archive and began linking archive samples with data streams.

What is the impact on institutional resources that form infrastructure?

Nothing to report.

What is the impact on information resources that form infrastructure?

The website for Hubbard Brook (<http://hubbardbrook.org>) is now hosted on a server at the University of NH, providing local control of the system to the HBR-IM. The physical location of this server is at the Research Computing and Instrumentation (RCI) Center, in a climate controlled environment, with emergency power. RCI provides system administration, upgrades, backups, helpdesk support, and expertise for special projects as needed. Changes to the website now take place on a separate development server, providing a platform for developing/testing new datasets, metadata, changes in webpage functionality, etc. A mirror of this webserver will be established at the LNO, providing offsite redundancy, and failover capability.

What is the impact on technology transfer?

Nothing to report.

What is the impact on society beyond science and technology?

Society is confronted with difficult choices about the degree of pollution abatement that is necessary to achieve desirable outcomes in terms of environmental quality. The long-term data sets from HBR-LTER provide among the best objective information available on which to base judgments about the threats of pollution to forest health, soil and water quality, and about the effectiveness of pollution abatement efforts in reducing those threats. Temporal trends can be evaluated against the backdrop of natural variation in reference and manipulated catchments, providing both parameter values and validation data for predictive models. Cost-effective environmental protection depends upon using these models to project the benefits of particular pollution abatement strategies. Hubbard Brook is a cornerstone of such efforts.

[Back to the top](#)

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.

[Back to the top](#)

[< Back](#)

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- [Award Cash Management Service \(ACM\\$\)](#)
- [Notifications & Requests](#)
- [Project Reports](#)
- [Proposal Status](#)
- [Public Access](#)
- [User Management](#)

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- [Research Spending & Results](#)

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- [Contact Help Desk](#)

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- [News](#)
- [Discoveries](#)
- [Multimedia Gallery](#)

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- [Upcoming Funding Opportunity Due Dates](#)
- [A-Z Index of Funding Opportunities](#)
- [Find Funding](#)
- [Award Search](#)
- [Proposal & Award Policies & Procedures Guide \(PAPPG\)](#)
 - [Part I: Grant Proposal Guide \(GPG\)](#)
 - [Part II: Award & Administration Guide \(AAG\)](#)

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