

Preview of Award 1637685 - Annual Project Report

Cover

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PD/PI Name:	Gary M Lovett, Principal Investigator Matthew P Ayres, Co-Principal Investigator Melany C Fisk, Co-Principal Investigator Peter M Groffman, Co-Principal Investigator Pamela H Templer, Co-Principal Investigator
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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 is causing an 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 pre-acid rain 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 and vegetation models are useful tools for understanding and predicting the interactive effects of climate change, atmospheric CO₂, atmospheric deposition and invasive species on the forest growth, 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, mostly coordinated through the Hubbard Brook Research Foundation, a non-profit group that supports research at Hubbard Brook through outreach, education and maintenance of research facilities. 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 and our collaboration in the Science-Policy Exchange, a consortium of academic institutions and LTER sites dedicated to using scientific information in the policy process. We have initiated an Advisory Council that consists of regional stakeholders, and we host "Roundtable" discussions that allow stakeholders and HBR scientists to discuss issues of regional importance. The project also seeks to provide high-quality programs for the training and development of scientists and educators.

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

Major Activities:

Changing Atmospheric Chemistry

Acid rain remediation experiment. We completed analysis of shifts in soil and watershed C, Ca and nitrogen (N) cycling in the watershed (watershed 1) treated with Ca for this experiment. We also examined stream nitrate dynamics in this watershed for indicators of N saturation in the terrestrial and aquatic ecosystems.

Nitrogen oligotrophication. While much research over the past 30 years has focused on the deleterious effects of excess N on forests and associated aquatic ecosystems, recent declines in atmospheric N deposition and unexplained declines in N export from these ecosystems have raised new concerns about N oligotrophication, limitations of forest productivity, and the capacity for forests to respond dynamically to disturbance and environmental change. We analyzed multiple long-term data streams from HBR to test the idea that N oligotrophication in forest soils is driven by increased C flow from the atmosphere through soils that stimulates microbial immobilization of N and decreases available N for plants.

The MELNHE project (Multiple Element Limitation in Northern Hardwood Ecosystems): 2018 was the eighth year of addition of N and P in stands of different ages at Hubbard Brook, Jeffers Brook, and Bartlett Experimental Forests. The specific objectives of this work are to: 1) test nutrient limitation or co-limitation of forest productivity, above- and belowground, 2) test nutrient limitation of microbial growth and activity using 18O stable-isotope probing and vector analysis of the activities of N-, P-, and C-mineralizing enzymes, and 3) examine plant and microbial feedbacks and shifts in allocation that influence nutrient availability and acquisition, including a) ratios of N-, P-, and C-mineralizing enzymes,

b) rhizosphere microbial populations and respiratory activity, c) root foraging activities, vertical distribution, total growth, and species composition, and d) soil nutrient availability.

Changing Climate

Ongoing experiments. We continued monitoring the throughfall exclusion experiment which was initiated in 2015 as part of the International Drought Experiment Research Coordination Network. We reduced the intensity of monitoring in 2018 to focus on data analysis and synthesis, and to reduce the effect of destructive sampling within the plots. No sapflow or root production data were collected in 2018, though we continued to monitor soil moisture, tree growth, soil respiration, and decomposition bags. In October 2018, we installed litter decomposition bags and root ingrowth cores for the 2019 field season. We also conducted tree-ring analyses from trees outside the treatment plots to assess the results of historical climate variability on growth and water-use efficiency in the study stand. We also continued measurements in the Climate Change Across Seasons Experiment (CCASE) which examines the interaction between reduced snowpack and warmer soils.

Eddy flux tower. Flux tower measurements, which began in 2017, are being analyzed with ancillary data to provide us with better understanding of water and energy budgets for the Hubbard Brook forests and to improve understanding of the role of headwater areas in regional salinity issues.

Changing Biota:

Wildlife cameras. In 2018, we completed site selection for wildlife monitoring cameras and determined camera type/model for the project. We established 26 motion detecting cameras using a modified Segmented Road Method. Twenty of the cameras were deployed in January 2018. Data were collected for each of the twenty cameras in May 2018, using CPW photo warehouse for image organization and handling prior to analysis (software produced by Colorado Parks and Wildlife). Preliminary analysis of camera data (PRESENCE 2.12.8 - Occupancy Model by USGS) and CPW helped determine additional locations for monitoring cameras. An additional six cameras were deployed to fill in gaps in the camera monitoring network in July 2018. Data was collected again from the twenty cameras in July (for a total of 2 data collection periods in 2018) representing almost 7 months of continuous animal monitoring.

Salamanders. We continued long-term sampling of stream salamander populations in three first-order streams in the Hubbard Brook Valley: Bear, Paradise, and Zigzag Brooks. In addition to our standard capture-mark-recapture surveys of these streams, we sampled stream invertebrate communities in riffle and pool habitats to assess variation in salamander prey availability along streams. Specifically, we sampled invertebrates directly from streams and collected salamander gut contents to identify specific prey taxa.

Vegetation. 2018 saw the completion of repeated vegetation surveys of a series of plots distributed across the Hubbard Brook valley as well as a plot dominated by Hemlock, which provides an important baseline as we anticipate arrival of the hemlock woolly adelgid. We continued long-term demography studies on sugar maple seedling cohorts with marking of the 2017 cohort (we still follow 2007 and 2010 cohorts as well). We continued a round-leaved orchid demography study that now encompasses over 1,000 individuals being followed over time. A new experiment involving caging of a sub-sample of flowering individuals was initiated to study the impact of white-tailed deer herbivory on the population in the valley. We continue to track the development of northern red oak and eastern white pine seedlings in the valley with a new cohort of pine seedlings identified in 2018.

Terrestrial gastropods. Herbivory by terrestrial gastropods, particularly *Arion* sp., can alter epiphytic lichen communities; however, little is known about this interaction in forests of North America. We used three lines of evidence to explore this interaction: field grazing assessments on lichen thalli, a ten-year re-measure of gastropod abundance, and gastropod feeding trials.

Epiphytic macrolichens. We conducted lichen surveys on mixed broadleaf-conifer plots along an elevation gradient in a northern hardwood forest to test whether current community patterns were more indicative of a gradient in atmospheric inputs of sulfur and N or a gradient of moisture availability with elevation gain. The surveys were made on 12 0.38-ha plots distributed throughout the Hubbard Brook valley.

Demography modeling. To merge Hubbard Brook data with the Ecosystem Demography Model, version 2 (ED2), we have built a module within the Predictive Ecosystem Analyzer (PEcAn) to read Hubbard Brook vegetation data. We are conducting Bayesian data-model assimilation to improve simulations of vegetation dynamics and conducting sensitivity analyses and variance partitioning to identify sources of uncertainty in model simulations. We are also forecasting the impact of the hemlock woolly adelgid (HWA) and the emerald ash borer (EAB) (two invasive insects) on vegetation dynamics and ecosystem processes.

Stream ecology. In 2018, we set up sampling platforms, cameras, sensors and sticky traps in watersheds 1 – 6 and 9 to

capture fine scale stream ecosystem, aquatic insect and canopy dynamics. We also developed a MODIS- based model of leaf area index and light available to streams for all Hubbard Brook watersheds back to 1989. An additional effort was to begin synthesizing and collating datasets on snow pack, snow depth, river ice, lake ice, air temperature and LAI to build multiple reasonable estimates for vernal and autumnal window length changes through time. Our ultimate objective is to build a time series dataset for weekly stream algal biomass, rates of instream decomposition, organic matter standing stocks in the stream channel, and numbers and identity of emerging aquatic insects. We then hope to link these biological measurements to chemical time series datasets. A further effort is to synthesize all stream macroinvertebrate work at Hubbard Brook from 1965-present.

Specific Objectives:

- To assess the structure and function of a northern hardwood forest ecosystem in various stages of development.
- To quantify hydrologic and element cycle interactions in undisturbed watershed and lake ecosystems.
- To evaluate the short-term and long-term responses of ecosystems to disturbance (i.e., clear-cutting, changes in land use, air pollutants, insect outbreaks, climate).
- To assess long-term trends in meteorology, hydrology, biogeochemistry, biomass and populations.
- To link process-level research with regional, national, and global assessments of major environmental issues (i.e. acidic deposition, N saturation, trace metal deposition, clear-cut practices, climatic change).
- To provide information to policymakers and resource managers.

Significant Results:

Changing atmospheric chemistry.

Acid rain remediation experiment. Analysis of shifts in soil and watershed C, Ca and N cycling show that streamwater exports of nitrate from the treated watershed increased dramatically following the experimental addition of Ca, indicating a larger pool of available dissolved inorganic N is accumulating in soil solution and groundwater in this watershed. We also found that increasing soil pH leads to greatly enhanced soil respiration from acidic HBEF soils in the presence of plants but has no effect on soil microbial activity when plants are absent. In contrast, Ca enrichment without any change in pH leads to higher plant growth without any soil microbial response. Our analysis of stream nitrate dynamics in this watershed showed that post-treatment, the (positive) slope of the relationship between nitrate concentration and discharge increased. This resulted in greater flushing of nitrate during storm events, a key indicator of early stage N saturation. Hysteretic behavior of the concentration-discharge relationship indicated that the mobilization of soil nitrate pools was responsible for this increased flushing. In contrast to this evidence for N saturation in the terrestrial ecosystem, we found that N uptake increased, post-treatment, in the aquatic ecosystem, substantially attenuating growing-season nitrate flux.

