Preview of Award 1637685 - Annual Project Report

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

The HBR LTER project has an active program of outreach and education activities, mostly coordinated through the Hubbard Brook Research Foundation, a non-profit group that supports research at Hubbard Brook through outreach, education and maintenance of research facilities. Long-term research should play a crucial role in addressing grand challenges in environmental stewardship at local and national scales. The HBR LTER takes this responsibility very seriously. We attempt to inform policy decisions through our Science Links program and our collaboration in the Science-Policy Exchange, a consortium of academic institutions and LTER sites dedicated to using scientific information in the policy process. We have initiated an Advisory Council that consists of regional stakeholders, and we host “Roundtable” discussions that allow stakeholders and HBR scientists to discuss issues of regional importance. The project also seeks to provide high-quality programs for the training and development of scientists and educators.

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

Major Activities:

Hydropedology

Podzolization controls on acid neutralization and streamwater chemistry. A model of acid neutralization proposed in the 1980s was evaluated across three sub-watersheds that represent an acidity spectrum to explain streamwater chemistry spatial variation. Stream networks, including intermittent streams, were synoptically sampled at approximately 100 m intervals in three sub-watersheds. Data were used to develop a new conceptual model of acid neutralization and spatial stream chemistry where functional soil groups that reflect the role of groundwater, pathway, and soil forming processes, control gradients in stream chemistry.

Changing Climate

Climate change may alter mercury (Hg) fluxes in northern hardwood forests. Soils are the largest terrestrial pool of Hg, a neurotoxic pollutant. Pathways of Hg accumulation and loss in forest soils include throughfall, litterfall, soil gas fluxes, and leaching in soil solution, all of which will likely be altered under changing climate. We took advantage of three ongoing climate-change manipulation experiments at HBR: a combined growing-season warming and winter freeze-thaw cycle experiment, a throughfall exclusion to mimic drought, and a simulated ice storm experiment to examine the response of the forest Hg cycle to climatic disturbances. Across these three experiments, we compared Hg inputs in throughfall and leaf litterfall and Hg outputs in soil gas fluxes. Soil solution was measured only in the simulated ice storm experiment.

Phenology and Ecosystem Processes. Andrew Richardson worked with PhD student Aaron Teets on modeling the impacts of shifts in phenology on ecosystem processes. We used the phenoR package to calibrate a suite of spring phenology models to spring onset dates derived from PhenoCam data for Bartlett Experimental Forest (a companion site near HBR) with field data from HBR. We quantified model performance using AIC, which compensated for model complexity based on the number of parameters.

Changing atmospheric chemistry

Using metagenomics to reveal landscape scale patterns of denitrifiers in a montane forest ecosystem. Denitrification is an important process in the nitrogen (N) cycle of many soil ecosystems, but the relationships between process rates and the genotype of denitrifying microorganisms are poorly understood. Genotyping may identify denitrifiers with less than the full complement of N-oxide reductases, which might be crucial for denitrification in N-limited environments, such as in montane forest landscapes. Therefore, a metagenomics survey was undertaken using soils from HBR where steep elevation, vegetation, and soil gradients provide a complex landscape matrix to assess occurrence patterns of the genes involved in denitrification. DNA was extracted from soils taken from three soil horizons, at three elevations, in two watersheds.

Multiple Element Nutrient Limitation project. Analysis of data from our ongoing N and phosphorus (P) fertilization study addressed interactions among N, P, and C and nutrient limitation of plant productivity and soil processes. One key response variable is leaf litterfall nutrient concentrations and their ratios, which are a common indicator of site nutrient status and a critical component of many ecosystem calculations. Concentrations of N and P in leaf litter are related to foliar concentrations, but they are reduced by nutrient resorption during senescence. Although nutrient resorption occurs gradually during the autumn in winter-deciduous species, no study to date has assessed how the timing of litter collection affects estimates of nutrient concentration. To quantify the importance of this effect we analyzed the nutrient concentrations of leaf litter collected weekly for three dominant tree species: Acer saccharum, Betula alleghaniensis, and Fagus grandifolia.

Conceptual models of nutrient retention in ecosystems suggest that mature forests receiving chronically elevated atmospheric N deposition should experience increased nitrate losses to streams. However, at HBR, recent stream nitrate concentrations have been unexpectedly low in mature watersheds. Poorly understood retention of nitrate in soil organic matter (SOM) may explain this discrepancy. The relative availability of C and N in SOM influences nitrate retention and may vary during succession due to processes of N mining and re-accumulation. To evaluate the strength of the SOM sink for nitrate, we applied a 15-nitrate tracer to the mineral soil in eight stands spanning a forest chronosequence from about 20 years to old growth (≫ 200 years). We tracked 15N recovery in SOM fractions in the upper 10 cm of B horizon over 5 weeks.

Changing biota

Modeling and mycorrhizae. Jackie Mathes continued to lead modeling and analysis of long-term vegetation dynamics at Hubbard Brook, moving toward a predictive framework for understanding future changes in the forest community, structure, and resulting ecosystem processes. HBR Brook vegetation data are being analyzed within the Predictive Ecosystem Analyzer (PEcAn) ecoinformatics system. In addition to analyzing and collecting long-term vegetation data, we completed a field project that investigated the role of mycorrhizal functional type on soil respiration.

Heterotrophs. We continued valley-wide surveys of birds and mammals. The database now includes > 250,000 observations of > 100 species distributed across 373 locations x 3 surveys per year since 1999. Two manuscripts are in final preparation; one on bird habitat choice across years, and the other on temporal relations between seed masting by trees, rodent abundance, and songbird nest predation by rodents.

Bats. We completed year 5 of a new long-term monitoring study of bats in Hubbard Brook Experimental Forest using passive ultrasonic sound recorders. As part of this study, we developed a sound library of bat calls recorded at HBEF and computer code for partially automating the extraction and identification of bat calls from sound recordings.

Aquatic organisms. In 2018, we set up sampling platforms, cameras, sensors and sticky traps to capture fine scale stream ecosystem, aquatic insect and canopy dynamics. We also developed a MODIS- based model of leaf area index and light available to streams for all HBR watersheds back to 2001. An additional effort was to begin synthesizing and collating datasets on snow pack, snow depth, river ice, lake ice, air temperature and forest phenology to anzlyze changes in for vernal and autumnal window length through time. A further effort is to synthesize all stream macroinvertebrate work at Hubbard Brook from 1965-present.

Wildlife Camera Monitoring. A total of 26 motion detecting cameras are located across the HBR site and image data from

the cameras is collected twice per year. CPW photo warehouse is used for image organization and determination of detection and activity periods (software produced by Colorado Parks and Wildlife). Analysis of camera data (PRESENCE 2.12.8 - Occupancy Model by USGS) is used to predict the probability of a species being present given the imperfect detection of wildlife species with motion detecting cameras using a suite of variables. Cameras have been collecting image data continuously for 24 months (January 2018-January 2020).

