

Award 1633026 - Annual Project Report

Cover

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

The HBR LTER project has an active program of outreach and education activities, 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. 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:

Hydropedology: Redistribution of soil metals and organic carbon via lateral flowpaths at the catchment scale in a glaciated upland setting. Emerging evidence shows that interactions between soils and subsurface flow paths contribute to spatial variations in stream water chemistry in headwater catchments. However, few have yet attempted to quantify chemical variations in soils at catchment and hillslope scales. Watershed 3 (WS3) at HBR was studied in order to better understand pedogenesis and its relationship to subsurface water dynamics. In WS3, 99 soil profiles were described, sampled by horizon, and assigned to a hydropedologic unit (HPU), a functional classification previously developed using landscape and morphological metrics which corresponded with distinct water table regimes. Soil samples were extracted and analyzed for different forms of Fe, Mn, Al, La, Ce, and Pr, as well as total organic C.

Climate change: The near-term prediction of drought and flooding conditions in the northeastern United States. We investigated hydroclimatic teleconnection patterns between variations in either Atlantic or Pacific oceanic indices with precipitation and discharge anomalies in the northeastern United States. We hypothesized that temporal annual or seasonal changes in discharge could be explained by variations in extreme phases of the Atlantic Multi-decadal

Oscillation (AMO index, SST: Sea Surface Temperature anomalies) and the North Atlantic Oscillation (NAO index, SLP: Sea-Level Pressure anomalies) up to three seasons in advance. The Merrimack River watershed, the fourth largest basin in New England, with a drainage area of 13,000 km², provides an opportunity to investigate the teleconnection between hydrologic variables and large-scale climate circulation patterns, and also how those patterns may become obscured by anthropogenic disturbances such as river regulation or urban development. We considered precipitation and discharge data of 21 gauging stations within the Merrimack River watershed, including the HBR, with a median record length of 55 years beginning as early as 1904 to investigate potential teleconnectivity of climate circulation patterns with discharge.

Eddy flux tower: Evapotranspiration and photosynthesis. The eddy flux tower at Hubbard Brook began making accurate evapotranspiration (ET) measurements in 2017. The data are being analyzed with ancillary data to provide us with better understanding of short-term controls on ET at Hubbard Brook. We have continued to conduct eddy covariance CO₂ flux measurements at the Bartlett Experimental Forest AmeriFlux tower, which are entering their 15th year. We wrapped up work on model-data fusion analyses of the tower flux data, together with other measurements of ecosystem C pools and fluxes, using the ecosystem model FöBAAR. A focus during 2017 was completing and publishing analysis of the differential effects of direct and diffuse radiation on ecosystem photosynthesis.

We also characterized the relationship between photosynthetic capacity (A_{max}) and foliar nitrogen within and across species in northern hardwood and evergreen stands of the White Mountain National Forest, a region that has been underrepresented in past leaf trait studies. Spatially, relationships among leaf traits can vary as a function of climate, soils and species composition and, as modeling approaches to estimate C gain improve, the need to understand regional variability in leaf traits becomes increasingly important. Results were used to parameterize a forest ecosystem model (PnET) that has been widely used in the Northeast region to predict ecosystem C fluxes.

Modeling ecosystem nitrogen dynamics: We parameterized and ran the PnET-SOM model to help understand the degree to which mineral soil N pools explain the long term imbalances in the ecosystem N budgets seen at HBR. This included incorporating 14C in PnET-SOM to predict 14C signatures in soil organic matter as well as improved parameterization for HBEF. We used the improved model to conduct simulations of soil organic nitrogen dynamics across forest succession. Our specific objective was to evaluate the soil “N bank” hypothesis to address long term imbalances in ecosystem nitrogen budgets at control watersheds within Hubbard Brook, where deeper soil is believed to act as a reservoir from which N can be mined and retained during periods of high and low net N demand. In a related study, we used the Spe-CN model to evaluate how changes in tree species composition could affect the ability of Northeastern forests to retain N from atmospheric deposition.

Biodiversity studies: Motion activated trail cameras. Currently 8 motion detecting cameras are operating at HBR to document occurrence of wildlife species found in this area and 36 new cameras are being installed at fixed distances from random points along roads and trails, including vegetation type, elevation and aspect as main factors. A major focus of the project is to determine what factors affect the distribution and occupancy of the forest’s moose population and if moose are declining in the area. Also of interest are how deer or the presence of other animals (coyotes and bear) may be utilizing the areas occupied by moose.

Seed production of sugar maple and American beech in northern hardwood forests. Mast seeding is the synchronous production of large seed crops in plant populations and for many tree species is known to be determined by the interaction between weather cues and internal plant resources. We used a 24-year record of seedfall for sugar maple (*Acer saccharum* Marsh.) and American beech (*Fagus grandifolia* Ehrh.) from HBR to quantify their masting patterns and explore the relationship between mast years, resources, and weather cues, particularly the difference between summer temperatures in the two years prior to the seedfall year.

Terrestrial gastropod gastronomy in relation to epiphytic lichen biodiversity and abundance. Acid deposition has caused a decline in lichen communities which are sensitive to air pollution and substrate pH. However, acid rain has steadily decreased since the Clean Air Act of 1970 without an apparent resurgence in lichen populations. Several European studies have been conducted on the ability of terrestrial gastropods, particularly *Arion* spp., to alter lichen community structure by way of herbivory. Terrestrial gastropods were surveyed at HBR from 1997 to 2006. We conducted a 10-year re-measure of gastropod densities to compare current population densities. In addition, we conducted an initial baseline lichen survey of 13 plots, which contained 72 species of macro lichens.

Population trends of songbirds. Recent work suggests current and future broad-scale declines across forest bird species. However, drawing firm conclusions from such trends can be complicated due to spatial biases in sampling, differential trends across spatial scales, and biases caused by imperfect detection. We estimated population trends from 1999-2012 for 38 forest bird species that were sampled systematically across an undisturbed forested watershed at HBR. We then compared these trends to those estimated at regional and local scales to address three questions: (1) Are any species consistently declining across each of these scales? (2) Are life history or ecological traits predictive of putative declines?

(3) To what extent does imperfect detection obscure long-term trends? We derived regional trends from the Breeding Bird Survey (BBS) and local trends from a 10-ha plot within HBR.

Disturbance studies: Long-term decline of sugar maple following forest harvest. Forest harvesting can impact site quality by removing essential nutrients, exacerbating the effects of historic base cation losses associated with acid deposition. We studied the 30-year trajectory of forest recovery from clearcutting (whole-tree harvest) in a forest originally dominated by sugar maple at both the watershed and small plot scale.

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, nitrogen saturation, trace metal deposition, clear-cut practices, climatic change).
- To provide information to policymakers and resource managers.

Significant Results:

Hydropedology: Analysis of soil profiles in WS3 grouped into different hydropedologic units showed that different forms of Fe, Mn, Al, La, Ce, and Pr were redistributed via vertical and lateral podzolization. Typical (horizontally layered) podzols developed in the majority of the catchment due to predominantly vertical, unsaturated flow. However, lateral flow produced four other podzol types with distinct chemistry. The spatial distribution of positive cerium-anomalies in soil profiles proved to be a consistent hydropedologic indicator of lateral flow and seasonally high water table in three hillslopes. Despite occasional high water table in some of the HPU, they were not hydric soils and were distinct from wetter podzols of coastal plains due to their high Fe content. This study suggests that vertical and lateral spatial variation in soil chemical composition, including the complexity of Ce distribution, as it relates to subsurface water dynamics should be considered when studying or predicting catchment scale functions such as stream solute export and biogeochemical processes.

Climate change: The near-term prediction of drought and flooding conditions in the northeastern United States. Analysis of precipitation and discharge data of 21 gauging stations within the Merrimack River watershed, including the HBR, revealed the potential teleconnectivity of climate circulation patterns with discharge. Annual and seasonal correlations of discharge were examined with the extreme phases of AMO and NAO at zero-, one-, or two- year/season lags (total of 30 scenarios). When AMO was greater than 0.2, the strongest correlations of AMO and NAO with discharge were observed at headwater catchments. This correlation weakened downstream towards larger regulated and/or developed sub-basins. The Merrimack watershed will most likely experience greater than average discharge as its extreme condition, therefore development should be avoided on flood plains. Furthermore, the current reservoir storage capacity in the Merrimack should be improved in order to accommodate excess water input and minimize flood damage. Future research should target changes in the magnitude and timing of high discharge events in order to develop adaptation strategies for aging hydraulic infrastructure in the region.

Eddy flux tower: Evapotranspiration and photosynthesis. Our analysis of the differential effects of direct and diffuse radiation on ecosystem photosynthesis leveraged the long-term CO₂ flux measurements from the Bartlett tower. Clouds and aerosols increase the fraction of global solar irradiance that is diffuse light. This phenomenon is known to increase the photosynthetic light use efficiency (LUE) of closed-canopy vegetation by redistributing light from saturated, sunlit leaves at the top of the canopy, to shaded leaves deeper in the canopy. We found that modeled annual gross primary productivity (GPP) increased by $\approx 0.94\%$ when observed levels of diffuse fraction were increased by 0.01 (holding total irradiance constant). The sensitivity of GPP to increases in diffuse fraction was highest when the diffuse fraction was low to begin with, and lowest when the diffuse fraction was already high. Diffuse fraction also explained significantly more of the interannual variability of modeled net ecosystem exchange (NEE), than did total irradiance. Our findings highlight the importance of incorporating LUE enhancement under diffuse light into models of global primary production, and improving models of diffuse fraction.