Nitrogen oligotrophication. Our analysis of multiple long-term data streams from HBR to test the idea that N oligotrophication in forest soils is driven by increased C flow from the atmosphere through soils that stimulates microbial immobilization of N and decreases available N for plants showed that several of these data streams support this idea. In addition, there is evidence for feedbacks whereby decreased available N in soils can result in increased N resorption by trees, which reduces litterfall N input to soils, further limiting available N supply and leading to further declines in soil N availability. Moreover, N oligotrophication has been likely exacerbated by changes in climate that increase the length of the growing season and decrease production of available N by mineralization during both winter and spring. These results suggest a need to re-evaluate the nature and extent of N cycling in temperate forests.

The MELNHE project. We found that tree growth experiences mostly single nutrient limitation, and that P is unexpectedly important relative to N in these northern systems. It is possible that the legacy of N deposition from air pollution has altered the controls of forest growth in this region; however, the P limitation of productivity that was found in mid-age and mature forests was unexpected on these relatively young soils and in the context of apparent N oligotrophication at Hubbard Brook. The spatial variation in P versus N limitation that was evident across the broad extent of our study also cautions against generalizing about regional nutrient limitation. Evidence of N limitation of forest growth in young stands suggests a transition in the primary limiting nutrient over successional time, supporting recent modeling predictions.

Changing Climate.

Precipitation manipulation experiment. Despite a 50% year-round throughfall exclusion and significantly reduced soil moisture relative to the control plots, we have observed no significant effects of the throughfall exclusion treatment. Given this lack of a response after 4 years of treatment, we have agreed to increase the level of throughfall exclusion to at least 80% in 2019.

Eddy flux tower. Uncertainty analyses of high resolution data from the flux tower is allowing us to make hydrologic monitoring of small catchments more efficient, e.g., we have reduced the intensity of precipitation monitoring by >50%. We now have enough flux tower data to start analyzing energy budgets, which is giving us new insight into ET. Water

limitation of this flux is more prevalent than previously thought.

Changing biota.

Wildlife cameras. Cameras have performed well over the first seven months of continuous monitoring, capturing many mammal and bird species including, moose, white-tailed deer, red fox, eastern coyote, fisher, mink, black bear, bobcat and snowshoe hare. Continued monitoring will track the presence and frequency of animals, determining changes in species identified across the forest.

Salamanders. Our most exciting new results relate to morphological variation in our study species, the stream salamander *Gyrinophilus porphyriticus*. Morphology of *G. porphyriticus* differs in riffles and pools, the dominant habitats in headwater streams where the species occurs. Specifically, individuals found in riffles have shorter limbs than those found in pools. We used four years of spatially explicit capture-mark-recapture data from three streams to test the contributions of phenotypic plasticity and matching habitat choice to this phenotype-environment covariation. Under matching habitat choice, individuals distribute themselves based on self-assessment of the phenotype-environment match. We found that both phenotypic plasticity and matching habitat choice contribute to phenotype-environment covariation in *G. porphyriticus*.

Terrestrial gastropods. The analysis of terrestrial gastropods found that grazing damage was significantly higher on flatter terrain and on broadleaf trees. Slug densities were significantly lower in 2016 than in earlier surveys (1997-2006) on four of six plots. In feeding trials two common lichens, *Hypogymnia physodes* and *Platismatia glauca*, were grazed more heavily by both native and non-native slugs than other lichen species. However, the Succineidae (amber) snails preferred *Lobaria pulmonaria*, a lichen that has been declining at HBEF in the last decade. Overall, lichen communities in the HBEF were moderately impacted by terrestrial gastropod grazing, but potential effects of the non-native slugs at higher elevations and impacts on lichen health of the widespread, moderate grazing deserve further study.

Epiphytic macrolichens. Our lichen surveys of 12 0.38-ha plots throughout the Hubbard Brook valley revealed four new species records for the state: *Heterodermia squamulosa*, *Hypotrachyna afrorevoluta*, *Parmelia fertilis*, and *Parmotrema arnoldii*. Lichen composition was related to elevation, tree basal area and size of the largest tree. The percent of fruticose lichen species was significantly, positively related to elevation. Species richness also increased with elevation, but was only significantly related to aspect, particularly southness. Species abundance is related positively to tree basal area. Overall, the Hubbard Brook valley appears to have a relatively diverse lichen assemblage related more strongly to plot characteristics than to pollution indices.

Demography modeling. Code has been developed to merge long-term Hubbard Brook vegetation data with the ED2 model. Preliminary simulations have been conducted to evaluate the impact of HWA and EAB on Hubbard Brook Forests. The projected response of HWA is a persistent decline in evapotranspiration and C uptake, whereas EAB is a shorter transient response.

Stream ecology. The effort to synthesize and collate long-term datasets reveals that the period of time when streams are both warm enough and well lit enough to support algal growth (the vernal window) has varied from 7-43 days since 1989, while the period of time between 50% of canopy litterfall and permanent snowpack (ideal conditions for high heterotrophic activity) varies from 37-105 days. Analysis of long-term macroinvertebrate data shows that methods have varied significantly over time and there is no consistent long-term record for examining long-term trends. We plan to resample some sites to do longitudinal analyses this summer.

Other achievements

A major outreach effort has focused on the importance of Importation of forest pests through global trade as a major environmental problem at Hubbard Brook and throughout the U.S. We targeted outreach activities to help ensure that scientific information was used in the development of new policies to prevent introduction of forest pests. With our technical assistance, Congressman John Faso included an amendment about importation of forest pests in the House version of the 2018 Farm Bill. Part of that amendment was included in the final Farm Bill passed by Congress in December 2018. We hosted a press briefing/webinar for journalists on this issue in June 2018. We made numerous presentations to the public and academic institutions about the problem of forest pests.

Information Management

The Information Management System at HBR addresses several major goals; (1) maintaining access to HBR data, with an emphasis on high quality data/documentation and data preservation (2) enabling data discovery/access to the HBR, LTER, and broader scientific communities (3) development and maintenance of a website to share information on site

Key outcomes
or Other
achievements:

history, current research, publications, photos, educational materials, etc. (4) maintaining a physical sample archive. The primary role of the HBR Information Manager is to support the HBR information management system (IM) and to provide expertise in data documentation, archiving and retrieval, for on and off-site scientists conducting research projects and data syntheses.

Data catalog: The HBR data catalog has been recently restructured, with the hubbardbrook.org website providing browse/search capabilities, and metadata and data access linked directly to the EDI dataset landing page. Accessing data through the EDI provides many advantages over the outdated local catalog that we have been maintaining. It reduces the time/effort involved in maintaining a now redundant system, insures that data are all downloaded from a single source, provides for complete open access (including the ability to programatically access data and metadata via API), and allows tracking through the EDI 'Data Package Access Reports'.

HBR datasets have been updated to include the new LTER Data Policy. To date, all the data collected at HBR are considered Type I, with a goal of release to the general public within 2 years from the time of collection.

Website: The HBR website (<http://hubbardbrook.org>) is the primary means by which HBR information is disseminated. A major HBR website redesign occurred in 2017 with the transition to Drupal. In this new website framework we combine the research-based content on <http://hubbardbrook.org>, with the education and outreach content formerly on the <http://hubbardbrookfoundation.org> website.

HBR Environmental Sensors: The Hubbard Brook Information Manager receives partial funding through a Cooperative Agreement with the Forest Service to support the environmental sensor network at the site. The core sensor network monitors height/temperature/conductivity from 9 watersheds in the Hubbard Brook valley, and meteorological data from 10+ stations throughout Hubbard Brook. Maintenance and operation of these sensors is done by Forest Service staff, and the HBR-IM works closely with that team on the implementation and operation of data processing and quality control.

Other projects involving HBR-IM:

Innovative data outreach: A water cycle visualization and sonification have been developed for Hubbard Brook (<http://waterviz.org>). To support this collaborative between hydrological scientists, artists, musicians, and computer scientists, the HBR-IM developed, and now maintains, 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. This was the final year of work for an interdisciplinary team, funded by a NSF-EAGER grant (*Collaborative Research: The Confluence of Music, Art and Science at Long Term Ecological Research Sites*, with UNH (lead institution with HBR-IM as PI with summer salary), Dartmouth College (Casey PI) and the Hubbard Brook Research Foundation (Garlick PI); \$300K total). Four lesson plans have been provided on waterviz.org, that range from background watercycle information from HBR, observations of the visualization, to independent inquiry using the underlying [waterviz](http://waterviz.org) data table.

Environmental Data Initiative (EDI) – The HBR-IM serves on the EDI advisory board as a representative of LTER sites.

EDI Semantics Working Group – The HBR-IM is a member of this newly formed working group, with the kickoff meeting to be scheduled within the month.