Stream Salamanders. We continued long-term monitoring of stream salamander populations in three first-order streams. In addition to our standard capture-mark-recapture surveys of these streams, we sampled baseline and stress-induced corticosterone (CORT; the primary stress hormone in amphibians) levels from salamanders in reaches with and without fish. We also started a fine-scale movement study in four reaches using PIT tag telemetry.

Specific Objectives:

Significant Results:

Hydropedology

The analysis of podzolization controls on acid neutralization and streamwater chemistry showed that streams differed in their longitudinal gradients of acidity, dissolved organic carbon, aluminum and iron, and other cations. A new conceptual model of acid neutralization and spatial stream chemistry was proposed where functional soil groups that reflect the role of groundwater and soil forming processes control gradients in stream chemistry. Acidic stream reaches were largely composed of soil in shallow to bedrock areas where lateral flow introduces organic acids to soil that subsequently leaches acid-mobile metals to streams. Downstream reaches were influenced by complexation and precipitation of organometallic compounds resulting in more circumneutral drainage water that contributes to streamflow.

Climate change

In the work on phenology and ecosystem processes, three models were selected and then validated against the long-term HBR data (Figure 1). The models generally captured the interannual variation in phenology, with negligible bias. We then incorporated the phenology models into the ecosystem model PnET and ran the model for 25 y at Bartlett. We found that the “original” phenology model in PnET was biased early by 20-40 days relative to the new models. This bias in spring phenology led to an over-estimate by about 50 g C m-2 y-1 in annual net C uptake by the forest. The next step is to investigate phenological impacts on ecosystem processes related to H2O and N, and to run PnET with the new phenological models using future climate scenarios.

Analysis of Hg dynamics in three climate change experiments at HBR (Yang et al. 2019) found that northern forest soils retained 16–60% less Hg in the three climate manipulations compared to the undisturbed controls, although all soils still served as a net sink for Hg. Growing-season soil warming and combined soil warming and winter freeze-thaw cycles had little effect on litterfall and throughfall flux, but they increased soil Hg0 evasion by 31 and 35%, respectively. The drought plots had 5% lower litterfall Hg flux, 50% lower throughfall Hg flux, and 21% lower soil Hg0 evasion. The simulated ice storm had 23% higher litterfall Hg flux, 1% higher throughfall Hg flux, 37% higher soil Hg0 evasion, and 151% higher soil Hg leaching. These observations suggest that climate changes such as warmer soils in the growing season or more intense ice storms in winter are likely to exacerbate Hg pollution by releasing Hg sequestered in forest soils via evasion and leaching.

Changing atmospheric chemistry

Results of the work using metagenomics to reveal landscape scale patterns of denitrifiers (Roco et al. 2019) showed that the relative abundance of denitrification genes within a community did not differ across soil depths but did vary among elevation zones, with total denitrification reads in High Hardwood > Spruce Fir > Low Hardwood (Figure 2). Reads from nirS were extremely rare, which suggests that complete denitrification is uncommon across this forest landscape. The gene with the largest proportion of denitrification specific reads was the quinol-oxidizing nitric oxide reductase, qnor, which reduces toxic nitric oxide to nitrous oxide. The relative enrichment of specialized denitrification genes involved in intermediate reactions may indicate that environmental factors are selecting for a partial denitrification process, rather than complete denitrification. High Hardwood soils had the highest denitrification gene abundance and the greatest potential rate of denitrification, indicating that metagenomics information was consistent with process measurements.

Results from the Multiple Element Nutrient Limitation project fertilization study show that P availability can limit tree growth in northern hardwood forests (Goswami et al. 2018), especially in trees of smaller size classes (< 30 cm DBH), whereas N can limit growth of trees in larger size classes found only in mature forests. Despite suppression of N availability where P availability is elevated, we have not found any evidence that sequential N and P limitation of aboveground growth develops over time in these forests. The analysis of shifting N and P concentrations and stoichiometry during autumn litterfall (See et al. 2019) found that both N and P concentrations declined significantly

during the litterfall season in all species. Because P concentrations declined proportionately more than N concentrations, leaf litter N:P ratios increased throughout the season, likely reflecting the ordered breakdown of the different cellular constituents containing these nutrients. Our results suggest that sampling senesced leaf tissue at a single point in time leads to biased estimates of nutrient concentrations, stoichiometry, and litterfall and resorption fluxes. This bias is likely greater for P than for N.

Results from the 15N tracer addition to forests of different ages (Fuss et al. 2019) found that overall, forest age did not directly control the 5-week recovery of 15N, but it had an indirect effect via its influence on SOM properties such as C/N (Figure 3). Old-growth forest soils had the lowest C/N, implying closer proximity to effective N saturation. Across sites, both the particulate- and mineral-associated SOM fractions rapidly incorporated 15N, but recovery in each fraction generally declined with time, reflecting the dynamic nature of SOM. These results indicate that mineral horizons can provide an important N sink through the short term in forests of all ages, but that SOM-N remains subject to active cycling and potential loss over the longer term.

Changing biota

Analysis of the role of mycorrhizal functional type on soil respiration found that areas with a higher abundance of trees at associated with arbuscular mycorrhizae had higher rates of soil respiration, and that these rates were associated with soil properties (Lang et al 2019).

Comparisons of beetle abundance during 1973-1977 and 2015-2017 revealed an 83% decline in the number of beetles captured per 48-h (Harris et al. 2019). In addition, 19 beetle families that were trapped in the 1970s were no longer found. These declines were linked to winter warming.

Aquatic organisms. After one year of data, we found that: a) algae increased in all watersheds throughout the summer, and b) insects peak in the spring and are variable among sites. We tested the influence of substrate (moss-like vs. bare rock), nutrients, and light availability on both algal biomass and productivity and found that the moss substrate always had greater algal biomass. We replicated measurements of moss made in the early 2000s and found that moss cover has both changed in time and is spatially variable.

Wildlife monitoring cameras detected nine species in 2018 (northern raccoon, bobcat, mink, black bear, fisher, red fox, coyote, moose and white-tailed deer) while an additional 2 species (river otter, pine marten) were detected in 2019. Detection rates/activity levels were highest for white-tailed deer (0.60) followed by moose (0.55), coyotes (0.45) and red fox (0.25). Moose and deer are detected/active at different times of the year, with higher activity for moose during the winter and spring season and at higher elevation locations. Moose and deer overlap at 8 out of 11 sites where these ungulates have been detected.