Analysis of relationships between photosynthetic capacity (A_{max}) and foliar nitrogen within and across species in northern hardwood and evergreen stands found that within all species, A_{max} was strongly and positively related to mass-based foliar percent nitrogen (%N). The observed relationship between foliar %N and A_{max} differed significantly from the

previously used model parameterization and was largely a function of differences in leaf mass per area (LMA). Use of the newly measured photosynthesis parameters in PnET, along with other locally derived data, improved the estimation of GPP by 8.9% in comparison with GPP estimates derived from the eddy covariance tower.

Modeling ecosystem nitrogen dynamics: Model analysis using the PnET-SOM model to help understand the degree to which mineral soil N pools explain the long term imbalances in the ecosystem N budgets seen at HBR suggested that N mining in mineral soils provides extra available N for plant growth and N losses from the system during succession and that N retention in mineral soils repaid the mining nitrate retention in A and B horizons. The predicted nitrogen balance showed that N gas losses could account for 14-46% total N deposition and that N retention could account for around 52%.

SPe-CN modeling shows that changes in tree species composition can change N dynamics in forests. For example, if emerald ash borer eliminates white ash and it is replaced by sugar maple, N leaching will increase, but if it is replaced by red oak, leaching will decrease.

Biodiversity studies: Motion activated trail cameras have produced observations of moose, white-tailed deer, black bear, coyote, pine marten, wild turkey, red fox, flying squirrel, unidentified owl and bat species and beaver. This preliminary survey has provided the basis for an enhanced study that will assess occupancy across the forest.

Our analysis of seed production of sugar maple and American beech in found clear evidence of masting in these species, and mast years were often coincident in the two species; masting was best predicted by ΔT or ΔT plus previous-year seedfall. We saw no evidence for correspondence of masting in these trees to precipitation cues. A soil calcium addition modified elevation effects on seed production. Clarification of the controls on mast seeding for these important tree species will aid in predicting such resources as mast for wildlife and maple sugar production in northern hardwood forests.

Analysis of terrestrial gastropod gastronomy in relation to epiphytic lichen biodiversity and abundance found that *Arion* spp. (introduced to the United States from Europe) have a significant presence at HBR and have potential to affect the community structure of lichen at HBEF and elsewhere. *Lobaria pulmonaria* may be especially affected as has been suggested in the literature.

Analysis of population trends of songbirds shows that the abundance of most forest bird species at HBR was relatively stable over the period observed; we detected statistically significant declines in only 7 of 38 species (18.4%). More than double the number of species declined at the regional scale (16 of 38, 42.1%) and more than double increased (10 of 23, 43.5%) at the local scale. Life history and ecological traits did not predict HBEF trends, but regionally, species occurring at higher elevations were more likely to have declined and species associated with older forests tended to increase. We conclude that the relatively stable breeding habitat in the HBEF appears to translate into mostly stable bird populations. This contrasts with trends between 1969 and 1998 showing consistent declines across many species (~50%), and is therefore cause for cautious optimism.

Disturbance studies: Analysis of the 30-year trajectory of forest recovery from clearcutting showed a dramatic decline of sugar maple, maintenance of American beech, and an increase in birch, mainly yellow birch (*Betula alleghaniensis* Britt.). Many of the plots where sugar maple failed to recruit became unoccupied rather than being “won” by another species. The decline of sugar maple was most severe in the upper elevation zones of the watershed, where low base status (especially Ca) of the soils was a likely driver. The results support previous studies indicating that regeneration by sugar maple is severely compromised on base cation depleted soils.

Information Management

The Information Management System at HBR (1) maintains a catalog of HBR data (2) enables data discovery/access to serve the HBR, LTER, and broader scientific communities (3) maintains a website to share information on site history, current research, publications, photos, educational materials, etc. (4) maintains a physical sample archive.

Data catalog - The content of the HBR data catalog is available on the HBR website and all content can be accessed through the LTER data portal, the Environmental Data Initiative (EDI) portal, and through DataONE. The data catalog contains over 150 data packages ranging from single year studies to long-term data collections, with more than 20 data packages containing data collected for more than 50 years, and another 30 covering a timespan of more than 20 years. Ongoing data package development addresses time-series additions to our core data sets and the addition of new data sets. We continue to restructure our legacy data sets to better serve the user community. For almost a decade, we have averaged 10 data downloads per day.

Key outcomes
or Other
achievements:

Data Access Policy - HBR datasets are being updated to adhere to the new LTER Data Policy. To date, all the data collected at HBR are considered Type I. When users view or download data from the local HBR data catalog, they self-identify by entering their name, affiliation, email address. This information is stored in a database and provides statistics on data use and users. Datasets accessed through the LTER-NIS are tracked through 'Data Package Access Reports'.

Website: The HBR website (<http://hubbardbrook.org>) is the primary means by which HBR information is disseminated, with additional non-digital data (charts, maps, photographs) made available upon request. A major HBR website redesign occurred in 2017 with the transition to Drupal. In this new website framework, we combined the research-based content on <http://hubbardbrook.org>, with the education and outreach content formerly on the <http://hubbardbrookfoundation.org> website. The new pages include K-12 curriculum materials, Science Links publications, products generated by stakeholder roundtable meetings.

The current website provides the following functionality:

Personnel database - A personnel database is used to display photo, contact information, research interests, and a list of publications by that author which is automatically generated from the HBR bibliography.

Current Research - includes research initiatives and preliminary findings.

Photo archive - The website has a searchable archive of digital images. Many of the historical HBR photographs and slides have been scanned at high resolution to ensure that these irreplaceable images are preserved.

Publications - A list of the more than 2,400 Hubbard Brook publications dating back to 1955 is accessible in a searchable format on the HBR website. New publications are identified through self-reporting by investigators, annual reports, and Google Scholar alerts. Citations are managed locally with Zotero (<http://zotero.org>). Early publications are archived in paper at the Cary Institute of Ecosystem Studies; publications since 2011 are archived in pdf format. The pre-2011 publications are being assembled in digital format by downloading pdfs from the publishers, and scanning original paper copies when a digital version is unavailable. Publications are now added to the list with a hyperlinked DOI to improve access to the documents.

HBR Environmental Sensors: HBR-IM provides support for 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. HBR-IM is funded through a Cooperative Agreement with the Forest Service to support this work.

Hubbard Brook Sample Archive: A dedicated building on-site serves as the archive facility, and now houses approximately 100,000 samples. Samples are preserved, barcoded, and cataloged with associated metadata in the HBR centralized database; Requests for analysis of these samples (e.g. isotopic analyses, heavy metals) are received regularly, and have resulted in at least 37 publications (soils n=8; water n=15; forest floor n=11; plant material n=3). During this current funding cycle, over 6000 samples have been cataloged and barcoded, with improvements to the sample organization and the addition of volume data for the streamwater and precipitation samples.

Other projects:

Website Guidelines – The HBR-IM is co-chair (with Marty Downs, NCO) of the committee tasked with revising the guideline document for site-level LTER websites.

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

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.

* 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.

During the summer field season, training and development occurs through interactions among PIs and senior scientists, science teachers, and technicians. Conference calls allow PIs and students to discuss results and plans, and Google documents and email are used to monitor progress and solicit input on specific topics. The research team at Hubbard Brook held weekly "Science Night" gatherings during the summer field season in which the research being conducted and papers from the current scientific literature were discussed. Weekly Science Nights included visiting speakers to offer additional perspectives on discussion topics.

Most students, including the summer crew, presented talks at the annual HBES Cooperators' Meeting. Summer crew participants also presented their final reports jointly with Hubbard Brook REU students. Additionally, some graduate students participated in grant writing, presented at Ecological Society of America meetings, and contributed project management, leadership, and mentorship of undergraduate students.

In addition to the professional development of emerging scientists, the Hubbard Brook Research Foundation (HBRF) 2017 programs served approximately 6,400 students, teachers, scientists, policy-makers, land-managers, business leaders, and other stakeholders. HBRF is a non-profit group dedicated to synthesis, outreach, education, and support of facilities associated with the HBR LTER. 2017 activities included:

- Guided tours of the Hubbard Brook Experimental Forest serving approximately 350 teachers and students

- Math and science lesson plans, practice exams, and slide shows for K-12 educators

- Summer Research Experiences for Undergraduates (REU): students live at the HBRF's scientist dormitory and study the dynamic nature of Hubbard Brook's forest and aquatic ecosystems.

- Communal housing, lab, and storage spaces provided for approximately 100 investigators, research assistants, and field technicians annually

- Informal education and training activities for students:

- An Undergraduate Research Program: Using a combination of LTER funds, REU supplements to existing grants, USDA-Forest Service funds, and other support from research mentor teams, we hosted undergraduates from around the country for a 10-week REU program.