Smart Forests for the 21st Century is a Hubbard Brook Experimental Forest led effort to sensor technology to other USDA Forest Service Experimental Forests. This network utilizes the LTER-funded GCE Toolbox to manage the workflow for Smart Forests data and the centralized data portal for this environmental sensor network (<http://smartforests.org>). Funding to the HBR-IM for support of SmartForests comes from a USFS cooperative agreement with UNH.

Workshop: Creating EML with R and publishing data packages in the EDI repository - HBR-IM attended this workshop held in June 2018, in the combined role of participant and advisory board observer.

LTER All Scientists Meeting - HBR-IM co-chaired (with Steven Earl [CAP-LTER] and John Porter [VCR-LTER]) a session entitled 'Making your data work harder: Using shared data to enhance your research'. This session consisted of a short presentation, followed by a panel discussion of synthesis working group investigators.

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

The Hubbard Brook LTER project takes its responsibilities for the training and development of scientists and educators very seriously and has a rich history of mentoring postdocs, graduate, and undergraduate students. The project provides opportunities to learn or improve project design skills,

hands-on field research techniques, and the crafts of scientific writing and presentation. Each undergraduate and graduate student has a mentor or a committee of mentors who review proposals and consult on implementation of projects.

In addition to the production of dozens of peer-reviewed journal publications and other products, in 2018 Hubbard Brook investigators presented their research at conferences and other public events, including four collaborative Committee of Scientists (COS) meetings.

The 55th Annual Hubbard Brook Cooperators meeting was held on-site in July with over 150 attendees. The event included a keynote speaker, two days of ongoing and proposed Hubbard Brook research presentation from senior investigators, post-docs, and both graduate and undergraduate students, and a half-day COS meeting. The 2018 keynote speaker was Dr. David George Haskell, Professor of Biology and Environmental Studies at the University of the South and award-winning author of *The Forest Unseen: A Year's Watch in Nature*.

Both co-investigator Christenson and research assistant Kovari have been advancing their use of occupancy modeling through local camera trapping workshops and outreach events sponsored by the Northeastern Natural History Conference and the EMMA (Environmental Monitoring and Management Alliance) network.

We trained two Cornell undergraduates on the vegetation crew, one REU student in conducting a research project and writing two articles: one EcoPict and one for the HBES online Multi-media stories.

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

The Hubbard Brook Research Foundation (HBRF) leads Hubbard Brook's public engagement with science initiative, co-funded through an Advancing Informal STEM Learning grant from the National Science Foundation, and the U.S. Forest Service. The goals are to present stakeholders with current findings from Hubbard Brook and to make the data relevant and serviceable. We strive to synthesize ecosystem research and link it to policy and practitioner concerns. Outcomes include: (1) raised awareness among ecosystem scientists of stakeholder interests and needs; (2) raised awareness among stakeholders, practitioners, and decision-makers of emerging science from Hubbard Brook; (3) a co-created science-based framework for informed policy and forest management; and (4) a cohesive network of scientists, stakeholders, decision-makers, and media professionals that connects institutions across and beyond the region.

In order to advance outreach goals, in 2018 HBRF:

- Provided planning and logistical support for large and small-scale events including the Annual Meeting of Hubbard Brook Cooperators
- Produced public engagement with science programs and products including roundtable dialogue events with regional stakeholders, focus groups, communications workshops, and fact sheets

- Facilitated a scientist working group meeting and held a roundtable dialogue for scientists and practitioners to advance Hubbard Brook's Winter Climate Change Science Links project

- Launched a new Advisory Council with a roundtable event at Hubbard Brook. Advisors include regional foresters, non-profit leaders, political advisors, and White Mountain National Forest officials, all working on forest issues in our region

- Facilitated a workshop in July with the goal of developing a volunteer ice accretion measurement protocol inspired by the Ice Storm Experiment. Participants included Hubbard Brook PIs, representatives from CoCoRaHS (the National Community Collaborative Rain Hail and Snow Network), and the National Weather Service.

- Maintained Hubbard Brook's suite of media outreach programs, including: a redesigned website, a system of regular press releases, an e-newsletter, and a stronger social media campaign (i.e., Facebook, Twitter).
- Launched an internal e-newsletter in January 2018, called the Hubbard Brook Monthly, designed to enhance information sharing within the Hubbard Brook community. The objective of the newsletter is to improve internal communication within the Hubbard Brook community. Each issue includes highlights from the previous month of work, including Recent Publications, Hubbard Brook in the News, Outreach and Education, New or Proposed Research, Save the Date, and Announcements.
- Launched a monthly "Forest Science News" for sharing emerging forest science for stakeholder audiences. Forest Science News is a monthly newsletter featuring select research on the forests of the northeastern United States and southeastern Canada. Subscribers receive a carefully curated email roundup of press releases and abstracts presented in an engaging, reader friendly format.

- Began working with the Society for the Protection of New Hampshire Forests (SPNHF) on a collaborative citizen science project inspired by Hubbard Brook research (e.g., sugar maple regeneration) and using SPNHF lands and volunteer stewards. The relationship between the HBRF and SPNHF developed after a HB roundtable event several years ago.

- Initiated outreach to the business sustainability community through a meeting with Cabot Creamery's Sustainability Officer and their sustainability consultant to exchange information and provide an initial scientific review of Cabot's water metric.

Followed up with a roundtable meeting involving Dartmouth College's Tuck School of Business to explore the intersection of ecosystem science

and corporate sustainability in an emerging clean air and water economy. This included a follow-up project with four first-year students from the Tuck School of who have undertaken a Tuck Community Consulting project designed to explore the potential for HB science to contribute to corporate sustainability efforts.

- Cooperated with the White Mountain National Forest and Plymouth State University on the WMNF's Centennial Exhibit at the Museum of the White Mountains .
- Organized two visits to Hubbard Brook from a producer and videographer from New Hampshire Chronicle. The team finished shooting footage for a forthcoming 6-minute feature on Hubbard Brook—airdate TBD.
- Coordinated a visit from U.S. Senator Jeanne Shaheen to Hubbard Brook on August 8.
- Participated in the SciComm Training Summit meeting at the Chan Zuckerberg Initiative BioHub in San Francisco in early December. This invitation-only event, funded by the Kavli Foundation, brought together ~50 practitioners and researchers from the international science communication field to develop a community of practice about evidence-based science communication training.
- Continued work on the WaterViz hydrology visualization tool, with supporting lessons. The updated WaterViz website had a soft launch on October 14 at the New Hampshire Science Teachers Fall Conference, and the hard launch was held at the Miami New Media Festival at Concrete Space gallery in Doral, Florida.

* 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.

Products

Books

Book Chapters

DeMott, R. and Campbell, J. L. and Groffman, P. M. and Rustad, L. E. and Templer, P. H. (2019). Soil warming and winter snow packs: Implications for northern forest ecosystem functioning. *Ecosystem Consequences of Soil Warming: Microbes, Vegetation, Fauna and Soil Biogeochemistry*. Mohan, J. E.. Academic Press. New York. . Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

Inventions

Journals or Juried Conference Papers

View all journal publications currently available in the [NSF Public Access Repository](#) for this award.

The results in the NSF Public Access Repository will include a comprehensive listing of all journal publications recorded to date that are associated with this award.

Yanai, Ruth D. and See, Craig R. and Campbell, John L.. (2017). Current Practices in Reporting Uncertainty in Ecosystem Ecology. *Ecosystems*. . Status = Deposited in NSF-PAR [doi:10.1007/s10021-017-0197-x](https://doi.org/10.1007/s10021-017-0197-x) ; Federal Government's License = Acknowledged.

Sorensen, Patrick O. and Finzi, Adrien C. and Giasson, Marc-André and Reinmann, Andrew B. and Sanders-DeMott, Rebecca and Templer, Pamela H.. (2018). Winter soil freeze-thaw cycles lead to reductions in soil microbial biomass and activity not compensated for by soil warming. *Soil Biology and Biochemistry*. 116 (C) 39 to 47. Status = Deposited in NSF-PAR [doi:10.1016/j.soilbio.2017.09.026](https://doi.org/10.1016/j.soilbio.2017.09.026) ; Federal Government's License =

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Kulkarni, Madhura V. and Yavitt, Joseph B. and Groffman, Peter M.. (2016). Rapid Conversion of Added Nitrate to Nitrous Oxide and Dinitrogen in Northern Forest Soil. *Geomicrobiology Journal*. 34 (8) 670 to 676. Status = Deposited in NSF-PAR [doi:10.1080/01490451.2016.1238981](https://doi.org/10.1080/01490451.2016.1238981) ; Federal Government's License = Acknowledged.

Vuyovich, Carrie M. and Jacobs, Jennifer M. and Hiemstra, Christopher A. and Deeb, Elias J.. (2017). Effect of spatial variability of wet snow on modeled and observed microwave emissions. *Remote Sensing of Environment*. 198 (C) 310 to 320. Status = Deposited in NSF-PAR [doi:10.1016/j.rse.2017.06.016](https://doi.org/10.1016/j.rse.2017.06.016) ; Federal Government's License = Acknowledged.