Stream salamander results show the effects of increasing streamflow variability on survival through metamorphosis in our study species, the stream salamander Gyrinophilus porphyriticus (Lowe et al. 2019, Figure 4). We observed that hydrologic variability reduces the demographic resilience and adaptive capacity of G. porphyriticus populations by decreasing recruitment of breeding adults. The results provide insight on how increasing hydrologic variability is affecting freshwater species, and on the broader effects of environmental variability on species with vulnerable metamorphic stages.

Key outcomes or Other achievements:

INFORMATION MANAGEMENT

The Information Management System at HBR addresses several major goals; (1) maintaining access to HBR data, with an emphasis on high quality data/documentation and data preservation (2) enabling data discovery/access to the HBR, LTER, and broader scientific communities (3) development and maintenance of a website to share information on site history, current research, publications, photos, educational materials, etc. (4) maintaining a physical sample archive. The primary role of the HBR Information Manager is to support the HBR information management system (IM) and to provide expertise in data documentation, archiving and retrieval, for on and off-site scientists conducting research projects and data syntheses.

Data catalog: HBR data are submitted to the Environmental Data Initiative (EDI) repository, and are discoverable by searching the primary HBR website, the LTER data portal, and DataONE. The data catalog contains over 190 data packages ranging from single year studies to longterm data collections (more than 50 new data packages have been added in this LTER funding cycle). Core long-term datasests include 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. In 2019, we adopted an early release of the LTER Core Metabase database schema to support data package management. This system dramatically

improved the workflow used to prepare HBR data packages. We are now preparing to implement EML2.2, which provides EML elements that make our data packages more analysis- and synthesis-ready.

The HBR data catalog on https://hubbardbrook.org is now structured to provide local browse/search capabilities, with metadata and data access linked directly to the EDI dataset landing page. This new HBR data catalog structure reduces the time/effort involved in maintaining a redundant local system, insures that data are are all downloaded from a single source, provides for complete open access (including the ability to programatically access data and metadata via API), and allows tracking thorough the EDI 'Data Package Access Reports'.

All HBR datasets include the revised LTER Data Access Policy adopted in 2017. To date, all the data collected at HBR are considered Type I, with a goal of release to the general public within 2 years from the time of collection.

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

The current website provides the following functionality, and is continuously updated:
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 - A description of current research activities is available through the HBR website to inform the research community and public about research initiatives and preliminary findings.
Hubbard Brook Research Synthesis: and Online Book - this novel and dynamic web resource synthesizes more than 60 years of research at the Hubbard Brook Experimental Forest (https://hubbardbrook.org/online-book). This content is presented at the level of a graduate or advanced undergraduate student audience. The 15 chapters currently online have been developed by scientific experts on topics studied within the Hubbard Brook research community. 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.

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

Education and Outreach Material – Educational pages include K-12 curriculum materials, Science Links publications, products generated by stakeholder roundtable meetings.
Publications - The publications from the Hubbard Brook Experimental Forest date back to 1955, and number more than 2,700 books, journal articles, conference presentations, and theses. A list of these publications is accessible in a searchable format on the HBR website. New publications are identified through self-reporting by investigators, annual reports, Google Scholar alerts, and through a new 'Hubbard Brook Monthly' newsletter, where publications and products are reported on a regular basis throughout the year. Citations are managed locally with Zotero (http://zotero.org). HBR-LTER records were tagged and reported to LTER-NCO for the LTER 40-year update.

Hubbard Brook Sample Archive: A dedicated building on-site serves as the archive facility, and now houses approximately 100,000 samples. Our efforts in the sample archive facility are all targeted at improving researcher interest and access in further resampling and analysis. Samples are preserved, barcoded, and cataloged with associated metadata in the HBR centralized database; a process that ensures the discoverability and access to samples for future research. During this current funding cycle, we completed cataloging the backlog of 20,000 stream and precipitation samples. We developed a new hierarchical system for identifying (naming) the collections with the assistance of two individuals hired to assist with curating and archiving the collection. They also made an assessment of the space taken up by the existing collection and many of the collections that will soon be housed in the Archive to facilitate the re-organization of the collection.

HBR-IM Activities/Projects:

Presentation of HBR Information Management - 2019 HBR-LTER Midterm review, June, 2019
Innovative data outreach: A water cycle visualization and sonification have been developed for Hubbard Brook (http://waterviz.org). To support this collaborative between hydrological scientists, artists, musicians, and computer scientists, the HBR-IM developed, and now maintains, a real-time data workflow that combines data from multiple dataloggers, calculates variables on-the-fly (e.g evapotranspiration), and stages an hourly custom datafile for access by this interdisciplinary team.
Environmental Data Initiative (EDI) – The HBR-IM serves on the EDI advisory board as a representative of LTER sites.
EDI/LTER Working Groups – The HBR-IM is a member of the sematics working group and the non-tabular data working group, and participates in the planning discussions for the next generation of ClimHydroDB.
Smart Forests for the 21st Century is a Hubbard Brook Experimental Forest led effort to sensor technology to other USDA Forest Service Experimental Forests. Funding to the HBR-IM for support of SmartForests comes from a USFS cooperative agreement with UNH.
LTER Information Management Committee (IMC) Meeting - Tacoma, WA July 2019.
Earth Science Information Partners (ESIP) Annual Meeting - Taocma, WA July 2019

* 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, graduate and undergraduate students, and technicians. Hubbard Brook has a long history of communal housing, meals, and events which facilitate the building of relationships within the entire research community. Periodic “Science Night” gatherings allow for informal interactions between the summer resident community – mainly undergraduate and graduate students – and more senior researchers. This decades-long tradition involves a senior scientist visiting the group housing for dinner, a brief talk, and an open-ended discussion. In the summer of 2019 the site hosted 9 graduate students, 21 undergraduates, and 7 early-career research technicians for at least two months of residency, in addition to numerous short-term visits by students, technicians, and senior researchers.

In addition to the professional development of emerging scientists, the Hubbard Brook Research Foundation (HBRF) and U.S. Forest Service staff coordinate efforts to reach K-12 students and educators, 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. 2019 activities included:

Guided tours of the Hubbard Brook Experimental Forest, serving approximately 303 visitors in 2019.
Participated and presented at both the NH Science Teachers’ Association’s annual meeting and the NH Environmental Educator’s annual conference.
Continued to support and maintain data lessons on the Hubbard Brook website.
Worked with partners on three separate citizen science initiatives:

The Society for the Protection of New Hampshire Forests (SPNHF) on a collaborative citizen science project investigating sugar maple regeneration on a statewide scale.
The Squam Lakes Conservation Society on a forest health monitoring initiative.
The Nature Conservancy on a project looking at the impacts of recreational trail use on wildlife.

* 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 2019 Hubbard Brook investigators presented their research at conferences and other public events, including four collaborative Committee of Scientists (COS) meetings.

The 56th Annual Hubbard Brook Cooperators meeting was held on-site in July with over 150 attendees. The event included two days of ongoing and proposed Hubbard Brook research presentations from senior investigators, post-docs, and both graduate and undergraduate students, and a half-day COS meeting.