- The Environmental Literacy Program (ELP), a cooperative effort with the USDA-Forest Service and the Schoolyard LTER aimed at supporting secondary science teachers through the development of teaching resources. A central aim of the ELP program is to provide HBES data to teachers in a format that builds students' science-process skills and content knowledge. In 2017, we created a lesson for Advanced Placement Biology students designed to develop two quantitative skills required within the AP Bio curriculum. The lesson highlights the role of calcium within forest ecosystems and its importance to plants. Students hone math and science skills (error bars and Chi-squared test) using data from the Hubbard Brook Ecosystem Study's calcium addition experiment. The lesson includes a summary, objectives, notes for teachers, alignment with Next Generation Science and Advanced Placement Biology standards, a three-part Introductory "Reading and Check for Understanding" assignment, the actual data-based lesson, an answer key, and an extension activity. The lesson will be piloted in spring 2018.

- On-site tours: In 2017, Hubbard Brook educators conducted 16 tours for groups of elementary, high school, undergraduate, and graduate students and visiting researchers.

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

In addition to the production of dozens of peer-reviewed journal publications and other products, in 2017 Hubbard Brook investigators presented their research at over 70 conferences and other public events including three collaborative Committee of Scientists (COS) meetings at the Cary Institute of Ecosystem Studies.

The 54th Annual Hubbard Brook Cooperators meeting was held on-site in July with over 150 attendees. This meeting, as always, was free and open to the public. The event included a keynote speaker, two days of ongoing and proposed Hubbard Brook research presentations from senior investigators, postdocs, and graduate and undergraduate students, and a half-day COS meeting. The 2017 keynote speaker was Michael Oppenheimer, Professor of Geosciences and International Affairs in the Woodrow Wilson School of Public and International Affairs and the Department of Geosciences at Princeton University. He spoke insightfully and enthusiastically about the importance of science communication.

The Hubbard Brook Research Foundation 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 2017 HBRF:

- Provided media outreach in support of Hubbard Brook projects.

Provided planning and logistical support for large and small-scale events including the Annual Meeting of Hubbard Brook Cooperators and the 2017 annual meeting of the LTER Science Council.

Produced public engagement with science programs and products including roundtable dialogue events with regional stakeholders, focus groups, communications workshops, and fact sheets

Developed Hubbard Brook's first "Science Links Fact Sheet" based on climate data at Hubbard Brook. This is the first in a series of these mini-syntheses to support our ongoing communication and engagement work.

Held a focus group of educators at Hubbard Brook to explore and refine the Waterviz visualization and sonification tools and classroom materials. Waterviz explores the benefits of artist-scientist collaborations and the learning that takes place using novel data visualizations.

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. HBRF staff and collaborators have compiled and are analyzing a dataset of ~100 years of temperature, snow pack, and precipitation data from across the Northeast, including Hubbard Brook. The analysis emphasizes indicators of change that are relevant to regional stakeholders (e.g., number of days in a season when conditions are favorable for making snow; number of home-heating days in a season; number of days in a season when conditions are favorable for winter logging operations).

Expanded Hubbard Brook's suite of media outreach programs which now includes a redesigned website (live in July 2017), a system of regular press releases, an e-newsletter, and a stronger social media campaign (i.e., Facebook, Twitter). Enhanced outreach has contributed to increased coverage in local, regional, and national television, radio, and print media. This work resulted in more than 1,000,000 readers, listeners, and viewers learning about Hubbard Brook science.

Represented Hubbard Brook at the annual American Association for the Advancement of Science meeting in Boston in a presentation featuring results from our stakeholder roundtable program.

Launched an internal e-newsletter, designed to enhance information-sharing within the Hubbard Brook community. These monthly bulletins now enable Hubbard Brook researchers, educators, program staff, and administrators across the country to share new projects, publications, speaking engagements, employment opportunities, and outreach activities. This initiative was inspired by feedback from the research community and will improve communication, raise awareness, and support deeper collaboration across institutions and projects.

* 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

Inventions

Journals or Juried Conference Papers

- Baatz, R., P. L. Sullivan, L. Li, S. Weintraub, H. W. Loescher, M. Mirtl, P. M. Groffman, D. H. Wall, M. Young, T. White, H. Wen, S. Zacharias, I. Kühn, J. Tang, J. Gaillardet, I. Braud, A. N. Flores, P. Kumar, H. Lin, T. Ghezzehei, H. L. Gholz, H. Vereecken, and K. Van Looy. (2018). Integration of terrestrial observational networks: opportunity for advancing Earth system dynamics modelling.. *Earth System Dynamics Discussions*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: <https://doi.org/10.5194/esd-2017-94>
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Templer, Pamela H. and Reinmann, Andrew B. and Sanders-DeMott, Rebecca and Sorensen, Patrick O. and Juice, Stephanie M. and Bowles, Francis and Sofen, Laura E. and Harrison, Jamie L. and Halm, Ian and Rustad, Lindsey and Martin, Mary E. and Grant, Nicholas (2017). Climate Change Across Seasons Experiment (CCASE): A new method for simulating future climate in seasonally snow-covered ecosystems. *PLOS ONE*. 12 (2), e0171928. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1371/journal.pone.0171928

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Yanai, Ruth D. and See, Craig R. and Campbell, John L. (2017). Current Practices in Reporting Uncertainty in Ecosystem Ecology. *Ecosystems*. 1--11. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s10021-017-0197-x

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Licenses

Other Conference Presentations / Papers

Liu, K., M.M. Koppers and C.E. Johnson. (2017). *Accumulation of Woody Debris in the Hubbard Brook Forest Over a Forty-Year Period*.. Northeastern Ecosystem Research Cooperative Meeting, 28-29 March 2017.. Saratoga Springs, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Driscoll, C.T. (2017). *Air quality, health, and ecosystem co-benefits and dis-benefits of policy options for a U.S. powerplant carbon standard*.. Center of Excellence Symposium 4 October. Syracuse, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Lasser, G.A., M.T. Johnston, M.J. Mahoney, V.A. Leimanis, and J.R. Stoodley. (2017). *An investigation of nutritional effects on causal organisms of beech bark disease in aftermath forests*.. Rochester Academy of Sciences Fall Scientific Paper Session. November 11, 2017.. St. John Fisher College.. Status = OTHER; Acknowledgement of Federal Support = Yes

Hong, D.S., A.D. Wild, and R.D. Yanai. (2017). *Battle of the babies: Beech interference with maple regeneration*.. Rochester Academy of Sciences Fall Scientific Paper Session. November 11, 2017. St. John Fisher College.. Status = OTHER; Acknowledgement of Federal Support = Yes

Box, O. (2017). *Beech bark disease fungus: Which Neonectria species are found at Hubbard Brook Forest?*. HB cooperators meeting.. North Woodstock, NH. Status = OTHER; Acknowledgement of Federal Support = Yes

Hess, B.J, M.M. Koppers and C.E. Johnson. (2017). *Calcium Forms in Decomposing Wood and Bark: A 24-Year Incubation Study*. Poster.. Northeastern Ecosystem Research Cooperative Meeting, 28-29 March 2017.. Saratoga Springs, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Battles, J.J. (2017). *Calculating biomass at Hubbard Brook: A simple, unified approach*.. HB cooperators meeting.. North Woodstock, NH. Status = OTHER; Acknowledgement of Federal Support = Yes

Driscoll, C.T. (2017). *Cation depletion, impacts on soil solution chemistry, PnET-BGC model simulations*.. Annual COS 3 Meeting at Cary Institute.. Millbrook, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Goodale, CL, C Fuss, BA Darby, A Lang, SV Ollinger, A Ouimette, M Vadeboncoeur, Z Zhou, and GM Lovett. (2017). *Century-scale variation in plant and soil nitrogen pools and isotopic composition in northern hardwood forests*.. American Geophysical Union annual meeting. December 2017.. New Orleans, LA. Status = OTHER; Acknowledgement of Federal Support = Yes

Ouimette A.P., Ollinger S.V., Hobbie E.A., Lepine L.C., Stephens R.B., Rowe R.J., Vadeboncoeur M.A., Tumber-Davila S.J. (2017). *Changes in carbon allocation to aboveground versus belowground forest components is driven by a trade-off involving mycorrhizal fungi, not fine roots*.. American Geophysical Union Fall Meeting.. New Orleans, LA.. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Jensen, C.K., McGuire, K.J. (2017). *Characterizing and modeling headwater stream length dynamics along a physiographic gradient in the Appalachian Highlands*. Gordon Research Conference, June 25-30., Lewiston, ME.. Status = OTHER; Acknowledgement of Federal Support = Yes

Ouimette A.P., Ollinger S.V., Richardson A.D., Hollinger D.Y., Keenan T.F., Lepine L.C., Vadeboncoeur M.A. (2017). *Comparison of carbon flux estimates using 13 years of eddy covariance data and plot-level biometric measurements from the Bartlett Experimental Forest, New Hampshire*.. 2017 Conference of the Northeastern Ecosystem Research Cooperative.. Saratoga Springs, NY. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Gonzales, K.E. and R.D. Yanai. (2017). *Could fertilization with N and P affect biodiversity by altering nutrient cycling via resorption in northern hardwood forests?*. ESA Annual Meeting. August 11, 2017.. Portland, OR. Status = OTHER; Acknowledgement of Federal Support = Yes

Harris, Jennifer. (2017). *Creepy crawlies and climate change: How beetles in forest floor have changed since the 1970s*.. Hubbard Brook Ecosystem Study 54th Annual Cooperators Meeting. July.. Thornton, NH. Status = OTHER; Acknowledgement of Federal Support = Yes

Groffman, P.M. (2017). *Data needs to support LTER science. Invited talk*.. National Center for Ecological Analysis and Synthesis Workshop. April 2017.. Santa Barbara, CA. Status = OTHER; Acknowledgement of Federal Support = Yes