Yang, Yang and Yanai, Ruth D. and See, Craig R. and Arthur, Mary A.. (2017). Sampling effort and uncertainty in leaf litterfall mass and nutrient flux in northern hardwood forests. *Ecosphere*. 8 (11) e01999. Status = Deposited in NSF-PAR [doi:10.1002/ecs2.1999](https://doi.org/10.1002/ecs2.1999) ; Federal Government's License = Acknowledged.

Cramer, E. R. and Kaiser, S. A. and Webster, M. S. and Sillett, T.S. and Ryder, T.B.. (2017). Characterizing selection in black-throated blue warblers using a sexual network approach. *Journal of Evolutionary Biology*. 30 (12) 2177 to 2188. Status = Deposited in NSF-PAR [doi:10.1111/jeb.13183](https://doi.org/10.1111/jeb.13183) ; Federal Government's License = Acknowledged.

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Yang, Y. and Meng, L. and Yanai, R. D. and Driscoll, C. T. and Montesdeoca, M. and Templer, P. H. and Rustad, L. E. and Asbjornsen, H. (2018). *Climate change may worsen mercury pollution in northern hardwood forests*. Ecological Society of America. New Orleans, LA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Darby, B. A. and Goodale, C. G. and Chin, N. A. and Fuss, C. B. and Lang, A. and Ollinger, S. V. and Lovett, G. M. (2019). *Connections between Gross N Cycling and Exoenzyme Activity across Soil Depths in Three Northern Hardwood Forests*. Soil Science Society of America Annual Meeting. San Diego, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Ross, D. S. and Bourgault, R. R. and Bailey, S. W. and McGuire, K. J. (2018). *Critical zone architecture and the redistribution of soil metals and organic carbon in a New Hampshire headwater catchment*. 2018 Geological Society of America Northeastern Section. Burlington, VT. Status = OTHER; Acknowledgement of Federal Support = Yes

Young, A. R. and Gabriel, M. and Yanai, R. D. (2018). *Detecting nutrient limitation from the sky*. 2018 LTER All Scientists' Meeting. Pacific Grove, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Vadeboncoeur, M. A. (2018). *Droughts and Deluges – effects in forest ecosystems*. 2018 LTER All Scientists' Meeting. Pacific Grove, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Gonzales, K. E. and Yanai, R. D. (2018). *Evidence for P limitation in a young northern hardwood forest*. Ecological Society of America. New Orleans, LA. Status = OTHER; Acknowledgement of Federal Support = Yes

Hong, D. S. and Gonzales, K. E. and Yanai, R. D. (2018). *Foliar analysis of five northern hardwood species indicates nutrient limitation*. Spotlight on Student Research, SUNY ESF, Syracuse, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Morley, M. S. and Walsh, G. E. and Yanai, R. D. (2018). *Overachieve and retain the leaves: Nutrients affect fall leaf retention in northern hardwood species*. Spotlight on Student Research, SUNY ESF. Syracuse, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Bower, J. and Ross, D. S. and Bailey, S. W. and McGuire, K. J. and Strahm, B. D. and Schreiber, M. E. and Ashe, K. and Benton, J. and Duston, S. (2018). *Quantifying mineral weathering across lateral gradients using a whole-regolith approach*. American Geophysical Union Fall Meeting. Washington, DC. Status = OTHER; Acknowledgement of Federal Support = Yes

Bailey, S.W. (2017). *Soil and human influences on the fate of plagioclase weathering products*. Gordon Research Conference, June 25-30. Lewiston, ME. Status = OTHER; Acknowledgement of Federal Support = Yes

Barkley, M. and Kirkpatrick, S. and Yanai, R. D. and Miller, W. and Young, A. R. (2018). *Tardigrade response to nitrogen and phosphorus addition*,. Spotlight on Student Research, SUNY ESF. Syracuse, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Vadeboncoeur, M. A. and Jennings, K. and Morley, M. and Rustad, L. E. and McIntire, C. D. and Brigham, L. M. and Yanai, R. D. and Asbjornsen, H. (2018). *Teacomposition" in three global change experiments at HBR*. 2018 LTER All Scientists' Meeting. Pacific Grove, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Cleavitt, N. L. (2018). *The Besieged Northern Hardwood Forest*.. Quincy Bog Natural Area. . Status = OTHER; Acknowledgement of Federal Support = Yes

Vadeboncoeur, M. A. and Asbjornsen, H. and McIntire, C. D. and Berry, C. Z. and Coble, A. P. and Jennings, K. A. (2018). *The ecological impacts of extreme drought events in temperate forests*. 2018. Ecological Society of America Annual Meeting. New Orleans, LA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Dillon, G. A. and Young, A. R. and Campbell, J. L. and Green, M. B. and Yanai, R. D. (2018). *Tree measurement error in the Forest Inventory and Analysis (FIA) plots in the northern region*. Spotlight on Student Research, SUNY ESF,. Syracuse, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Horton, T. R. and Lamit, P. and Kennedy, P. and Yanai, R. D. (2018). *Using MiSeq on DNA extracted from in-growth bags to observe ectomycorrhizal fungi with N, P and N+P additions in mixed hardwood forests at Bartlett Experimental Forest, New Hampshire*,. International Mycological Association. San Juan, PR. Status = OTHER; Acknowledgement of Federal Support = Yes

McGuire, K. J. and Bailey, S. W. (2018). *Using Soil Development Patterns and Processes to Explain Sources of Streamflow Generation in a Glaciated Catchment*. American Geophysical Union Fall Meeting. Washington, DC. Status = OTHER; Acknowledgement of Federal Support = Yes

Other Products

Other Publications

Cleavitt, N.L., S. Thorne, C. Deegan. (2019). *Sugar Maple regeneration: Citizen Science Training Guide*.. Information and protocol guide for upcoming Citizen Science project.. Status = UNDER_REVIEW; Acknowledgement of Federal Support = Yes

Patents

Technologies or Techniques

Thesis/Dissertations

Bayer, M. O.. *Bottom-up and top-down controls on food webs in headwater streams*. (2018). University of Montana. Acknowledgement of Federal Support = Yes

Websites

Multiple Element Limitation in Northern Hardwood Ecosystems

<https://www.esf.edu/melnhe/>

Researchers in the Multiple Element Limitation in Northern Hardwood Ecosystems (MELNHE) project are studying N and P acquisition and limitation through a series of nutrient manipulations in northern hardwood forests. This project is supported by the National Science Foundation, and builds upon the [Northern Hardwood Forest Calcium Cycling Project](#), which established our sites at Bartlett.

Quantifying Uncertainty in Ecosystem Studies

<http://quantifyinguncertainty.org/>

The QUEST Research Coordination Network is dedicated to advancing uncertainty analysis in ecosystem studies. Efforts focus on outreach and research on quantifying uncertainty in five topic areas: soils, biomass, atmospheric deposition, stream water export, and ecosystem budgets.

This website includes sample code, links to papers, and news announcements. We seek input on developing discussion boards, wikis, and tutorials, and we support new collaborations and open-access publication.

The Bats of Hubbard Brook

<http://multimedia.hubbardbrook.org/the-bats-of-hubbard-brook>

Kernan, Ciara; Ralston, Jessica and ter Hofstede, Hannah. Website with photos of each bat species, natural history information and examples of echolocation calls.

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Lovett, Gary	PD/PI	2
Ayres, Matthew	Co PD/PI	1
Fisk, Melany	Co PD/PI	2
Groffman, Peter	Co PD/PI	1
Templer, Pamela	Co PD/PI	1
Asbjornsen, Heidi	Co-Investigator	1
Bailey, Scott	Co-Investigator	2
Battles, John	Co-Investigator	2
Bernhardt, Emily	Co-Investigator	2
Burchsted, Denise	Co-Investigator	1
Christensen, Lynn	Co-Investigator	1
Driscoll, Charles	Co-Investigator	2
Fahey, Timothy	Co-Investigator	2
Goodale, Christine	Co-Investigator	1
Green, Mark	Co-Investigator	4

Johnson, Chris	Co-Investigator	2
Kelsey, Eric	Co-Investigator	1
Lavallee, Anthea	Co-Investigator	12
Lowe, Winsor	Co-Investigator	3
Matthes, Jaclyn	Co-Investigator	1
McGuire, Kevin	Co-Investigator	2
Ollinger, Scott	Co-Investigator	1
Pardo, Linda	Co-Investigator	1
Richardson, Andrew	Co-Investigator	1
Rosi, Emma	Co-Investigator	2
ter Hofstede, Hannah	Co-Investigator	1
Vadeboncoeur, Matthew	Co-Investigator	1
Yanai, Ruth	Co-Investigator	3
Thorne, Sarah	K-12 Teacher	3
Fakhraei, Habibollah	Postdoctoral (scholar, fellow or other postdoctoral position)	2
Peralta-Tapia, Andres	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Chiasson, Clara	Other Professional	12
Cleavitt, Natalie	Other Professional	10
Garlick, Sarah	Other Professional	9
Martin, Mary	Other Professional	12
McCartney, Brenda	Other Professional	1
Swartz, Leah	Other Professional	4
Wilson, Geoff	Other Professional	12
Becker, Jennifer	Technician	3
Bird, Katherine	Technician	3
Burdo, Alexander	Technician	2
Gewirtzman, Jonathan	Technician	2
Jennings, Katie	Technician	1
Koppers, Mary	Technician	6
Leonardi, Brendan	Technician	2
LoRusso, Nicholas	Technician	12
Martel, Lisa	Technician	6
Montesdeoca, Mario	Technician	6
Ralston, Jessica	Technician	5
Seitz, Michael	Technician	4