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 overarching goal is to establish trusting relationships and two-way channels of communication between the Hubbard Brook scientific community and stakeholder networks across the northern forest region, and to build knowledge about the processes and practices of public engagement along the way. Our public engagement initiative involves building capacity in three key areas: face-to-face, dialogue-based engagement; co-production of knowledge; and outreach to broader audiences.

In order to advance outreach goals, in 2019 HBRF:

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

Held a Hubbard Brook Round Table on invasive pests and the future of New England forests and forest products.

The report is available here.

Collaborated with Northern Woodlands magazine and the Society for the Protection of New Hampshire Forests to co-host a round table discussion with the goal of understanding common misperceptions about forest health and management in NH.
Continued work on two separate Science Links projects, which produce policy- and stakeholder-relevant scientific syntheses, which are published in peer reviewed journals and in summary reports for public audiences:

Completed the Winter Climate Change Science Links project, including three peer-reviewed publications produced this year as well as a synthesis report for stakeholders, decision-makers, and other public audiences (see publications section of this report).
Continued work on the Science Links Resilience project, an investigation of ecological and social resilience in the White Mountains of New Hampshire. The project team is currently working on two papers: 1) a quantitative analysis of ecological resilience using the long-term record at Hubbard Brook and 2) an investigation of the linkages between ecological resilience and social resilience in the northern three counties of New Hampshire.

Held a joint meeting with the Hubbard Brook Committee of Scientists and the HBRF stakeholder Advisory Council in July 2019 on this topic.
Maintained Hubbard Brook's suite of science communication programs, including: a redesigned website, a system of regular press releases, a suite of e-newsletters, and a strong social media campaign (i.e., Facebook, Twitter).

Published a monthly, internal e-newsletter, called the Hubbard Brook Monthly, designed to enhance information sharing within the Hubbard Brook community. Each issue includes highlights from the previous month of work, including Recent Publications, Hubbard Brook in the News, Outreach and Education, New or Proposed Research, Save the Date, and Announcements.
Published the monthly "Forest Science News" public e-newsletter for sharing emerging forest science for stakeholder audiences. Subscribers receive a carefully curated email roundup of press releases and abstracts presented in an engaging, reader friendly format.
Coordinated a visit from U.S. NH Representative Ann Kuster to Hubbard Brook on August 21.

Worked with Representative Kuster's staff and Hubbard Brook Scientists to produce a regional climate fact-sheet in support of her work on the 100% Clean Economy Act.

Convened a joint meeting of the Hubbard Brook and Harvard Forest LTER programs to discuss public engagement with science in the region (March 20).

Participated and presented at professional conferences, including:

NH Department of Environmental Services Watershed Conference
Data Visualization conference held at the Exploratorium in San Francisco, CA
Climate Change Education Collaborative (Shelburne Farms) annual meeting
National Alliance for Broader Impacts (NABI) conference
United South and Eastern Tribes Climate Resilience Summit
Inclusive Science Communication Symposium at the University of Rhode Island
American Geophysical Union annual meeting.

* 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.

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Products

Books

Book Chapters

W. Keith Moser, USDA Forest Service, USA; Adam P. Coble, Oregon Department of Forestry, USA; Lea Hallik, University of Tartu, Estonia; Andrew D. Richardson, Northern Arizona University, USA; Jan Pisek and Kairi Adamson, University of Tartu, Estonia; Russell T. Graham, USDA Forest Service, USA; and Cynthia F. Moser, LLC Flagstaff, USA (2020). Advances in understanding canopy development in forest trees. *Achieving sustainable management of boreal and temperate forests 1.* 1. Dr John A. Stanturf. Burleigh Dodds Science Publishing Limited. Cambridge, UK. 1. Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes ; ISBN: 978 1 78676 292 4.

Inventions

Journals or Juried Conference Papers

View all journal publications currently available in the NSF Public Access Repository for this award.

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

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

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

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

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

Taylor, L. L., C. T. Driscoll, G. H. Rau, J. D. Blum, and J. D. Beerling (2018). *Increased Carbon Capture by a Silicate-Treated Forested Watershed Attenuated by Acid Deposition Nature Communications, abstract #GC23G-1283*. American Geophysical Union, Fall Meeting. Washington, DC. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

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

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

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

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

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

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

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

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

Other Products

Other Publications

Weintraub, S., A.N. Flores, W.R. Wieder, D. Sihi, C. Cagnarini, D.R.P. Gonçalves, M. Young, L. Li, Y. Olshansky, R. Baatz, P.L. Sullivan and P.M. Groffman (2019). *Leveraging environmental research and observation networks to advance soil carbon science*. Commentary, Journal of Geophysical Research: Biogeosciences,124, 1047–1055, https://doi.org/10.1029/2018JG004956. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

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

Patents

Technologies or Techniques

Thesis/Dissertations

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

Nicholas A. LoRusso. *Dissolved organic matter dynamics in calcium-treated and reference watersheds at Hubbard Brook Experimental Forest*. (2019). Syracuse University. Acknowledgement of Federal Support = Yes

Zheng Dong. *Dynamics of water, carbon, and nitrogen in forest and alpine tundra ecosystems in the Pacific Northwest and the Rocky Mountains of the U.S. under future climate change*. (2019). Syracuse University. Acknowledgement of Federal Support = Yes

Mahnaz Valipour. *Modeling the interactions of forest cutting and climate change on the hydrology, biomass and biogeochemistry of a northeastern forest*. (2019). Syracuse University. Acknowledgement of Federal Support = Yes

Gretchen A. Dillon. *NUTRITIONAL EFFECTS ON CAUSAL ORGANISMS OF BEECH BARK DISEASE IN AN AFTERMATH FOREST*. (2019). State University of New York College of Environmental Scienc. Acknowledgement of Federal Support = Yes

Alexandrea M. Rice. *TREE VARIABILITY LIMITS THE DETECTION OF NUTRIENT TREATMENT EFFECTS ON SAP FLOW IN A NORTHERN HARDWOOD FOREST*. (2019). State University of New York College of Environmental Scienc. Acknowledgement of Federal Support = Yes

Websites

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Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Lovett, Gary	PD/PI	2
Ayres, Matthew	Co PD/PI	2
Fisk, Melany	Co PD/PI	1
Groffman, Peter	Co PD/PI	1
Templer, Pamela	Co PD/PI	1
Asbjornsen, Heidi	Co-Investigator	1
Bailey, Scott	Co-Investigator	3
Battles, John	Co-Investigator	2
Bernhardt, Emily	Co-Investigator	2
Burchsted, Denise	Co-Investigator	1
Christenson, Lynn	Co-Investigator	1
Cleavitt, Natalie	Co-Investigator	11
Driscoll, Charles	Co-Investigator	2
Fahey, Timothy	Co-Investigator	2
Goodale, Christine	Co-Investigator	1
Green, Mark	Co-Investigator	1