Rice, A.M., M.T. Johnston, and R.D. Yanai. (2017). *Do nutrient additions affect sap flow in sugar maple trees?*. Rochester Academy of Sciences Fall Scientific Paper Session. 11 November.. St. John Fisher College. Status = OTHER; Acknowledgement of Federal Support = Yes

Driscoll, C.T. (2017). *Effects of changing climate on the structure and function of the Northern Forest: long-term measurements and experiments from the Hubbard Brook Experimental Forest, NH, USA*. Distinguished Speaker Seminar at University of Boulder, CO. 25 October.. Boulder, CO. Status = OTHER; Acknowledgement of Federal Support = Yes

Driscoll, C.T. (2017). *Effects of changing climate on the structure and function of the Northern Forest: long-term measurements and experiments from the Hubbard Brook Experimental Forest, NH, USA*.. Yale/Hubbard Brook – Legacy, Research, and Relevance Program. 22 September 2017.. West Thornton, NH. Status = OTHER; Acknowledgement of Federal Support = Yes

Groffman, P.M. (2017). *Forming and managing interdisciplinary research teams. Invited presentation*.. National Socio-Environmental Synthesis Center (delivered via Skype), November.. Annapolis, MD. Status = OTHER; Acknowledgement of Federal Support = Yes

Pardo, L.H., Green, M.B., Bailey, S.W., McGuire, K.J., Goodale, C. L., Groffman, P. (2017). *Identifying carbon and nitrogen cycling hotspots in a northern hardwood forest using a hydopedological framework*.. Biogeomon, August 20-24.. Litomyšl Chateau, Czech Republic. Status = OTHER; Acknowledgement of Federal Support = Yes

Rodenhouse, N. L. M. P. Ayres, S. W. Bailey, J. J. Battles, J. Campbell, M. C. Fisk, K. Gonzales, M. B. Green, P. M. Groffman, G. M. Lovett, W. Lowe, E. Rosi-Marshall, L. H. Pardo and P. Templer. (2017). *Integrating biogeochemistry and biodiversity: Exploring the unknowns*.. Annual Meeting of the Ecological Society of America, August.. Portland, OR. Status = OTHER; Acknowledgement of Federal Support = Yes

Rodenhouse, N.L. (2017). *Integrating biogeochemistry and biodiversity: Exploring the unknowns*.. Hubbard Brook Ecosystem Study 54th Annual Cooperators Meeting. July.. Thornton, NH. Status = OTHER; Acknowledgement of Federal Support = Yes

Fisk, M.C., S. Goswami, C.R. See, R.D. Yanai and T.J. Fahey. (2017). *Interactions in efficiency of N and P use for forest litter production*.. ESA Annual Meeting. August 7.. Portland, OR. Status = OTHER; Acknowledgement of Federal Support = Yes

Zhou Z., Ollinger S.V., Lepine L.C. (2017). *Landscape Variation of Canopy Nitrogen and Carbon Assimilation in a Temperate Mixed Forest*.. 2017 Conference of the Northeastern Ecosystem Research Cooperative. Saratoga Springs, NY.. Status = OTHER; Acknowledgement of Federal Support = Yes

Driscoll, C.T. (2017). *Legacies of acid deposition*. Annual Science Council meeting, 17 May 2017.. West Thornton, NH. Status = OTHER; Acknowledgement of Federal Support = Yes

Driscoll, C.T. (2017). *Legacies of acid deposition*. Annual Hubbard Brook Cooperators Meeting, 13 July 2017. West Thornton, NH. Status = OTHER; Acknowledgement of Federal Support = Yes

Driscoll, C.T. (2017). *Legacy of acid rain: A tale of two species*.. NSF sponsored LTER mini-symposium. 21 March 2017.. Arlington, VA. Status = OTHER; Acknowledgement of Federal Support = Yes

Zhou Z., Ollinger S.V., Ouimette A.P., Fuss, C.B., and Goodale C.L. (2017). *Modeling N Cycling during Succession after Forest Disturbance: an Analysis of N Mining and Retention Hypothesis*.. American Geophysical Union Fall Meeting.. New Orleans, LA. Status = ACCEPTED; Acknowledgement of Federal Support = Yes

Zhou, Z., Ollinger S.V., Ouimette A.P., Lovett G.M., Fuss C.B., Goodale C.L. (2017). *Modeling N cycling during succession after forest disturbance: an analysis of N mining and retention hypothesis*.. Hubbard Brook Annual Cooperators Meeting.. Thornton, NH.. Status = OTHER; Acknowledgement of Federal Support = Yes

Yanai, R.D. (2017). *Nitrogen versus phosphorus limitation: A factorial fertilization experiment in temperate hardwood forests*.. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, and the Entomological Society of America joint Annual Meeting, October 23, 2017.. Tampa, FL.. Status = OTHER; Acknowledgement of Federal Support = Yes

Fahey, T.J. (2017). *Nitrogen, phosphorus, and fine roots*.. HB cooperators meeting.. North Woodstock, NH. Status = OTHER; Acknowledgement of Federal Support = Yes

Groffman, P.M. (2017). *Opportunities for integrating and leveraging LTER, NEON, and CZO Networks. Invited talk*.. All Hands Meeting of U.S. Critical Zone Observatory Network. June 2017.. Arlington, VA. Status = OTHER; Acknowledgement of Federal Support = Yes

Yanai, R.D. (2017). *Propagating uncertainty in allometric models*.. Global Forest Observations Initiative, Silvacarbon, CONAFOR. June 8, 2017.. Zapopan, Jalisco, Mexico.. Status = OTHER; Acknowledgement of Federal Support = Yes

Cleavitt, N.L. (2017). *Regeneration dynamics following whole-tree harvesting: Insights from a 30-year record of tree establishment and persistence*.. HB cooperators meeting.. North Woodstock, NH. Status = OTHER; Acknowledgement of Federal Support = Yes

Driscoll, C.T. (2017). *Response of forest ecosystems to ice storm events: research from the Hubbard Brook Experimental Forest, NH and how to give an oral presentation*.. summer undergraduate research group, Department of Civil and Environmental Engineering, Syracuse University 7 June.. Syracuse, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Driscoll, C.T. (2017). *Response of forest ecosystems to ice storm events: research from the Hubbard Brook Experimental Forest, NH. Invited speaker*.. AGU Chapman Conference on Extreme Climate Event Impacts 24 January 2017.. San Juan, Puerto Rico. Status = OTHER; Acknowledgement of Federal Support = Yes

Goswami, S., M.C. Fisk, M.A. Vadeboncoeur and R.D. Yanai. (2017). *Seedling survival and allocation responses to nutrient additions in northern hardwood temperate forests*.. ESA Annual Meeting, August 7, 2017.. Portland, OR. Status = OTHER; Acknowledgement of Federal Support = Yes

Groffman, P.M. (2017). *Shooting at a moving target: Evaluating ecosystem response to extreme events in a changing world*.. Invited seminar at Karlsruhe Institute of Technology. May 2017.. Garmisch-Partenkirchen, Germany. Status = OTHER; Acknowledgement of Federal Support = Yes

Groffman, P.M. (2017). *Shooting at a moving target: Evaluating ecosystem response to extreme events in a changing world*.. Invited seminar at Hebrew University of Jerusalem, Department of Ecology and Behavior. October 2017.. Jerusalem, Israel. Status = OTHER; Acknowledgement of Federal Support = Yes

Groffman, P.M. (2017). *Shooting at a moving target: Evaluating ecosystem response to extreme events in a changing world*.. Invited seminar at University of Virginia, Department of Environmental Sciences.. Charlottesville, VA. Status = OTHER; Acknowledgement of Federal Support = Yes

Groffman, P.M. (2017). *Shooting at a moving target: Evaluating ecosystem response to extreme events in a changing world. Invited talk*.. Ben Gurion University Blaustein Institute for Desert Research Seminar. October 2017.. S'de Boker, Israel. Status = OTHER; Acknowledgement of Federal Support = Yes

Groffman, P.M. (2017). *Shooting at a moving target: Evaluating ecosystem response to extreme events in a changing world. January. Invited talk*.. Chapman Conference on Extreme Climate Events. San Juan, Puerto Rico. Status = OTHER; Acknowledgement of Federal Support = Yes