Stewart, Anthony	Technician	1
Van Tatenhove, Aimee	Technician	3
Vollmer, Hannah	Technician	1
Weber, David	Technician	2
Wooster, Tammy	Technician	12
Burakowski, Elizabeth	Staff Scientist (doctoral level)	1
Ouimette, Andrew	Staff Scientist (doctoral level)	2
Zhou, Zaixing	Staff Scientist (doctoral level)	2
Addis, Brett	Graduate Student (research assistant)	2
Baillargeon, Kaitlyn	Graduate Student (research assistant)	1
Bayer, Miriam	Graduate Student (research assistant)	4
Cochrane, Maddy	Graduate Student (research assistant)	4
Hastings, John	Graduate Student (research assistant)	1
Jevon, Fiona	Graduate Student (research assistant)	3
Kernan, Ciara	Graduate Student (research assistant)	9
Lang, Ashley	Graduate Student (research assistant)	12
Lee, David	Graduate Student (research assistant)	5
Ojo, Paul	Graduate Student (research assistant)	2
Shan, Shan	Graduate Student (research assistant)	6
Studer, Elizabeth	Graduate Student (research assistant)	12
Valipour, Mahnaz	Graduate Student (research assistant)	6
Artrip, Ben	Undergraduate Student	1
Bergum, Molly	Undergraduate Student	3
Cotnoir, Alexander	Undergraduate Student	3
Edwards, Cameron	Undergraduate Student	1
Ferguson, Camila	Undergraduate Student	0
Goland, Rachel	Undergraduate Student	3
Kovari, Stephen	Undergraduate Student	4
Leimanis, Vizma	Undergraduate Student	0
Schwinden, Megan	Undergraduate Student	2
Stutenroth, Spencer	Undergraduate Student	3
Vietorisz, Corinne	Undergraduate Student	3
von Hoyningen Huene, Balthasar	Undergraduate Student	3
Walsh, Griffin	Undergraduate Student	0
Wurtz, Maeve	Undergraduate Student	3

Zhang, James	Undergraduate Student	3
Burns, Simone	Research Experience for Undergraduates (REU) Participant	2
Kinsey, Ashe	Research Experience for Undergraduates (REU) Participant	2
Kuhn, Michaela	Research Experience for Undergraduates (REU) Participant	3
Holmes, Holmes	Other	1
Magill, Alison	Other	1
McCartney, Brenda	Other	1
Ralph, Zachariah	Other	1
Rodenhouse, Nicholas	Other	1
Rubenstein, Maribeth	Other	2
Speckert, Elisa	Other	1
Walsh, Griffin	Other	0

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</p> <p>Contribution to the Project: As the Lead Principal Investigator, I am responsible for overall organization of the project and all related reporting and planning. I am also doing LTER related research at Hubbard Brook.</p> <p>Funding Support: This grant and the Cary Institute.</p> <p>International Collaboration: No International Travel: No</p>
<p>Matthew P Ayres Email: matthew.p.ayres@dartmouth.edu Most Senior Project Role: Co PD/PI Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Overall coordination of the following project areas: 2.3.5 Climate change, N availability, and forest food webs; 2.4.4 The incipient loss of Fraxinus from HBR; and 2.5.3 Spatial patterns of animal populations. Oversight of undergraduate research assistants, technicians, and Dartmouth graduate students for above project areas.</p> <p>Funding Support: This award</p> <p>International Collaboration: No International Travel: No</p>
<p>Melany C Fisk Email: fiskmc@miamioh.edu Most Senior Project Role: Co PD/PI Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Studies of interactions among N, P, and C; nutrient limitation of plant productivity and soil processes</p> <p>Funding Support: home institution</p> <p>International Collaboration: No</p>

International Travel: No

Peter M Groffman

Email: Peter.Groffman@asrc.cuny.edu

Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 1

Contribution to the Project: Project management and ecosystem nitrogen cycling research.

Funding Support: N/A

International Collaboration: No

International Travel: No

Pamela H Templer

Email: ptempler@bu.edu

Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 1

Contribution to the Project: I am an ecosystem ecologist and forest ecologist. I manage projects at Hubbard Brook 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 students and technicians working at Hubbard Brook

Funding Support: I receive funds from this NSF LTER grant, along with funds from other federal grants

International Collaboration: No

International Travel: No

Heidi Asbjornsen

Email: heidi.asbjornsen@unh.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Project management, data analysis and interpretation.

Funding Support: Northeastern States Research Cooperative; New Hampshire Agricultural Experiment Station; University of New Hampshire – Iola Hubbard Climate Endowment

International Collaboration: No

International Travel: No

Scott W Bailey

Email: swbailey@fs.fed.us

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 2

Contribution to the Project: Lead researcher and field coordinator on the hydrogeology study. He has been responsible for soil and geochemical characterization in the reference watershed – WS3. Expanded hydrogeological mapping to include parts of Cascade and Zig-zag Brook watersheds and studying chemical spatial variation in headwater streams and its link to critical zone structure.

Funding Support: This grant and U.S. Forest Service

International Collaboration: No

International Travel: No

John J Battles

Email: jbbattles@berkeley.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 2

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

Committee.

Funding Support: This award

International Collaboration: No

International Travel: No

Emily Bernhardt

Email: emily.bernhardt@duke.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 2

Contribution to the Project: Co-oversight of stream sampling for LTER research. Supervisor of PhD student who will conduct research on stream ecosystem and ecological dynamics during vernal and autumnal windows.

Funding Support: LTER funds via Rosi LTER budget at the Cary for some travel. Paying for data science work out of discretionary funds. PhD students Richard Marinos (PhD 2018) and Audrey Thellman (new PhD begun in 2018) supported by Duke University funds.

International Collaboration: No

International Travel: No

Denise Burchsted

Email: dburchsted@keene.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Repeat log surveys in the streams in the experimental watersheds.

Funding Support: N/A

International Collaboration: No

International Travel: No

Lynn Christensen

Email: lchristensen@vassar.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Coordinate project and supervise all aspects of field work, data collection and data analysis.

Funding Support: Other sources

International Collaboration: No

International Travel: No

Charles T Driscoll

Email: ctdrisco@syr.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 2

Contribution to the Project: Designs and coordinates project, conducts data analysis and model simulations, works with students, technicians and other investigators.

Funding Support: NSF DEB 1637685 (NSF Award #1457675)

International Collaboration: Yes, China

International Travel: No

Timothy J Fahey

Email: tjf5@cornell.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 2

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

Christine Goodale

Email: clg33@cornell.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Direct measurements of soil and water stable isotopes and lead data analysis and interpretation.

Funding Support: NSF-1257808

International Collaboration: No

International Travel: No

Mark Green

Email: mbgreen@plymouth.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 4

Contribution to the Project: Led the forest hydrology research on atmosphere-vegetation-soil hydrologic interactions. In addition, played a strong role in forming new data management workflows for sensor data collected at HBEF.

Funding Support: US Forest Service

International Collaboration: Yes, Japan

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 chemistry and biogeochemistry.

Funding Support: N/A

International Collaboration: Yes, Sweden

International Travel: No

Eric Kelsey

Email: ekelsey2@plymouth.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: my contributions have focused on activities to understand water and energy budgets, and evapotranspiration at the flux tower site

Funding Support: Plymouth State University faculty research grant

International Collaboration: No

International Travel: No

Anthea Lavallee

Email: alavallee@hbresearchfoundation.org

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 12

Contribution to the Project: Anthea is the Executive Director of the Hubbard Brook Research Foundation. As Executive Director of HBRF, Anthea oversees the support

organization's efforts with regard to facilities and education/outreach, serving the HBR- LTER cooperators.

Funding Support: This award, Forest Service Joint Venture agreement 15-JV-11242307-064, NSF ASIL Award for Public Engagement with Science

International Collaboration: No

International Travel: No

Winsor Lowe

Email: winsor.lowe@umontana.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 3

Contribution to the Project: Oversight of stream salamander research, including design and implementation of field studies, data management and analyses, and publication and dissemination of results.

Funding Support: DEB-1655653, "The causes and consequences of variation in dispersal distance".