Johnson, Chris	Co-Investigator	1
Kelsey, Eric	Co-Investigator	1
Lavallee, Anthea	Co-Investigator	1
Lowe, Winsor	Co-Investigator	1
Matthes, Jaclyn	Co-Investigator	1
McGuire, Kevin	Co-Investigator	2
Ollinger, Scott	Co-Investigator	1
Pardo, Linda	Co-Investigator	3
Richardson, Andrew	Co-Investigator	1
Rosi, Emma	Co-Investigator	2
ter Hofstede, Hannah	Co-Investigator	2
Vadeboncoeur, Matthew	Co-Investigator	2
Yanai, Ruth	Co-Investigator	1
Fakhraei, Habibollah	Postdoctoral (scholar, fellow or other postdoctoral position)	6
Chiasson, Clara	Other Professional	3
Garlick, Sarah	Other Professional	3
Martin, Mary	Other Professional	10
McCartney, Brenda	Other Professional	1
Swartz, Leah	Other Professional	0
Thorne, Sarah	Other Professional	1
Wilson, Geoff	Other Professional	10
Dan, Evans	Technician	2
Gewirtzman, Jonathan	Technician	2
Heather, Malcom	Technician	1
Koppers, Mary	Technician	6
LoRusso, Nicholas	Technician	6
Martel, Lisa	Technician	3
Montesdeoca, Mario	Technician	2
Ralston, Jessica	Technician	3
Seitz, Michael	Technician	4
Vollmer, Hannah	Technician	1
Burakowski, Elizabeth	Staff Scientist (doctoral level)	0
Ouimette, Andrew	Staff Scientist (doctoral level)	2
Zhou, Zaixing	Staff Scientist (doctoral level)	2
Addis, Brett	Graduate Student (research assistant)	2

Baillargeon, Kaitlyn	Graduate Student (research assistant)	2
Benton, Joshua	Graduate Student (research assistant)	2
Blumenthal, Noah	Graduate Student (research assistant)	1
Bower, Jenny	Graduate Student (research assistant)	3
Butler, Samuel	Graduate Student (research assistant)	3
Cochrane, Maddy	Graduate Student (research assistant)	2
Duston, Stephanie	Graduate Student (research assistant)	3
Hastings, John	Graduate Student (research assistant)	1
Jevon, Fiona	Graduate Student (research assistant)	4
Kernan, Ciara	Graduate Student (research assistant)	6
Lang, Ashley	Graduate Student (research assistant)	12
Pennino, Amanda	Graduate Student (research assistant)	3
Shan, Shan	Graduate Student (research assistant)	6
Studer, Elizabeth	Graduate Student (research assistant)	12
Teets, Aaron	Graduate Student (research assistant)	4
Thellman, Audrey	Graduate Student (research assistant)	10
Valipour, Mahnaz	Graduate Student (research assistant)	4
Artrip, Ben	Undergraduate Student	1
Carreau, Chase	Undergraduate Student	3
Castaneda, Itzel	Undergraduate Student	4
Chien, Jennifer	Undergraduate Student	1
Conte, Abigail	Undergraduate Student	1
Cotnoir, Alexander	Undergraduate Student	2
Cox, Avery	Undergraduate Student	4
De La Cruz, Dayna	Undergraduate Student	1
Ding, Alex	Undergraduate Student	2
Edwards, Cameron	Undergraduate Student	1
Edwards, Tyler	Undergraduate Student	2
Frost, Tanner	Undergraduate Student	1
Giffard, Nathaniel	Undergraduate Student	2
Hodges, Tyler	Undergraduate Student	2
Huang, Erica	Undergraduate Student	1
Kovari, Stephen	Undergraduate Student	3
Kreger, Robert	Undergraduate Student	1
Marr, Hannah	Undergraduate Student	2

Moore, Kelsey	Undergraduate Student	3
Page, Catherine	Undergraduate Student	2
Qian, Jason	Undergraduate Student	2
Schulte, Ami	Undergraduate Student	1
Schwinden, Megan	Undergraduate Student	2
Sims, Katie	Undergraduate Student	2
Sullivan, Kyle	Undergraduate Student	5
Vietorisz, Corinne	Undergraduate Student	4
Weber, David	Undergraduate Student	3
Wurtz, Maeve	Undergraduate Student	0
Yener, Ayhan	Undergraduate Student	1
Kambhampaty, Abby	High School Student	0
Peterson, Delaney	Research Experience for Undergraduates (REU) Participant	3
Rasnake, Nathaniel	Research Experience for Undergraduates (REU) Participant	3
Vought, Olivia	Research Experience for Undergraduates (REU) Participant	3
Wentzell-Brehme, Sage	Research Experience for Undergraduates (REU) Participant	3
McCartney, Brenda	Other	1
Rubenstein, Maribeth	Other	3

Full details of individuals who have worked on the project:

Gary M Lovett
Email: lovettg@caryinstitute.org
Most Senior Project Role: PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: As the Lead Principal Investigator, I am responsible for overall organization of the project and all related reporting and planning. I am also doing LTER related research at Hubbard Brook.

Funding Support: This grant and the Cary Institute

International Collaboration: No
International Travel: No

Matthew P Ayres
Email: matthew.p.ayres@dartmouth.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 2

Contribution to the Project: Overall coordination of the following project areas: 2.3.5 Climate change, N availability, and forest food webs; 2.4.4 The incipient loss of Fraxinus from HBR; and 2.5.3 Spatial patterns of animal populations. Oversight of undergraduate research assistants, technicians, and Dartmouth graduate students for above project areas.

Funding Support: This award

International Collaboration: No
International Travel: No

Melany C Fisk
Email: fiskmc@miamioh.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Interactions among N, P, and C; nutrient limitation of plant productivity and soil processes

Funding Support: This grant and home institution

International Collaboration: No
International Travel: No

Peter M Groffman
Email: Peter.Groffman@asrc.cuny.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

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

Funding Support: Other sources

International Collaboration: No
International Travel: No

Pamela H Templer
Email: ptempler@bu.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

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

Funding Support: Funds from other federal grants

International Collaboration: No
International Travel: No

Heidi Asbjornsen
Email: heidi.asbjornsen@unh.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Project management, data analysis and interpretation associated with the DroughtNet project

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

International Collaboration: No
International Travel: No

Scott W Bailey
Email: swbailey@fs.fed.us
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 3

Contribution to the Project: Lead researcher and field coordinator on the hydropedology study. He has been responsible for soil and geochemical characterization in the reference watershed – WS3. Expanded 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.