Groffman, P.M. (2017). *Snow is good, worms are bad*.. New York University lecture.. New York, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Groffman, P.M. (2017). *Snow is good, worms are bad*.. Invited lecture at Mount Holyoke College.. South Hadley, MA. 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
- Johnson, C.E. (2017). *Soil carbon responses to acid rain and climate change at Hubbard Brook: 1977-2013*.. Presented at the Northeastern Ecosystem Research Cooperative Meeting, 29 March 2017.. Saratoga Springs, NY. Status = OTHER; Acknowledgement of Federal Support = Yes
- Yanai, R.D. (2017). *Soil nitrogen availability affects belowground carbon allocation and soil respiration in hardwood forests of New Hampshire, USA*.. International Congress of Ecology, August 23, 2017.. Beijing, China.. Status = OTHER; Acknowledgement of Federal Support = Yes
- Ollinger, S.V., Ouimette A.P., Sullivan, F., Sanders-Demott, M. Palace, X. Xiao, B. Braswell, L. Lepine. (2017). *Spatial and temporal variability in carbon cycling in a northeastern U.S. forest in relation to leaf traits, canopy diversity and climate variability*.. American Geophysical Union Fall Meeting.. New Orleans, LA. Status = ACCEPTED; Acknowledgement of Federal Support = Yes
- Young, A.R., R.D. Yanai, R. Minocha, and S. Long. (2017). *Specific leaf area and amino acids respond to nutrient amendments and canopy depth*.. November 11, 2017, Rochester Academy of Sciences Fall Scientific Paper Session.. St. John Fisher College.. Status = OTHER; Acknowledgement of Federal Support = Yes
- Jensen, C.K., McGuire, K.J. (2017). *Stream intermittency sensors monitor the onset and duration of stream flow along a channel network during storms, EP52A-05*.. 2017 Fall Meeting, AGU, 11-15 Dec.. New Orleans, LA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Oda, T., Green, M.B., Urakawa, R., Scanlon, T.M., Sebestyen, S., McGuire, K.J., Katsuyama, M., Fukuzawa, K., Adams, M.B., Ohte, N. (2017). *Stream runoff and nitrate recovery times after forest disturbance in US and Japan, H41C-1456*.. 2017 Fall Meeting, AGU, 11-15 Dec.. New Orleans, LA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Groffman, P.M. (2017). *Synergies between LTER and NEON*. National Center for Ecological Analysis and Synthesis Workshop. March 2017.. Santa Barbara, CA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Groffman, P.M. (2017). *Synergies from LTER and USFS research at Hubbard Brook*.. Invited presentation at USDA Forest Service Northern Forest National Leadership Team visit to Hubbard Brook Experimental Forest. Thornton, NH. Status = OTHER; Acknowledgement of Federal Support = Yes
- Groffman, P.M. (2017). *Terrestrial denitrification: A tale of misery, woe and the frontiers of environmental science*.. Invited seminar, University of Illinois. February.. Champaign, IL. Status = OTHER; Acknowledgement of Federal Support = Yes
- Johnson, C.E., W. Clymans and D. Conley. (2017). *The biological Si filter in temperate hardwood forest ecosystems*." Poster presented. National Science Foundation Workshop: Critical Zone Science: Current Advances & Future Opportunities, 5-6 June 2017.. Arlington VA. Status = OTHER; Acknowledgement of Federal Support = Yes
- Hallworth, M. (2017). *The cost of reproduction in a greening world*.. Hubbard Brook Ecosystem Study 54th Annual Cooperators Meeting.. Thornton, NH.. Status = OTHER; Acknowledgement of Federal Support = Yes
- Nijzink, R., Hutton, C., Pechlivanidis, I., Capell, R., Arheimer, B., Freer, J., Han, D., Wagener, T., McGuire, K., Savenije, H., Hrachowitz, M. (2017). *The evolution of root zone moisture storage capacities after deforestation: a step towards hydrological predictions under change*.. Geophysical Research Abstracts, 19, EGU2017-12848-1. ^[1]_{SEP}. Vienna, Austria. Status = PUBLISHED; Acknowledgement of Federal Support = Yes
- Nijzink, R., Hutton, C., Pechlivanidis, I., Capell, R., Arheimer, B., Freer, J., Han, D., Wagener, T., McGuire, K., Savenije, H., Hrachowitz, M. (2017). *The evolution of root zone moisture storage capacities after deforestation: a step towards hydrological predictions under change*.. International Association of Hydrological Sciences 2017 Scientific Assembly, 10-4 July.. Port Elizabeth, South Africa.. Status = OTHER; Acknowledgement of Federal Support = Yes
- Yanai, R.D., K.E. Gonzales, S. Goswami, M.C. Fisk and T.J. Fahey. (2017). *The first long-term N x P fertilization experiment in a temperate forest system*.. ESA Annual Meeting. August 7, 2017.. Portland, OR. Status = OTHER; Acknowledgement of Federal Support = Yes
- Groffman, P.M. (2017). *The nature of ecological change. March 2017*.. NSF symposium on "Drought, fire, rising seas: discovering the nature of ecosystem change. Washington, DC. Status = OTHER; Acknowledgement of Federal Support = Yes
- Groffman, P.M. (2017). *The role of ecosystem science in integrating ideas about ecological integrity, critical zone dynamics and socio-ecological*

interactions. Invited plenary talk. October 2017.. Workshop on "Toward a unified framework for life supporting systems in the Anthropocene.". Tzuba, Israel. Status = OTHER; Acknowledgement of Federal Support = Yes

Morley, M., C. Sosa, R.D. Yanai. (2017). *Time for tea: Nutrient affect on tea decomposition after three-month incubation in northern hardwood forest soils..* Rochester Academy of Sciences Fall Scientific Paper Session. November 11, 2017.. St. John Fisher College.. Status = OTHER; Acknowledgement of Federal Support = Yes

Jensen, C.K., McGuire, K.J. (2017). *Using logistic regression to model variable stream networks in Appalachian headwaters..* Gordon Research Seminar, June 24.. Lewiston, ME. Status = OTHER; Acknowledgement of Federal Support = Yes

Madison C., Ollinger S.V., Ouimette A.P., Lepine L.C., Zhou Z., Ducey M. (2017). *Variation in canopy leaf traits for improved application of remote sensing and modeling..* 2017 Conference of the Northeastern Ecosystem Research Cooperative.. Saratoga Springs, NY. Status = OTHER; Acknowledgement of Federal Support = Yes

Johnson, C.E. (2017). *Woody Debris on Watershed 6, 1978-2016..* Annual Hubbard Brook Cooperators Meeting, 13 July 2017.. West Thornton, NH. Status = OTHER; Acknowledgement of Federal Support = Yes

Other Products

Educational aids or Curricula.

Available at hubbardbrook.org: (<https://hubbardbrook.org/online-book>)

Hubbard Brook Research Synthesis and Online Book – A dynamic web resource synthesizing more than 60 years of research at the Hubbard Brook Experimental Forest. This content is presented at the level of a graduate or advanced undergraduate student audience. The primary objective, is to introduce students and other prospective researchers to the current state of knowledge about the Hubbard Brook ecosystem. The chapters have been developed by scientific experts on each of the topics studied within the Hubbard Brook research community, and they will be updated and expanded as new knowledge and data are generated. Links to the broader literature, outstanding research questions, and to HBR data sets are provided to facilitate more detailed explorations. A cross-discipline chapter includes exercises instructing students in the calculation of watershed-scale fluxes of water and chemical elements using the data sets available in the HBR data catalog.

Mobile app.

<https://itunes.apple.com/us/app/hubbard-brook-exp-forest/id1308630638?mt=8>

<https://play.google.com/store/apps/details?id=com.toursphere.hubbardbrook>

Developed and launched a virtual tour that enables users to experience the Hubbard Brook Experimental Forest remotely or to enhance the visit through digital content that interprets the Hubbard Brook Ecosystem Study. Available for free download.

Other Publications

Thorne, S. (2017). *Learning Lichens. The Science Teacher 884): 45-49.* Published science lesson from our RET.. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Patents

Technologies or Techniques

WaterViz at Hubbard Brook

<https://waterviz.org/>

An innovative water cycle visualization and sonification tool has been developed for Hubbard Brook. To support this collaborative between hydrological scientists, artists, musicians, and computer scientists, the HBR-IM has developed a real-time data workflow that combines data from multiple dataloggers, calculates variables on-the-fly (e.g. evapotranspiration), and stages an hourly custom datafile for access by this interdisciplinary team.

This is the second 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).

Thesis/Dissertations

Montague, Madeline.. *Beech Bark Disease at the Hubbard Brook Experimental Forest, NH..* (2017). Cornell University, Ithaca, NY..
Acknowledgement of Federal Support = Yes

Box, Olivia.. *Beech bark disease fungi: detecting relative prevalence of *Neonectria ditissima* and *N. faginata* in beech stands in New Hampshire and New York..* (2017). Hamilton College, Clinton, NY. Acknowledgement of Federal Support = Yes

Tiller JR.. *Effects of winter climate of fates of litter-derived carbon. MS thesis..* (2017). Miami University. Acknowledgement of Federal Support = Yes

Jennifer Harris.. *Forty years of change in the beetle community of the Hubbard Brook Experimental Forest. Undergraduate Honors Thesis..* (2017). Wellesley College. Acknowledgement of Federal Support = Yes

Goswami S.. *Investigating nutrient limitation in northern hardwood forests. PhD Dissertation..* (2017). Miami University. Acknowledgement of Federal Support = Yes

Ouimette, A.P.. *Patterns and Drivers of Carbon Fluxes in Temperate Forests. PhD Dissertation..* (2017). University of New Hampshire, Durham, NH.. Acknowledgement of Federal Support = Yes

Sarah Russell.. *Stable isotope analysis of the foliar food web at multiple elevations in northern hardwoods forest. Undergraduate Senior Thesis..* (2017). Wellesley College. Acknowledgement of Federal Support = Yes

Clyne, Ailís.. *Terrestrial Gastropod Gastronomy in Relation to Epiphytic Lichen Biodiversity and Abundance at Hubbard Brook Experimental Forest, Grafton County, New Hampshire..* (2017). Cornell University, Ithaca, NY. Acknowledgement of Federal Support = Yes

Berton, Rouzbeh, 2017.. *The Interacting Hydrologic Responses to Changing Climate, Watershed Physical Characteristics, River Regulation, and Land Development in the Northeastern United States, Ph.D.Thesis..* (2017). Syracuse University. Acknowledgement of Federal Support = Yes

Madison, C.. *The photosynthesis-foliar nitrogen relationship in deciduous and evergreen forests of New Hampshire. MS Thesis, In revision..* (2018). University of New Hampshire.. Acknowledgement of Federal Support = Yes

Websites

Climate Change in Hubbard Brook Forest
<https://nationalzoo.si.edu/migratory-birds/climate-change-hubbard-brook-forest>

A description of our research on the effects of climate change on Black-throated Blue Warblers

Geolocator_Geolight
https://github.com/SCBI-MigBirds/scbi-migbirds.github.io/blob/master/Geolocator_GeoLight.Rmd

Light-Level geolocator analysis using the GeoLight package

Hubbard Brook Online Photo Gallery
<http://data.hubbardbrook.org/photos/>

The online photo gallery uses Piwigo (<http://piwigo.org>) on the webserver. This full-featured, open source photo management software allows for photo upload, tagging, search, and for user accounts with varying permission levels.