International Collaboration: No

International Travel: No

Jaclyn Matthes

Email: jmatthes@wellesley.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Matthes and her students are using long-term Hubbard Brook vegetation data to simulate and forecast ecosystem dynamics at the Hubbard Brook Experimental Forest. To merge Hubbard Brook data with the Ecosystem Demography Model, version 2 (ED2), Matthes has built a module within the Predictive Ecosystem Analyzer (PEcAn) to read Hubbard Brook vegetation data. Her team is conducting Bayesian data-model assimilation to improve simulations of vegetation dynamics and conducting sensitivity analyses to identify sources of uncertainty in model simulations. They are also forecasting the impact of the hemlock woolly adelgid and the emerald ash borer (two invasive insects) on vegetation dynamics and ecosystem processes. Matthes's group has conducted initial simulations for the impacts of the invasive insects.

Funding Support: NSF EF-1638406

International Collaboration: No

International Travel: No

Kevin McGuire

Email: kevin.mcguire@vt.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 2

Contribution to the Project: Conducts research on hydrology and hydrogeology, which examines feedbacks between hydrology, soil characteristics and critical zone structure, and catchment biogeochemistry. Also, investigating chemical spatial variation in headwater streams and weathering gradients within catchments.

Funding Support: This grant, Virginia Tech, and another NSF grant.

International Collaboration: No

International Travel: No

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, eddy flux, ecosystem modeling and regionalization, project oversight and reporting.

Funding Support: Home institution and other grants

International Collaboration: No

International Travel: No

Linda H Pardo**Email:** lpardo@fs.fed.us**Most Senior Project Role:** Co-Investigator**Nearest Person Month Worked:** 1**Contribution to the Project:** Conducts research on carbon and nitrogen cycling across the geo-spatial template and co-ordinates long-term monitoring of foliar chemistry.**Funding Support:** This grant and U.S. Forest Service**International Collaboration:** No**International Travel:** No**Andrew Richardson****Email:** arichardson@oeb.harvard.edu**Most Senior Project Role:** Co-Investigator**Nearest Person Month Worked:** 1**Contribution to the Project:** Richardson supervised one PhD student working on this project (Aaron Teets), and maintained eddy covariance and phenocam instrumentation operating at Bartlett Experimental Forest.**Funding Support:** Northern Arizona University faculty salary**International Collaboration:** No**International Travel:** No**Emma Rosi****Email:** rosie@caryinstitute.org**Most Senior Project Role:** Co-Investigator**Nearest Person Month Worked:** 2**Contribution to the Project:** Co-oversight of stream sampling. Supervised Heather Malcom at Cary Institute who is running stream samples. Advising a PhD student at Duke who will be working on ecological dynamics during the spring and autumn.**Funding Support:** Institutional support**International Collaboration:** No**International Travel:** No**Hannah ter Hofstede****Email:** Hannah.ter.Hofstede@dartmouth.edu**Most Senior Project Role:** Co-Investigator**Nearest Person Month Worked:** 1**Contribution to the Project:** Co-leader with Ayres and Holmes in the following project areas: 2.3.5 Climate change, N availability, and forest food webs; and 2.5.3 Spatial patterns of animal populations. Project leader for studies of bats, including the development of a new long-term protocol for measurement of bat abundance and species composition via collection and analysis of automated sound recordings. Co-leader, with Ayres and Holmes, in the development of a new system for long-term studies of bird activity via the collection and analysis of automated passive sound recordings.**Funding Support:** This grant and Dartmouth University**International Collaboration:** No**International Travel:** No**Matthew Vadeboncoeur****Email:** matt.vad@unh.edu**Most Senior Project Role:** Co-Investigator**Nearest Person Month Worked:** 1**Contribution to the Project:** field logistics, data collection, data analysis**Funding Support:** Northeastern States Research Cooperative; New Hampshire Agricultural Experiment Station; University of New Hampshire – Iola Hubbard Climate Endowment

International Collaboration: No

International Travel: No

Ruth Yanai

Email: rdyanai@syr.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 3

Contribution to the Project: Ruth coordinates the MELNHE project (Multiple Element Limitation in Northern Hardwood Ecosystems), which is one of the manipulative experiments of the Hubbard Brook LTER. 2018 was the eighth year of addition of N and P 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 is 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 being the most active) as well as researchers at other institutions.

Funding Support: State University of New York

International Collaboration: No

International Travel: No

Sarah Thorne

Email: sthorne@hubbardbrookfoundation.org

Most Senior Project Role: K-12 Teacher

Nearest Person Month Worked: 3

Contribution to the Project: Sarah serves as our K-12 education coordinator and site education rep.

Funding Support: sLTER (this award)

International Collaboration: No

International Travel: No

Habibollah Fakhraei

Email: hfakhrae@syr.edu

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

Nearest Person Month Worked: 2

Contribution to the Project: Post-doctoral associate conducting research on regional analysis of atmospheric deposition; hydrochemical of reference and experimentally manipulated watersheds; simulation of biogeochemical impacts of ice storm disturbance

Funding Support: NSF DEB 1637685 (NSF Award #1457675)

International Collaboration: No

International Travel: No

Andres Peralta-Tapia

Email: anpeta@vt.edu

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

Nearest Person Month Worked: 1

Contribution to the Project: Examining nitrate patterns in groundwater and developing a water travel time model for several of the watersheds.

Funding Support: Umeå University

International Collaboration: Yes, Sweden

International Travel: No

Clara Chiasson

Email: cchiasson@hubbardbrookfoundation.org

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 12

Contribution to the Project: Outreach and Communications Manager for the Hubbard Brook Research Foundation.

Funding Support: NSF ASL award #1713204

International Collaboration: No

International Travel: No

Natalie L Cleavitt

Email: nlc4@cornell.edu

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 10

Contribution to the Project: Vegetation crew leader Long-term vegetation measures for all tree surveys, fine litter, coarse woody debris, tree regeneration and orchid demography Education and outreach

Funding Support: This award and Cornell University

International Collaboration: Yes, Canada

International Travel: No

Sarah Garlick

Email: sarahgarlick@gmail.com

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 9

Contribution to the Project: Director of Science Policy and Outreach with the Hubbard Brook Research Foundation. Sarah leads the public engagement with science efforts with the Hubbard Brook Research Foundation on behalf of the HBR-LTER.

Funding Support: NSF ASL award #1713204

International Collaboration: No

International Travel: No

Mary Martin

Email: mary.martin@unh.edu

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 12

Contribution to the Project: Information Manager

Funding Support: US Forest Service Cooperative Agreement; NSF EAGER grant # 548175

International Collaboration: No

International Travel: No

Brenda McCartney

Email: bmccartney@hubbardbrookfoundation.org

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 1

Contribution to the Project: Accounting for HBRF's participation in LTER activities.

Funding Support: This award and Forest Service Joint Venture agreement 15-JV-11242307

International Collaboration: No

International Travel: No

Leah Swartz

Email: leah.swartz@mso.umt.edu

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 4

Contribution to the Project: Lab manager and field research director: planning and executing field research, data management, data analysis, preparation of publications and reports, outreach.

Funding Support: DEB-1655653, "The causes and consequences of variation in dispersal distance".

International Collaboration: No

International Travel: No

Geoff Wilson

Email: gwilson@hbresearchfoundation.org

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 12

Contribution to the Project: Geoff is a research technician based at the site and works on a variety of field based projects, as well as data analysis and writing. Geoff does fieldwork for a variety of projects in the LTER, plus some data analysis and writing. He also manages the lab and research spaces for the summer students.

Funding Support: This award and Hubbard Brook Research Foundation covers .2 FTE of Geoff's time for management of the lab and other research spaces.

International Collaboration: No

International Travel: No

Jennifer Becker

Email: beckerj@caryinstitute.org

Most Senior Project Role: Technician

Nearest Person Month Worked: 3

Contribution to the Project: Field and laboratory analyses

Funding Support: N/A

International Collaboration: No

International Travel: No

Katherine Bird

Email: kbird@udel.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 3

Contribution to the Project: Valley-wide surveys

Funding Support: Dartmouth College

International Collaboration: No

International Travel: No

Alexander Burdo

Email: alexander_burdo@brown.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Valley-wide surveys

Funding Support: Home institution

International Collaboration: No

International Travel: No

Jonathan Gewirtzman

Email: jgewirtz@bu.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Jonathan is responsible for assisting with field and laboratory work at Hubbard Brook and Boston University, respectively.

Funding Support: Jonathan received funds from this NSF LTER grant, along with funds from other federal grants to Pamela Templer.

International Collaboration: No

International Travel: No

Katie Jennings

Email: kate.jennings@unh.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 1

Contribution to the Project: data collection, quality control and data analysis

Funding Support: Northeastern States Research Cooperative; New Hampshire Agricultural Experiment Station; University of New Hampshire – Iola Hubbard Climate Endowment

International Collaboration: No

International Travel: No

Mary Margaret Koppers

Email: mmkopper@syr.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 6

Contribution to the Project: Field sampling and laboratory analysis of soils.

Funding Support: N/A

International Collaboration: No

International Travel: No

Brendan Leonardi

Email: bleonardi171@gmail.com

Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Brendan is responsible for assisting with field work at Hubbard Brook.

Funding Support: Brendan receives funds from this NSF LTER grant.

International Collaboration: No

International Travel: No

Nicholas LoRusso

Email: nlorusso@syr.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 12

Contribution to the Project: Technician and now graduate student. Sampling and analysis of soil solution and stream samples.