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

International Collaboration: No
International Travel: No

John J Battles
Email: jbattles@berkeley.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

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

Funding Support: This award

International Collaboration: No
International Travel: No

Emily Bernhardt
Email: emily.bernhardt@duke.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: Co-oversight of stream sampling for LTER research. Supervisor of Audrey Thellman, PhD student, who is conducting research on stream ecosystem and ecological dynamics during vernal and autumnal windows. Co-advised REU student Olivia Vought. Advised undergraduate student Tyler Edwards who worked on counting emerged stream insect samples.

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

International Collaboration: No
International Travel: No

Denise Burchsted
Email: dburchsted@keene.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

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

Funding Support: N/A

International Collaboration: No
International Travel: No

Lynn Christenson
Email: lychristenson@vassar.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

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

Funding Support: Other sources

International Collaboration: No
International Travel: No

Natalie L Cleavitt
Email: nlc4@cornell.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 11

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

demography Education and outreach

Funding Support: This award and Cornell University

International Collaboration: Yes, Canada
International Travel: No

Charles T Driscoll
Email: ctdrisco@syr.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

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

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

International Collaboration: Yes, China
International Travel: No

Timothy J Fahey
Email: tjf5@cornell.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

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

Funding Support: This award

International Collaboration: No
International Travel: No

Christine Goodale
Email: clg33@cornell.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Measurements of denitrification and leaf, soil, and water stable isotopes; lead data analysis, interpretation, and manuscripts. Mentor graduate and undergraduate students.

Funding Support: NSF-1655818; Cornell University for graduate student support (E. Kreitinger, C. Mejia)

International Collaboration: No
International Travel: No

Mark Green
Email: mbg78@case.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

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

Funding Support: US Forest Service

International Collaboration: Yes, Japan
International Travel: No

Chris Johnson
Email: cejohns@syr.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Research on soil chemistry and biogeochemistry.

Funding Support: N/A

International Collaboration: Yes, Sweden
International Travel: No

Eric Kelsey
Email: ekelsey2@plymouth.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

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

Funding Support: This LTER grant, Plymouth State University, Mount Washington Observatory

International Collaboration: No
International Travel: No

Anthea Lavallee
Email: alavallee@hbresearchfoundation.org
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Anthea is the Executive Director of the Hubbard Brook Research Foundation. As Executive Director of HBRF, Anthea oversees the support organization's efforts with regard to facilities and education/outreach, serving the HBR- LTER cooperators.

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

International Collaboration: No
International Travel: No

Winsor Lowe
Email: winsor.lowe@umontana.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

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

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

International Collaboration: No
International Travel: No

Jaclyn Matthes
Email: jmatthes@wellesley.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

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

Funding Support: NSF EF-1638406 "MSB-ECA: A generalized framework for modeling the impacts of forest insects and pathogens in the Earth System"; NSF-1926454 "Collaborative Research: MSA: Incorporating canopy structural complexity to improve model forecasts of functional e

International Collaboration: No
International Travel: No

Kevin McGuire
Email: kevin.mcguire@vt.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

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

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

International Collaboration: No
International Travel: No

Scott Ollinger
Email: scott.ollinger@unh.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Carbon and nitrogen cycling, remote sensing, eddy flux, ecosystem modeling and regionalization, project oversight and reporting.

Funding Support: Home institution and other grants

International Collaboration: No
International Travel: No

Linda H Pardo
Email: linda.pardo@usda.gov
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 3

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

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

International Collaboration: No
International Travel: No

Andrew Richardson
Email: andrew.richardson@nau.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Richardson supervised one PhD student working on this project (Aaron Teets), and maintained eddy covariance and phenocam instrumentation operating at Bartlett Experimental Forest.

Funding Support: Northern Arizona University faculty salary

International Collaboration: No
International Travel: No

Emma J Rosi
Email: rosie@caryinstitute.org
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: Co-oversight of stream sampling. Supervised Heather Malcom at Cary Institute who is running stream samples. Advised Audrey Thellman, PhD student at Duke, who workedecological dynamics during the spring and autumn. Advised REU student Olivia Vought who measured moss dynamics in HB streams.

Funding Support: Institutional support

International Collaboration: No

International Travel: No

Hannah ter Hofstede
Email: Hannah.ter.Hofstede@dartmouth.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: Co-leader with Ayres and Holmes in the following project areas: 2.3.5 Climate change, N availability, and forest food webs; and 2.5.3 Spatial patterns of animal populations. Project leader for studies of bats, including the development of a new long-term protocol for measurement of bat abundance and species composition via collection and analysis of automated sound recordings. Co-leader, with Ayres and Holmes, in the development of a new system for long-term studies of bird activity via the collection and analysis of automated passive sound recordings.

Funding Support: This grant and Dartmouth University

International Collaboration: No
International Travel: No

Matthew Vadeboncoeur
Email: matt.vad@unh.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 2

Contribution to the Project: field logistics, data collection, and data analysis assocaited with drought experiment, forest ecophysiology, and MELNHE.

Funding Support: Northeastern States Research Cooperative; New Hampshire Agricultural Experiment Station; University of New Hampshire – Iola Hubbard Climate Endowment; NSF EAR 1562127

International Collaboration: No
International Travel: No

Ruth D Yanai
Email: rdyanai@syr.edu
Most Senior Project Role: Co-Investigator
Nearest Person Month Worked: 1

Contribution to the Project: Ruth coordinates the MELNHE project (Multiple Element Limitation in Northern Hardwood Ecosystems), which is one of the manipulative experiments of the Hubbard Brook LTER. 2019 was the ninth year of addition of N and P in stands of different ages at Hubbard Brook, Jeffers Brook, and Bartlett Experimental Forests. Uncertainty analysis was another theme of the HBR LTER. This effort is funded as a Research Coordination Network called QUEST (Quantifying Uncertainty in Ecosystem Studies), led by Yanai and other HBR researchers as well as researchers at other institutions.