Hubbard Brook – Climate Change Across Seasons Experiment
<http://hbrsensor.sr.unh.edu/data/soilwarm/>

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

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

Modeling abundance and occupancy using point count data

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

This project is considered a part of the Hubbard Brook LTER; It includes stands at Jeffers Brook and Bartlett in addition to two stands at Hubbard Brook.

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

This web site was established before QUEST was funded as a Research Coordination Network; the uncertainty effort was proposed in the LTER. Hubbard Brook data are featured in many QUEST projects.

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Lovett, Gary	PD/PI	2
Bailey, Scott	Co-Investigator	2
Battles, John	Co-Investigator	2
Blum, Joel	Co-Investigator	3
Christensen, Lynn	Co-Investigator	1
Driscoll, Charles	Co-Investigator	2
Fahey, Timothy	Co-Investigator	2
Fisk, Melany	Co-Investigator	2
Goodale, Christine	Co-Investigator	1
Green, Mark	Co-Investigator	1
Groffman, Peter	Co-Investigator	1
Johnson, Chris	Co-Investigator	2

Lavallee, Anthea	Co-Investigator	1
Likens, Gene	Co-Investigator	1
McGuire, Kevin	Co-Investigator	2
Ollinger, Scott	Co-Investigator	1
Pardo, Linda	Co-Investigator	2
Richardson, Andrew	Co-Investigator	1
Templer, Pamela	Co-Investigator	1
Yanai, Ruth	Co-Investigator	4
Corzilius, Pauline	K-12 Teacher	1
Wilson, Jackie	K-12 Teacher	1
Burakowski, Elizabeth	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Fakhraei, Habibollah	Postdoctoral (scholar, fellow or other postdoctoral position)	2
Hallworth, Michael	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Peralta-Tapia, Andres	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Thorne, Alexandra	Postdoctoral (scholar, fellow or other postdoctoral position)	1
Cleavitt, Natalie	Other Professional	10
Garlick, Sarah	Other Professional	3
Martin, Mary	Other Professional	11
McCartney, Brenda	Other Professional	1
Wilson, Geoff	Other Professional	10
Becker, Jennifer	Technician	1
Charash, Leah	Technician	2
Clerx, Laura	Technician	6
DePietro, Deanna	Technician	1
Filiberti, Emily	Technician	2
Harper, Caroline	Technician	2
Hulsey, Aaron	Technician	4
Koppers, Mary	Technician	6
LoRusso, Nicholas	Technician	12
Martel, Lisa	Technician	3
Montesdeoca, Mario	Technician	6
Van Tatenhove, Aimee	Technician	2
Vollmer, Hannah	Technician	1
Wooster, Tammy	Technician	1
Gleason, Jamie	Staff Scientist (doctoral level)	3

Ouimette, Andrew	Staff Scientist (doctoral level)	2
Zhou, Zaixing	Staff Scientist (doctoral level)	2
Berton, Rouzbeh	Graduate Student (research assistant)	6
Goswami, Shinjini	Graduate Student (research assistant)	3
Gu, Weiyao	Graduate Student (research assistant)	1
Lee, David	Graduate Student (research assistant)	10
Madison, Conor	Graduate Student (research assistant)	2
Ojo, Paul	Graduate Student (research assistant)	3
Shan, Shan	Graduate Student (research assistant)	6
Struder, Elizabeth	Graduate Student (research assistant)	2
Tiller, Jenna	Graduate Student (research assistant)	1
Valipour, Mahnaz	Graduate Student (research assistant)	6
Burns, Simone	Undergraduate Student	2
Diaz De Villegas, Sofia	Undergraduate Student	1
Ferguson, Camila	Undergraduate Student	0
Grahman, Patricia	Undergraduate Student	1
Harris, Jennifer	Undergraduate Student	1
Hastings, John	Undergraduate Student	1
Heinrich, Sam	Undergraduate Student	2
Hess, Benjamin	Undergraduate Student	1
Jimenez, Luz	Undergraduate Student	2
Kernen, Hannah	Undergraduate Student	1
Kovari, Stephen	Undergraduate Student	4
Marroquin, Erica	Undergraduate Student	2
McDonald, Kyle	Undergraduate Student	1
O'Wesny, Syd	Undergraduate Student	2
Schaffer, Jacob	Undergraduate Student	3
Silva, Anya	Undergraduate Student	1
Smith, Grace	Undergraduate Student	2
Turner, Jessica	Undergraduate Student	2
Liu, Kristina	High School Student	1
Dickinson, Todd	Research Experience for Undergraduates (REU) Participant	3
Klein, Zoe	Research Experience for Undergraduates (REU) Participant	3
Leimanis, Vizma	Other	0
Lepine, Lucie	Other	2

Ralph, Zachariah	Other	1
Rubenstein, Maribeth	Other	1
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: PI</p> <p>Funding Support: LTER and other sources</p> <p>International Collaboration: No International Travel: No</p>
<p>Scott W Bailey Email: swbailey@fs.fed.us Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Lead researcher and field coordinator on the hydropedology study. Responsible for soil and geochemical characterization in the reference watershed – WS3. Expanding hydropedological 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.</p> <p>Funding Support: This grant and US Forest Service</p> <p>International Collaboration: No International Travel: No</p>
<p>John J Battles Email: jbbattles@berkeley.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2</p> <p>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 for the Hubbard Brook Ecosystem Study.</p> <p>Funding Support: This award</p> <p>International Collaboration: No International Travel: No</p>
<p>Joel D Blum Email: jdblum@umich.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Analyses of vegetation and stream water, data interpretation and publication.</p> <p>Funding Support: Faculty position at University of Michigan</p> <p>International Collaboration: No International Travel: No</p>

<p>Lynn Christensen Email: lchristensen@vassar.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Biodiversity project coordination and supervision - documenting occurrence of wildlife species</p> <p>Funding Support: Other sources</p> <p>International Collaboration: No International Travel: No</p>
<p>Charles T. Driscoll Email: ctdrisc@sy.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Designs and coordinates project, conducts data analysis and works with students and technicians.</p> <p>Funding Support: This grant</p> <p>International Collaboration: Yes, China International Travel: No</p>
<p>Timothy J Fahey Email: tjf5@cornell.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Co-lead scientist for long-term monitoring of primary productivity, forest composition, and tree demography.</p> <p>Funding Support: This award</p> <p>International Collaboration: No International Travel: No</p>
<p>Melany Fisk Email: fiskmc@miamioh.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Studies of interaction among N, P, and C; nutrient limitation of plant productivity and soil processes.</p> <p>Funding Support: This grant.</p> <p>International Collaboration: No International Travel: No</p>
<p>Christine Goodale Email: clg33@cornell.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Direct measurements of soil and water stable isotopes and lead data analysis and interpretation</p> <p>Funding Support: NSF-1257808</p> <p>International Collaboration: No International Travel: No</p>
<p>Mark Green Email: mbgreen@plymouth.edu</p>

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Hydrologic research

Funding Support: US Forest Service and Plymouth State University

International Collaboration: Yes, Japan

International Travel: No

Peter Mark Groffman

Email: groffmanp@caryinstitute.org

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Leads long-term monitoring of soil microbial biomass and activity, winter climate change and nitrogen gas flux research.

Funding Support: NSF Hubbard Brook LTER

International Collaboration: No

International Travel: No

Chris E. Johnson

Email: cejohns@syr.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 2

Contribution to the Project: Research on soil biogeochemistry; supervision of students and technician.

Funding Support: This grant

International Collaboration: Yes, China

International Travel: Yes, China - 0 years, 0 months, 13 days; Australia - 0 years, 0 months, 15 days

Anthea Lavallee

Email: alavallee@hbresearchfoundation.org

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Executive director of the Hubbard Brook Research Foundation (HBRF) - oversight and administration related to the Hubbard Brook Research Foundation's participation in LTER activities.

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

International Collaboration: No

International Travel: No

Gene Likens

Email: likensg@ecostudies

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Ecosystem and biogeochemical research on forest, stream, and lake ecosystems of the Hubbard Brook Valley.

Funding Support: Other sources

International Collaboration: No

International Travel: No

Kevin J McGuire

Email: kevin.mcguire@vt.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 2

Contribution to the Project: 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 developing passive chemical and flow sensors for streams and groundwater.

Funding Support: This 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, ecosystem modeling and regionalization.