Funding Support: NSF DEB 1637685 (NSF Award #1457675)

International Collaboration: No

International Travel: No

Lisa Martel

Email: martell@caryinstitute.org

Most Senior Project Role: Technician

Nearest Person Month Worked: 6

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

Funding Support: N/A

International Collaboration: No

International Travel: No

Mario Montesdeoca

Email: mmontesd@syr.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 6

Contribution to the Project: Coordinates field and laboratory activities. Oversees data management.

Funding Support: NSF DEB 1637685 (NSF Award #1457675)

International Collaboration: No

International Travel: No

Jessica Ralston

Email: jessica.s.ralston@dartmouth.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 5

Contribution to the Project: Bioacoustics of birds and bats

Funding Support: Dartmouth College

International Collaboration: No

International Travel: No

Michael Seitz

Email: mseitz@syr.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 4

Contribution to the Project: Hourly worker, conducting laboratory analysis of soil solutions and stream water chemistry.

Funding Support: NSF DEB 1637685 (NSF Award #1457675)

International Collaboration: No

International Travel: No

Anthony Stewart

Email: ajs544@cornell.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 1

Contribution to the Project: Install sensors (O₂, temperature, moisture) and data loggers at multiple sites, and assist with direct N gas flux measurements.

Funding Support: NSF DEB 1655818

International Collaboration: No

International Travel: No

Aimee Van Tatenhove

Email: aimee.van.tatenhove@gmail.com

Most Senior Project Role: Technician

Nearest Person Month Worked: 3

Contribution to the Project: Valley-wide surveys

Funding Support: Dartmouth College

International Collaboration: No

International Travel: No

Hannah Vollmer

Email: hvollmer@hubbardbrookfoundation.org

Most Senior Project Role: Technician

Nearest Person Month Worked: 1

Contribution to the Project: Educator and Field/Maintenance Technician, Hubbard Brook Research Foundation

Funding Support: This award and Forest Service Joint Venture agreement 15-JV-11242307

International Collaboration: No

International Travel: No

David Weber

Email: djw322@cornell.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Valley-wide surveys

Funding Support: Home institution

International Collaboration: No

International Travel: No

Tammy Wooster

Email: woostert@caryinstitute.org

Most Senior Project Role: Technician

Nearest Person Month Worked: 12

Contribution to the Project: Tammy is a technician responsible for collection and processing the long term stream and precipitation chemistry.

Funding Support: Long-term research in environmental biology (LTREB) award # 1256696

International Collaboration: No

International Travel: No

Elizabeth Burakowski

Email: elizabeth.burakowski@gmail.com

Most Senior Project Role: Staff Scientist (doctoral level)

Nearest Person Month Worked: 1

Contribution to the Project: Ecosystem-climate interactions, modeling

Funding Support: Other sources

International Collaboration: No

International Travel: No

Andrew Ouimette

Email: andrew.ouimette@unh.edu

Most Senior Project Role: Staff Scientist (doctoral level)

Nearest Person Month Worked: 2

Contribution to the Project: Estimates of net ecosystem carbon balances using plot data and eddy flux measurements. Analysis of soil C and N data and belowground allocation.

Funding Support: Other sources

International Collaboration: No

International Travel: No

Zaixing Zhou

Email: zaixingzhou@gmail.com

Most Senior Project Role: Staff Scientist (doctoral level)

Nearest Person Month Worked: 2

Contribution to the Project: Ecosystem modeling, simulation of C and N cycling, development of PnET-CN and PnET-SOM.

Funding Support: This grant and other sources

International Collaboration: No

International Travel: No

Brett Addis

Email: brett.addis@gmail.com

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 2

Contribution to the Project: Assisting with stream salamander research, primarily in data analysis and preparation of publications.

Funding Support: Institutional support

International Collaboration: No

International Travel: No

Kaitlyn Baillargeon

Email: b2014@wildcats.unh.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 1

Contribution to the Project: Biodiversity studies, remote sensing

Funding Support: Other sources

International Collaboration: No

International Travel: No

Miriam Bayer

Email: clarice.bayer@umconnect.umt.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 4

Contribution to the Project: Assisting with stream salamander research, primarily in data analysis and preparation of publications.

Funding Support: Institutional support

International Collaboration: No

International Travel: No

Maddy Cochrane

Email: madaline.cochrane@umconnect.umt.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 4

Contribution to the Project: Assisting with fieldwork and planning PhD dissertation research.

Funding Support: Maddy was partially supported by an internal grant from the University of Montana.

International Collaboration: No

International Travel: No

John Hastings

Email: jhc33@wildcats.unh.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 1

Contribution to the Project: Remote sensing, biodiversity, soil N data analysis

Funding Support: Other sources

International Collaboration: No

International Travel: No

Fiona Jevon

Email: fiona.v.jevon.gr@dartmouth.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 3

Contribution to the Project: Conducting studies of soil carbon in northeastern hardwood forests. Ph.D. Dissertation in progress, Dartmouth College. Dissertation research supported by research assistants and infrastructure.

Funding Support: Stipend provided by Dartmouth College.

International Collaboration: No

International Travel: No

Ciara Kernan

Email: Ciara.E.Kernan.GR@dartmouth.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 9

Contribution to the Project: Conducting studies on bat ecology at Hubbard Brook. Ph.D. Dissertation in progress, Dartmouth College.

Funding Support: Stipend provided by Dartmouth College. Dissertation research supported by research assistants and infrastructure.

International Collaboration: No

International Travel: No

Ashley K Lang

Email: ashley.k.lang.gr@dartmouth.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 12

Contribution to the Project: Conducting studies of soil ecology in northeastern hardwood forests, bats within study. Ph.D. dissertation in progress, Dartmouth College.

Funding Support: Dartmouth College stipend.

International Collaboration: No

International Travel: No

David P Lee

Email: dplee@vt.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 5

Contribution to the Project: Developing passive flux meters for characterizing chemical and water fluxes in streams and groundwater.

Funding Support: This grant and Virginia Polytechnic Institute and State University

International Collaboration: No

International Travel: No

Paul Ojo

Email: paulo@miamioh.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 2

Contribution to the Project: Nutrient controls of decomposition.

Funding Support: This grant and Miami University

International Collaboration: No

International Travel: No

Shan Shan

Email: shans@miamioh.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 6

Contribution to the Project: Belowground resource allocation - interactions of nutrient limitation and rhizosphere microbial processes.

Funding Support: Miami University

International Collaboration: No

International Travel: No

Elizabeth A Studer

Email: elizabeth.a.studer.gr@dartmouth.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 12

Contribution to the Project: Conducting studies of heterotroph ecology; supervisor of undergraduate students. Ph.D. Dissertation in progress, Dartmouth College. Dissertation research supported by stipend, research assistants, and infrastructure.

Funding Support: Dartmouth University stipend

International Collaboration: No

International Travel: No

Mahnaz Valipour

Email: mvalipou@syr.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 6

Contribution to the Project: Research on simulation of the hydrologic and biogeochemical effects of forest harvesting.

Funding Support: NSF DEB 1637685 (NSF Award #1457675)

International Collaboration: No

International Travel: No

Ben Artrip

Email: artripbl@miamioh.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 1

Contribution to the Project: Litterfall nutrient dynamics

Funding Support: Miami University

International Collaboration: No

International Travel: No

Molly Bergum

Email: bergu035@umn.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 3

Contribution to the Project: Working on herbivory and pollination of round-leaved orchids and she was part of the veg crew.

Funding Support: LTER supplement

International Collaboration: No

International Travel: No

Alexander Cotnoir

Email: Alexander.W.Cotnoir.19@dartmouth.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 3

Contribution to the Project: Parental investments by Black-throated Blue Warblers (Honor's Thesis)

Funding Support: Home institution

International Collaboration: No

International Travel: No

Cameron Edwards

Email: cnedward@syr.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 1

Contribution to the Project: Participated in field sampling and laboratory preparation and analysis of organic and mineral soils from watersheds 1 and 6.

Funding Support: N/A

International Collaboration: No

International Travel: No

Camila Ferguson

Email: cofergus@syr.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 0

Contribution to the Project: Camila supervised high school students and undergraduates in the lab, who were sorting leaf litter, picking roots, and making sap flow probes.

Funding Support: N/A

International Collaboration: No

International Travel: No

Rachel Goland

Email: rcg228@cornell.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 3

Contribution to the Project: field assistant on the vegetation crew

Funding Support: LTER

International Collaboration: No

International Travel: No

Stephen Kovari

Email: stkovari@vassar.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 4

Contribution to the Project: Implement camera installation at field site, collect and analyze data.

Funding Support: Vassar College

International Collaboration: No

International Travel: No

Vizma Leimanis

Email: vizmaleimanis@gmail.com

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 0

Contribution to the Project: Vizma supervised high school students and undergraduates in the lab, who were sorting leaf litter, picking roots, and making sap flow probes.