Funding Support: State University of New York

International Collaboration: No
International Travel: No

Habibollah Fakhraei
Email: hfakhrae@syr.edu
Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)
Nearest Person Month Worked: 6

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

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

International Collaboration: No
International Travel: No

Clara Chiasson
Email: cchiasson@hubbardbrookfoundation.org

Most Senior Project Role: Other Professional
Nearest Person Month Worked: 3

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

Funding Support: NSF ASL award #1713204

International Collaboration: No
International Travel: No

Sarah Garlick
Email: sarahgarlick@gmail.com
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 3

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

Funding Support: NSF ASL award #1713204

International Collaboration: No
International Travel: No

Mary Martin
Email: mary.martin@unh.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 10

Contribution to the Project: Information Manager

Funding Support: This award, and US Forest Service Cooperative Agreement

International Collaboration: No
International Travel: No

Brenda McCartney
Email: bmccartney@hubbardbrookhfoundation.org
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

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

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

International Collaboration: No
International Travel: No

Leah Swartz
Email: leah.swartz@mso.umt.edu
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 0

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

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

International Collaboration: No
International Travel: No

Sarah Thorne
Email: sthorne@hubbardbrookfoundation.org

Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

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

Funding Support: sLTER (this award)

International Collaboration: No
International Travel: No

Geoff Wilson
Email: wilsong@caryinstitute.org
Most Senior Project Role: Other Professional
Nearest Person Month Worked: 10

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

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

International Collaboration: No
International Travel: No

Evans Dan
Email: dmevans1@plymouth.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 2

Contribution to the Project: supervising technician for new flux tower in Hubbard Brook

Funding Support: This LTER grant, Plymouth State University

International Collaboration: No
International Travel: No

Jonathan Gewirtzman
Email: jgewirtz@bu.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 2

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

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

International Collaboration: No
International Travel: No

Malcom Heather
Email: malcomh@caryinstitute.org
Most Senior Project Role: Technician
Nearest Person Month Worked: 1

Contribution to the Project: Sample processing and analysis

Funding Support: This award and Cary Institute

International Collaboration: No
International Travel: No

Mary Margaret Koppers
Email: mmkopper@syr.edu
Most Senior Project Role: Technician

Nearest Person Month Worked: 6

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

Funding Support: N/A

International Collaboration: No
International Travel: No

Nicholas LoRusso
Email: nlorusso@syr.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 6

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

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

International Collaboration: No
International Travel: No

Lisa Martel
Email: martell@caryinstitute.org
Most Senior Project Role: Technician
Nearest Person Month Worked: 3

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

Funding Support: N/A

International Collaboration: No
International Travel: No

Mario Montesdeoca
Email: mmontesd@syr.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 2

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

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

International Collaboration: No
International Travel: No

Jessica Ralston
Email: jessica.s.ralston@dartmouth.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 3

Contribution to the Project: Bioacoustics of birds and bats

Funding Support: Dartmouth College

International Collaboration: No
International Travel: No

Michael Seitz
Email: mseitz@syr.edu
Most Senior Project Role: Technician
Nearest Person Month Worked: 4

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

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

International Collaboration: No
International Travel: No

Hannah Vollmer
Email: hvollmer@hubbardbrookfoundation.org
Most Senior Project Role: Technician
Nearest Person Month Worked: 1

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

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

International Collaboration: No
International Travel: No

Elizabeth Burakowski
Email: elizabeth.burakowski@gmail.com
Most Senior Project Role: Staff Scientist (doctoral level)
Nearest Person Month Worked: 0

Contribution to the Project: Ecosystem-climate interactions, modeling

Funding Support: Other sources

International Collaboration: No
International Travel: No

Andrew Ouimette
Email: andrew.ouimette@unh.edu
Most Senior Project Role: Staff Scientist (doctoral level)
Nearest Person Month Worked: 2

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

Funding Support: Other sources

International Collaboration: No
International Travel: No

Zaixing Zhou
Email: zaixingzhou@gmail.com
Most Senior Project Role: Staff Scientist (doctoral level)
Nearest Person Month Worked: 2

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

Funding Support: This grant and other sources

International Collaboration: No
International Travel: No

Brett Addis
Email: brett.addis@gmail.com
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

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

Funding Support: Institutional support

International Collaboration: No
International Travel: No

Kaitlyn Baillargeon
Email: b2014@wildcats.unh.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

Contribution to the Project: Biodiversity studies, remote sensing

Funding Support: Other sources

International Collaboration: No
International Travel: No

Joshua Benton
Email: joshuabenton@vt.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

Contribution to the Project: Examining shallow groundwater flow direction and flux

Funding Support: Virginia Tech and another NSF grant

International Collaboration: No
International Travel: No

Noah Blumenthal
Email: blumennm@miamioh.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

Contribution to the Project: Nutrient limitation of aboveground growth

Funding Support: This award and Miami University

International Collaboration: No
International Travel: No

Jenny Bower
Email: Jennifer.bower@uvm.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: Examining mineral weathering and solid phase chemistry across lateral gradients using a whole-regolith approach

Funding Support: UVM and another NSF grant

International Collaboration: No
International Travel: No

Samuel Butler
Email: butlersj@miamioh.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: Nutrient limitation of belowground processes

Funding Support: This award and Miami University

International Collaboration: No
International Travel: No

Maddy Cochrane
Email: madaline.cochrane@umconnect.umt.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 2

Contribution to the Project: Conducting studies on salamander responses to changes in headwater stream hydrology. Dissertation in progress, University of Montana

Funding Support: This grant and University of Montana

International Collaboration: No
International Travel: No

Stephanie Duston
Email: stephad5@vt.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: Developing resin approaches to quantify dissolved organic carbon fluxes in the subsurface

Funding Support: Virginia Tech

International Collaboration: No
International Travel: No

John Hastings
Email: jhc33@wildcats.unh.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 1

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

Funding Support: Other sources

International Collaboration: No
International Travel: No

Fiona Jevon
Email: fiona.v.jevon.gr@dartmouth.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

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

Funding Support: Stipend provided by Dartmouth College.

International Collaboration: No
International Travel: No

Ciara Kernan
Email: Ciara.E.Kernan.GR@dartmouth.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

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

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

International Collaboration: No

International Travel: No

Ashley K Lang
Email: ashley.k.lang.gr@dartmouth.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

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

Funding Support: Dartmouth College stipend.

International Collaboration: No
International Travel: No

Amanda Pennino
Email: penninoa@vt.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 3

Contribution to the Project: Investigating weathering fluxes as solute sources to streams.

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

International Collaboration: No
International Travel: No

Shan Shan
Email: shans@miamioh.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 6

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

Funding Support: Miami University

International Collaboration: No
International Travel: No

Elizabeth A Studer
Email: elizabeth.a.studer.gr@dartmouth.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 12

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

Funding Support: Dartmouth University stipend

International Collaboration: No
International Travel: No

Aaron Teets
Email: aft49@nau.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Research on vegetation phenology, and impact of phenology on ecosystem processes related to C and H2O

Funding Support: This award and Northern Arizona University

International Collaboration: No
International Travel: No

Audrey Thellman
Email: audrey.thellman@duke.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 10

Contribution to the Project: Ran stream algae samples, fieldwork from May-August at Hubbard Brook

Funding Support: This award and Duke University

International Collaboration: No
International Travel: No

Mahnaz Valipour
Email: mvalipou@syr.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

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

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

International Collaboration: No
International Travel: No

Ben Artrip
Email: artripbl@miamioh.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Litterfall nutrient dynamics

Funding Support: Miami University

International Collaboration: No
International Travel: No

Chase Carreau
Email: chase.p.carreau@hotmail.com
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Valley-wide surveys