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: 2

Contribution to the Project: Conducts research on nitrogen and carbon cycling across the Geo-spatial template and co-ordinates long-term monitoring of foliar chemistry.

Funding Support: This grant and USFS

International Collaboration: No

International Travel: No

Andrew D Richardson

Email: arichardson@oeb.harvard.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Managed CO2 flux measurements at Bartlett Experimental Forest; supervised undergraduates and postdocs conducting empirical and model-data fusion analyses of Bartlett Data.

Funding Support: Funded through Harvard faculty position

International Collaboration: No

International Travel: No

Pamela Templer

Email: ptempler@bu.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

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

Funding Support: This grant and a NSF CAREER grant.

International Collaboration: No

International Travel: No

<p>Ruth D Yanai Email: rdyanai@syr.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 4</p> <p>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. 2017 was the seventh year of treatment of N, P, and Ca in stands of different ages at Hubbard Brook, Jeffers Brook, and Bartlett Experimental Forests. Uncertainty analysis was another theme of the HBR LTER. This effort 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.</p> <p>Funding Support: State University of New York</p> <p>International Collaboration: No International Travel: No</p>
<p>Pauline Corzilius Email: paulinecorzilius@gmail.com Most Senior Project Role: K-12 Teacher Nearest Person Month Worked: 1</p> <p>Contribution to the Project: High school math/science lesson plan development based on Hubbard Brook research</p> <p>Funding Support: This award and Forest Service Joint Venture Agreement 15-JV-11242307-064</p> <p>International Collaboration: No International Travel: No</p>
<p>Jackie Wilson Email: jackie03262@gmail.com Most Senior Project Role: K-12 Teacher Nearest Person Month Worked: 1</p> <p>Contribution to the Project: K-12 teacher, math/science lesson plan consultant for the Hubbard Brook Research Foundation.</p> <p>Funding Support: This grant and Forest Service Joint Venture Agreement 15-JV-11242307-064</p> <p>International Collaboration: No International Travel: No</p>
<p>Elizabeth Burakowski Email: elizabeth.burakowski@gmail.com Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position) Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Remote sensing, albedo, ecosystem-climate interactions</p> <p>Funding Support: Other (UNH Institutional support, NCAR Fellowship)</p> <p>International Collaboration: No International Travel: No</p>
<p>Habibollah Fakhraei Email: hfakhrae@syr.edu Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position) Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Conduct model simulations and field research on experimental ice storm.</p> <p>Funding Support: Another research grant</p> <p>International Collaboration: No International Travel: No</p>

<p>Michael Hallworth Email: mhallwor@masonlive.gmu.edu Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position) Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Spatial and temporal components of community dynamics identify assembly rules, Smithsonian Institution, Washington, D.C.</p> <p>Funding Support: This grant and Wellesley College</p> <p>International Collaboration: No International Travel: No</p>
<p>Andres Peralta-Tapia Email: anpeta@vt.edu Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position) Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Examining nitrate patterns in groundwater</p> <p>Funding Support: Umea University</p> <p>International Collaboration: Yes, Sweden International Travel: No</p>
<p>Alexandra Thorne Email: mail@alexandrathorn.com Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position) Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Modeling and development of future land cover scenarios for New Hampshire.</p> <p>Funding Support: LTER and other.</p> <p>International Collaboration: No International Travel: No</p>
<p>Natalie L Cleavitt Email: nlc4@cornell.edu Most Senior Project Role: Other Professional Nearest Person Month Worked: 10</p> <p>Contribution to the Project: Dr. Cleavitt oversees the tree survey crew and runs several other long-term plant ecology projects. She conducts the collection of fine litter, coarse woody debris and leaves for foliar chemistry. This season she mentored one REU student and three senior thesis projects related to student work at HB. She curates the long-term vegetation data sets. She takes full part in data analysis and paper writing. She also conducted outreach activities with NH public schools for “Seeking the Wolf Tree”, the schoolyard book for Hubbard Brook.</p> <p>Funding Support: This award and Cornell University</p> <p>International Collaboration: No International Travel: No</p>
<p>Sarah Garlick Email: sarahgarlick@gmail.com Most Senior Project Role: Other Professional Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Director of Science Policy and Outreach for the Hubbard Brook Research Foundation and directs the site's Forest Science Dialogs project.</p> <p>Funding Support: This award, Forest Service Joint Venture Agreement 15-JV-11242307-064, NSF AISL Award for Public Engagement with Science</p> <p>International Collaboration: No</p>

International Travel: No
Mary Martin Email: mary.martin@unh.edu Most Senior Project Role: Other Professional Nearest Person Month Worked: 11 Contribution to the Project: Information management Funding Support: this grant, US Forest Service, NSF EAGER grant #1548175 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 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
Geoff Wilson Email: gwilson@hbresearchfoundation.org Most Senior Project Role: Other Professional Nearest Person Month Worked: 10 Contribution to the Project: Assists with facility management and coordination of REU living arrangements and undergraduate community activities. Funding Support: This grant International Collaboration: No International Travel: No
Jennifer Becker Email: beckerj@caryinstitute.org Most Senior Project Role: Technician Nearest Person Month Worked: 1 Contribution to the Project: Field, laboratory, and data analysis. Funding Support: NSF Hubbard Brook LTER International Collaboration: No International Travel: No
Leah R. Charash Email: lrc219@lehigh.edu Most Senior Project Role: Technician Nearest Person Month Worked: 2 Contribution to the Project: Data analysis of streamwater chemistry and nitrogen dynamics. Funding Support: This grant. International Collaboration: No International Travel: No

Laura Clerx

Email: lclerx@bu.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 6

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

Funding Support: Laura received funds from this NSF LTER grant, along with funds from a NSF CAREER grant to Pamela Templer.

International Collaboration: No

International Travel: No

Deanna DePietro

Email: dipietrod@caryinstitute.org

Most Senior Project Role: Technician

Nearest Person Month Worked: 1

Contribution to the Project: Laboratory, and data analysis.

Funding Support: NSF Hubbard Brook LTER

International Collaboration: No

International Travel: No

Emily Filiberti

Email: efiliberti@une.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Conducted point-counts of birds valley-wide; assisted with arthropod surveys.

Funding Support: This award and Wellesley College

International Collaboration: No

International Travel: No

Caroline Harper

Email: charper@wellesley.edu

Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Conducted point-counts of birds valley-wide; assisted with arthropod surveys

Funding Support: this grant and Wellesley College

International Collaboration: No

International Travel: No

Aaron Hulsey

Email: thomas.hulsey487@gmail.com

Most Senior Project Role: Technician

Nearest Person Month Worked: 4

Contribution to the Project: Crew co-leader; assisted plot teams with data collection; organized data entry and proofing.

Funding Support: This award and Wellesley College

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: Research on soil biogeochemistry.

Funding Support: This 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: Sampling and analysis of soil solution and stream samples.

Funding Support: This grant

International Collaboration: No

International Travel: No

Lisa Martel

Email: martelL@caryinstitute.org

Most Senior Project Role: Technician

Nearest Person Month Worked: 3

Contribution to the Project: Field, laboratory and data analysis

Funding Support: NSF Hubbard Brook LTER

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: Supervised laboratory activities at Syracuse University

Funding Support: Syracuse University

International Collaboration: No

International Travel: No

Aimee Van Tatenhove

Email: aimee.van.tatenhove@gmail.com

Most Senior Project Role: Technician

Nearest Person Month Worked: 2

Contribution to the Project: Conducted point-counts of birds valley-wide; assisted with arthropod surveys.

Funding Support: this award and Wellesley 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: Conducts guided tours of HBES, developed the Hubbard Brook mobile tour app, oversight of REU community

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

International Collaboration: No

International Travel: No

Tammy Wooster

Email: woostert@caryinstitute.org

Most Senior Project Role: Technician

Nearest Person Month Worked: 1

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

Funding Support: NSF Hubbard Brook LTER

International Collaboration: No

International Travel: No

Jamie D. Gleason

Email: jdgleaso@umich.edu

Most Senior Project Role: Staff Scientist (doctoral level)

Nearest Person Month Worked: 3

Contribution to the Project: Laboratory analysis of isotope ratios and trace elements

Funding Support: LTER and Univ of Michigan Research Faculty.

International Collaboration: No

International Travel: No

Andrew Ouimette

Email: andres.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

International Collaboration: No

International Travel: No

Rouzbeh Berton

Email: rouzbeh_berton@yahoo.com

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 6

<p>Contribution to the Project: Hydrologic analysis of the Merrimack River.</p> <p>Funding Support: This grant</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Shinjini Goswami Email: goswams@miamioh.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Shinjini Goswami is a PhD student at Miami University studying nitrogen and phosphorus limitation in forests</p> <p>Funding Support: This grant and Miami University</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Weiyao Gu Email: wgu100@syr.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Research on soil biogeochemistry</p> <p>Funding Support: This grant</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>David P Lee Email: dplee@vt.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 10</p> <p>Contribution to the Project: Master’s student who is developing passive flux meters for characterizing chemical and water fluxes in streams and groundwater.</p> <p>Funding Support: Virginia Polytechnic Institute and State University and this grant.</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Conor Madison Email: conormadison9@gmail.com Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Forest productivity and leaf physiology</p> <p>Funding Support: This grant and other</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Paul Ojo Email: paulo@miamioh.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Nutrient controls of decomposition</p>

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: Shan Shan is a PhD student at Miami University studying resource allocation belowground - interactions of nutrient limitation and rhizosphere microbial processes

Funding Support: This grant and Miami University

International Collaboration: No

International Travel: No

Elizabeth Struder

Email: lizzy.struder@gmail.com

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 2

Contribution to the Project: Dissertation research focuses on above and belowground biodiversity - understanding drivers of green and brown food web arthropod assemblages in a changing world.