Funding Support: N/A

International Collaboration: No

International Travel: No

Megan Schwinden

Email: schwinm@miamioh.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 2

Contribution to the Project: Nutrient limitation of belowground processes

Funding Support: Miami University

International Collaboration: No

International Travel: No

Spencer Stutenroth

Email: stutensm@miamioh.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 3

Contribution to the Project: Nutrient limitation of belowground processes

Funding Support: Miami University

International Collaboration: No

International Travel: No

Corinne Vietorisz

Email: Corinne.R.Vietorisz.19@dartmouth.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 3

Contribution to the Project: Mycorrhizal ecology of Hubbard Brook (Honor's Thesis)

Funding Support: Dartmouth College

International Collaboration: No

International Travel: No

Balthasar von Hoyningen Huene

Email: Balthasar.L.von.Hoyningen.Huene.19@dartmouth.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 3

Contribution to the Project: Ecology ash and beech

Funding Support: Home institution

International Collaboration: No

International Travel: No

Griffin Walsh

Email: gewalsh97@gmail.com

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 0

Contribution to the Project: Griffin supervised high school students and undergraduates in the lab, who were sorting leaf litter, picking roots, and making sap flow probes.

Funding Support: Institutional support

International Collaboration: No

International Travel: No

Maeve Wurtz

Email: mawurtz@syr.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 3

Contribution to the Project: Contributed to field sampling of organic and mineral soils on watersheds 1 and 6 during the summer. Conducted research on soil organic matter.

Funding Support: Institutional support

International Collaboration: No

International Travel: No

James Zhang

Email: jz447@cornell.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 3

Contribution to the Project: supported Veg Crew

Funding Support: This grant

International Collaboration: No

International Travel: No

Simone Burns

Email: srburns@syr.edu

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

Nearest Person Month Worked: 2

Contribution to the Project: Undergraduate research. Conducting research on effects of ice storm disturbance on the carbon cycle.

Funding Support: NSF DEB 1637685 (NSF Award #1457675)

International Collaboration: No

International Travel: No

Year of schooling completed: Junior

Home Institution: Syracuse University

Government fiscal year(s) was this REU participant supported: 2018

Ashe Kinsey

Email: Kinsey.Ashe@uvm.edu

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

Nearest Person Month Worked: 2

Contribution to the Project: Installed wells, sampled soil, and mapped soil.

Funding Support: UVM

International Collaboration: No

International Travel: No

Year of schooling completed: Freshman

Home Institution: University of Vermont

Government fiscal year(s) was this REU participant supported: 2018

Michaela Kuhn

Email: michaela.kuhn@maine.edu

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

Nearest Person Month Worked: 3

Contribution to the Project: Michaela working on a hydrogeology project as part of a larger project on subsurface flow and soil development. Installed wells, sampled soil, and mapped soil.

Funding Support: This award and HBRF

International Collaboration: No

International Travel: No

Year of schooling completed: Freshman

Home Institution: University of Maine

Government fiscal year(s) was this REU participant supported: 2018

Holmes T. Holmes

Email: Richard.T.Holmes@dartmouth.edu

Most Senior Project Role: Other

Nearest Person Month Worked: 1

Contribution to the Project: Retired, Volunteer Project leader for studies of birds, including the continuation of long-term censuses on the "Main Bird Plot", which reached year 50 in summer of 2018. Co-leader, with Ayres and ter Hofstede, in the development of a new system for long-term studies of bird activity via the collection and analysis of automated passive sound recordings.

Funding Support: N/A

International Collaboration: No

International Travel: No

Alison Magill

Email: alimagill@gmail.com

Most Senior Project Role: Other

Nearest Person Month Worked: 1

Contribution to the Project: Assistant to Information Manager - prepared datasets for publication.

Funding Support: LTER

International Collaboration: No

International Travel: No

Brenda McCartney

Email: bmccartney@hubbardbrookfoundation.org

Most Senior Project Role: Other

Nearest Person Month Worked: 1

Contribution to the Project: Accounting related to the Hubbard Brook Research Foundation's participation in LTER activities

Funding Support: This award and Forest Service Joint Venture Agreement 15-JV-11242307-064

International Collaboration: No

International Travel: No

Zachariah Ralph

Email: zralph@hubbardbrookfoundation.org

Most Senior Project Role: Other

Nearest Person Month Worked: 1

Contribution to the Project: Event planning for the LTER Science Council Meeting at HB

Funding Support: This award and Forest Service Joint Venture agreement 15-JV-11242307

International Collaboration: No

International Travel: No

Nicholas Rodenhouse

Email: nrodenho@wellesley.edu

Most Senior Project Role: Other

Nearest Person Month Worked: 1

Contribution to the Project: Former PI, now retired, still working on papers from field work done in previous years - conceptual development, data analysis, and writing.

Funding Support: N/A

International Collaboration: No

International Travel: No

Maribeth Rubenstein

Email: rubensteinm@caryinstitute.org

Most Senior Project Role: Other

Nearest Person Month Worked: 2

Contribution to the Project: Event planning for HBR Quarterly meetings, administrative and logistical support for the LTER Science Council Meeting, HB Cooperators meeting and Outreach as requested.

Funding Support: Cary Institute of Ecosystem Studies

International Collaboration: No

International Travel: No

Elisa Speckert

Email: especkert@hubbardbrookfoundation.org

Most Senior Project Role: Other

Nearest Person Month Worked: 1

Contribution to the Project: Administration and bookkeeping related to HBRF's participation in LTER activities.

Funding Support: This award and Forest Service Joint Venture agreement 15-JV-11242307

International Collaboration: No

International Travel: No

Griffin Walsh

Email: griffin.walsh@yale.edu

Most Senior Project Role: Other

Nearest Person Month Worked: 0

Contribution to the Project: Griffin supervised high school students and undergraduates in the lab, who were sorting leaf litter, picking roots, and making sap flow probes.

Funding Support: Institutional support

International Collaboration: No

International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
USDA Forest Service	Other Organizations (foreign or domestic)	West Thornton, NH

Full details of organizations that have been involved as partners:

<p>USDA Forest Service</p> <p>Organization Type: Other Organizations (foreign or domestic)</p> <p>Organization Location: West Thornton, NH</p> <p>Partner's Contribution to the Project:</p> <p>In-Kind Support</p> <p>Facilities</p> <p>Collaborative Research</p> <p>More Detail on Partner and Contribution: The USFS maintains the Hubbard Brook Experimental Forest and its scientists are collaborators in the project.</p>
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What other collaborators or contacts have been involved?

USDA Forest Service White Mountain National Forest and Northern Research Station
Boston University
New York University
University of Vermont
Vassar College
Society for the Protection of New Hampshire Forests
Chinese Academy of Sciences
Cornell University
Cary Institute of Ecosystem Studies
SUNY-ESF
University of New Hampshire
University of Michigan
Vassar College
Boston University
Society for the Protection of NH Forests
Lund University (Sweden)
Griffith University (Australia)
Plymouth State University
USDA Forest Service, Northern Research Station
Smithsonian Institution
Wellesley College

Dana Warren, OSU
Bill McDowell, UNH
John Magee, New Hampshire Fish & Game
Eric Berry, St. Anselm's College
Nicolas Belanger, TELUQ, Quebec
Zhangwei Wang, Chinese Academy of Sciences
Dan Evans (PSU technician)
Dr. Fred W. Allendorf, University of Montana, Missoula, MT
Dr. Bret W. Tobalske, University of Montana, Missoula, MT

Dr. Jon M. Davenport, Appalachian State University, Boone, NC
Lindsey Rustad, Hubbard Brook Team Leader and Research Ecologist, U.S. Forest Service
Amey Bailey, Forestry Technician, U.S. Forest Service;
Ian Halm, Hubbard Brook Site Manager, U.S. Forest Service;
Lindsey Rustad, Hubbard Brook Team Leader and Research Ecologist, U.S. Forest Service
Dr. Michael Hallworth, Post-doctoral Fellow, U Mass Amherst
Dr. Caitlin Hicks Pries, Assistant Professor, Dartmouth College
Dr. Christine Palmer, Assistant Professor, Castleton University, Castleton, VT
Dr. T. Scott Sillett, Senior Scientist, Migratory Bird Center, Smithsonian Conservation Biology Institute, Washington, DC, Associate Director, Bioacoustics Research Laboratory, Cornell Laboratory of Ornithology
Dr. Michael Webster, Professor, Cornell University

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 three 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 continued linking archive samples with data streams, and 3) we began a process of gradual replacement of aging stream weirs.

What is the impact on institutional resources that form infrastructure?

Nothing to report.

What is the impact on information resources that form infrastructure?

The HBR data catalog has been recently restructured, with the hubbardbrook.org website providing browse/search capabilities, and metadata and data access linked directly to the EDI dataset landing page. Accessing data through the EDI provides many advantages over the outdated local catalog that

we have been maintaining.

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. Our research on the impact of forest pests on U.S. forests was a fundamental resource for a section of the U.S. House of Representatives Farm Bill that seeks to limit the importation of new forest pests into the country. A portion of this amendment was included in the final Farm Bill signed in to law in December 2018. US Customs and Border Protection used this information in deciding to strengthen the enforcement of current regulations regarding importation of forest pests.

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.