Funding Support: This award and Wellesley College.

International Collaboration: No

International Travel: No

Jenna Tiller

Email: tillerjr@miamioh.edu

Most Senior Project Role: Graduate Student (research assistant)

Nearest Person Month Worked: 1

Contribution to the Project: Winter climate effects on N movement through soil profile.

Funding Support: Miami University of Ohio and this grant

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: Model simulations of soil and water response to clear-cutting disturbance.

Funding Support: This grant

International Collaboration: No

International Travel: No

Simone Burns

Email: srburns@syr.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 2

Contribution to the Project: Research effects of ice storm on the forest carbon cycle.

<p>Funding Support: This grant</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Sofia Diaz De Villegas Email: sdiazdev@wellesley.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Assisted with processing insect samples from earlier years and field collection of seed samples</p> <p>Funding Support: Wellesley College</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Camila Ferguson Email: cofergus@syr.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 0</p> <p>Contribution to the Project: Supervising high school students and undergraduates in the lab, who are sorting leaf litter and picking roots from the MELNHE stands.</p> <p>Funding Support: No other support.</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Patricia Grahman Email: pgrahman@wellesley.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Assisted with data entry management and verification and sorting seed samples</p> <p>Funding Support: Wellesley College</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Jennifer Harris Email: jharri11@wellesley.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Assisted with entry of beetle community data from the 1970's and collected and sorted window trap samples to monitor the current beetle community of the forest floor.</p> <p>Funding Support: Wellesley College</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>John Hastings Email: jhc33@wildcats.unh.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Leaf chemistry field work, soil N data analysis</p> <p>Funding Support: Other (UNH student research support)</p>

International Collaboration: No
International Travel: No

Sam Heinrich

Email: skh83@cornell.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 2

Contribution to the Project: Conducted point-counts of birds valley-wide; assisted with arthropod surveys

Funding Support: Wellesley College

International Collaboration: No

International Travel: No

Benjamin J. Hess

Email: bjhess@syr.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 1

Contribution to the Project: Research on forest ecology.

Funding Support: This grant

International Collaboration: No

International Travel: No

Luz Jimenez

Email: lmj67@cornell.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 2

Contribution to the Project: Worked as a field assistant on 5-year resurvey of reference watershed 6 and northern hardwood demography plot. Helped with data entry and bar coding of samples in the archives.

Funding Support: This award.

International Collaboration: No

International Travel: No

Hannah Kernen

Email: hkernen@wellesley.edu

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 1

Contribution to the Project: Assisted with processing insect samples from earlier years and sorting seed samples

Funding Support: Wellesley College

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: Assisted with motion activated camera documentation of wildlife occurrences at HB. Attended 2-week workshop on camera trapping protocols, help put up and check cameras, as well as data processing and management, study designs, and data analysis.

Funding Support: Other sources.

<p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Erica Marroquin Email: em628@cornell.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Worked as a field assistant on 5-year resurvey of reference watershed 6. Helped with data entry and bar coding of samples in the archives.</p> <p>Funding Support: This grant.</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Kyle McDonald Email: km2014@wildcats.unh.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Leaf chemistry field work, analysis of terrain effects</p> <p>Funding Support: Other sources</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Syd O'Wesny Email: owesnesr@miamioh.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Seedling allocation and architecture</p> <p>Funding Support: This grant and Miami University</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Jacob Schaffer Email: jbs384@cornell.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Worked as field assistant on 5-year resurvey of reference watershed 6 and northern hardwood demography plot. Stayed longest of the crew and helped with end of season tasks and maintenance of long-term litter collectors. Completed USFS chainsaw safety training.</p> <p>Funding Support: This award</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Anya Silva Email: asilva@wellesley.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Assisted with processing insect samples from earlier years and sorting seed samples</p> <p>Funding Support: Wellesley College</p> <p>International Collaboration: No</p>

<p>International Travel: No</p>
<p>Grace Smith Email: gas262@cornell.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Worked as a field assistant on 5-year resurvey of reference watershed 6 and northern hardwood demography plot.</p> <p>Funding Support: This grant.</p> <p>International Collaboration: No International Travel: No</p>
<p>Jessica Turner Email: jturner9@buffalo.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Research effects of ice storm on the forest carbon cycle.</p> <p>Funding Support: This grant</p> <p>International Collaboration: No International Travel: No</p>
<p>Kristina Liu Email: kristyliu.2000@gmail.com Most Senior Project Role: High School Student Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Research on forest ecology.</p> <p>Funding Support: This grant</p> <p>International Collaboration: No International Travel: No</p>
<p>Todd Dickinson Email: tdickinson@plymouth.edu Most Senior Project Role: Research Experience for Undergraduates (REU) Participant Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Developed a protocol for use of salt dilution to quantify stream discharge rates at Hubbard Brook.</p> <p>Funding Support: This award</p> <p>International Collaboration: No International Travel: No Year of schooling completed: Other Home Institution: Plymouth State University Government fiscal year(s) was this REU participant supported: 2017</p>
<p>Zoe Klein Email: zoeklein@berkeley.edu Most Senior Project Role: Research Experience for Undergraduates (REU) Participant Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Led a research project quantifying allometry of standing dead trees and oversaw 2-year tree status survey of the long-term tree demography transects with help of other crew members. Completed USFS chainsaw safety training.</p>

<p>Funding Support: LTER supplement.</p> <p>International Collaboration: No</p> <p>International Travel: No</p> <p>Year of schooling completed: Junior</p> <p>Home Institution: University of California, Berkeley</p> <p>Government fiscal year(s) was this REU participant supported: 2017</p>
<p>Vizma Leimanis Email: vizmaleimanis@gmail.com Most Senior Project Role: Other Nearest Person Month Worked: 0</p> <p>Contribution to the Project: Supervising high school students and undergraduates in the lab, who are sorting leaf litter and picking roots from the MELNHE stands.</p> <p>Funding Support: No other support.</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Lucie Lepine Email: lucie.lepine@unh.edu Most Senior Project Role: Other Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Staff scientist, MS level: Remote sensing using high spectral resolution aircraft data. Preparation of spatial data layers for modeling. Supervision of undergraduate students.</p> <p>Funding Support: This grant and other</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Zachariah Ralph Email: zralphr@hubbardbrookfoundation.org Most Senior Project Role: Other Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Event planning for the LTER Science Council Meeting at Hubbard Brook</p> <p>Funding Support: This award and Forest Service Joint Venture Agreement 15-JV-11242307-064</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Maribeth Rubenstein Email: rubenstein@caryinstitute.org Most Senior Project Role: Other Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Event planning for 2017 quarterly meetings, administrative and logistical support for the Science Council Meeting at Hubbard Brook, HB Cooperators Meeting, and Outreach as requested</p> <p>Funding Support: Cary Institute of Ecosystem Studies</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Elisa Speckert Email: especkert@hubbardbrookfoundation.org Most Senior Project Role: Other</p>

Nearest Person Month Worked: 1

Contribution to the Project: Administration and bookkeeping 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

Griffin Walsh

Email: griffin.walsh@yale.edu

Most Senior Project Role: Other

Nearest Person Month Worked: 0

Contribution to the Project: Sample processing and data management

Funding Support: No other 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:

USDA Forest Service

Organization Type: Other Organizations (foreign or domestic)

Organization Location: West Thornton, NH

Partner's Contribution to the Project:

In-Kind Support

Facilities

Collaborative Research

More Detail on Partner and Contribution: The USFS maintains the Hubbard Brook Experimental Forest and its scientists are collaborators in the project.

What other collaborators or contacts have been involved?

- Dr. Matthew Ayres, Dartmouth College

Dr. Winsor Lowe, University of Montana

Dr. T. Scott Sillett, Smithsonian Institution

Dr. Michael Webster, Cornell University

Dr. Richard Holmes, Dartmouth College

Dr. Matthew Betts, Oregon State University

Dr. Dorata Czeszczewik, Siedlce Univerity, Poland

Dr. Wieslaw Walankiewicz, Siedlce Univerity, Poland

Dr. John Battles, University of California at Berkeley

Dr. Sara Kaiser, Cornell University

Dr. Lindsey Rustad, US Forest Service

Dr. Scott Ollinger, University of New Hampshire

Dr. Zaixing Zhou, University of New Hampshire

Dr. Mary Martin, University of New Hampshire
Dr. Kevin McGuire, Virginia Polytechnic Institute
Cary Institute of Ecosystem Studies
State University of New York, College of Environmental Science and Forestry
University of Michigan
Vassar College
Boston 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 two ways: 1) we refined our realtime environmental sensor network and completed cross-checking with historic analog data sets, and 2) we expanded the capacity of our physical sample archive and began linking archive samples with data streams.

What is the impact on institutional resources that form infrastructure?

Nothing to report.

What is the impact on information resources that form infrastructure?

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

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 draft bill in the U.S. House of Representatives that seeks to limit the importation of new forest pests into the country. The bill is currently being debated and revised within the House Agriculture Committee. 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.