Funding Support: This award

International Collaboration: No
International Travel: No

Itzel Castaneda
Email: Itzel.P.Castaneda.Ruvalcaba.20@dartmouth.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: Bioacoustics of birds and bats

Funding Support: This award and undergraduate research grant from Dartmouth

International Collaboration: No
International Travel: No

Jennifer Chien

Email: jchien3@wellesley.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Conducted lab research on long-term vegetation changes

Funding Support: This award

International Collaboration: No
International Travel: No

Abigail Conte
Email: aconte@wellesley.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Conducted lab research on long-term vegetation changes

Funding Support: This award

International Collaboration: No
International Travel: No

Alexander Cotnoir
Email: Alexander.Wayne.Cotnoir@dartmouth.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Ecology of ash demise

Funding Support: This award and undergraduate research grant from Dartmouth

International Collaboration: No
International Travel: No

Avery Cox
Email: averybcox@hotmail.com
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: Soil ecology

Funding Support: This award

International Collaboration: No
International Travel: No

Dayna De La Cruz
Email: ddelacru@wellesley.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Conducted lab research on field data related to seedling survival at Hubbard Brook.

Funding Support: This award

International Collaboration: No
International Travel: No

Alex Ding
Email: ad939@cornell.edu
Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 2

Contribution to the Project: W5 re-measure, B-line 2-yr re-measure for tree VIG; sugar maple seedling and orchid demography

Funding Support: This award and Cornell University

International Collaboration: No
International Travel: No

Cameron Edwards
Email: cnedward@syr.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

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

Funding Support: N/A

International Collaboration: No
International Travel: No

Tyler Edwards
Email: tyler.edwards@duke.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Counted and identified emerged stream insects from HB streams

Funding Support: Duke University

International Collaboration: No
International Travel: No

Tanner Frost
Email: ay1025@wildcats.unh.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: DroughtNet lab and field work

Funding Support: NH Agricultural Experiment Station

International Collaboration: No
International Travel: No

Nathaniel Giffard
Email: Nathan.G.Giffard.21@Dartmouth.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Soil ecology

Funding Support: This award

International Collaboration: No
International Travel: No

Tyler Hodges
Email: tyhodges@syr.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Valley-wide surveys

Funding Support: This award

International Collaboration: No
International Travel: No

Erica Huang
Email: ehuang2@wellesley.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Conducted lab research on long-term vegetation changes

Funding Support: This award

International Collaboration: No
International Travel: No

Stephen Kovari
Email: stkovari@vassar.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

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

Funding Support: Vassar College

International Collaboration: No
International Travel: No

Robert Kreger
Email: kregerrr@miamioh.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Nutrient limitation of aboveground growth

Funding Support: This award and Miami University

International Collaboration: No
International Travel: No

Hannah Marr
Email: Hannah.J.Marr.20@dartmouth.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Bioacoustics of birds and bats

Funding Support: This award

International Collaboration: No
International Travel: No

Kelsey Moore
Email: kelsey.a.moore13@gmail.com
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Valley-wide surveys

Funding Support: This award

International Collaboration: No
International Travel: No

Catherine Page
Email: Catherine.A.Page.20@Dartmouth.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Ecology of ash demise

Funding Support: This award

International Collaboration: No
International Travel: No

Jason Qian
Email: Jason.Y.Qian.19@Dartmouth.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Ecology of ash demise

Funding Support: This award

International Collaboration: No
International Travel: No

Ami Schulte
Email: schultan@miamioh.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Nutrient limitation of belowground processes

Funding Support: Miami University

International Collaboration: No
International Travel: No

Megan Schwinden
Email: schwinm@miamioh.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: Nutrient limitation of belowground processes

Funding Support: Miami University

International Collaboration: No
International Travel: No

Katie Sims
Email: kms425@cornell.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 2

Contribution to the Project: W5 re-measure, B-line 2-yr re-measure for tree VIG; sugar maple seedling and orchid demography

Funding Support: This award and Cornell University

International Collaboration: No
International Travel: No

Kyle Sullivan
Email: Kyle.H.Sullivan.20@Dartmouth.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 5

Contribution to the Project: Ecology of ash demise

Funding Support: This award

International Collaboration: No
International Travel: No

Corinne Vietorisz
Email: crvietorisz@optimum.net
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 4

Contribution to the Project: Soil ecology

Funding Support: This award and undergraduate research grant from Dartmouth

International Collaboration: No
International Travel: No

David Weber
Email: dweber1594@gmail.com
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 3

Contribution to the Project: Valley-wide surveys

Funding Support: This award

International Collaboration: No
International Travel: No

Maeve Wurtz
Email: mawurtz@syr.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 0

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

Funding Support: Institutional support

International Collaboration: No
International Travel: No

Ayhan Yener
Email: tf1007@wildcats.unh.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: DroughtNet lab and field work

Funding Support: NH Agricultural Experiment Station

International Collaboration: No

International Travel: No

Abby Kambhampaty
Email: abby.kambhampaty@gmail.com
Most Senior Project Role: High School Student
Nearest Person Month Worked: 0

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.

Funding Support: Institutional support

International Collaboration: No
International Travel: No

Delaney Peterson
Email: delanp98@vt.edu
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 3

Contribution to the Project: Installed wells, sampled temporary streams and groundwater wells for chemistry

Funding Support: Virginia Tech

International Collaboration: No
International Travel: No
Year of schooling completed: Junior
Home Institution: Virginia Tech
Government fiscal year(s) was this REU participant supported: 2019

Nathaniel Rasnake
Email: nataras@vt.edu
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 3

Contribution to the Project: Research on hydropedology in reference watershed

Funding Support: This award

International Collaboration: No
International Travel: No
Year of schooling completed: Junior
Home Institution: Virginia Tech
Government fiscal year(s) was this REU participant supported: 2019

Olivia Vought
Email: Olivia.Vought@uvm.edu
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 3

Contribution to the Project: Sampled moss in HB streams

Funding Support: Cary Institute of Ecosystem Studies REU program

International Collaboration: No
International Travel: No
Year of schooling completed: Junior
Home Institution: University of Vermont
Government fiscal year(s) was this REU participant supported: 2019

Sage Wentzell-Brehme

Email: swentzel@wellesley.edu
Most Senior Project Role: Research Experience for Undergraduates (REU) Participant
Nearest Person Month Worked: 3

Contribution to the Project: Conducted independent project on red oak and white pine seedling survival in addition to supporting the summer vegetation crew.

Funding Support: NSF REU

International Collaboration: No
International Travel: No
Year of schooling completed: Sophomore
Home Institution: Wellesley College
Government fiscal year(s) was this REU participant supported: 2019

Brenda McCartney
Email: bmccartney@hubbardbrookfoundation.org
Most Senior Project Role: Other
Nearest Person Month Worked: 1

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

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

International Collaboration: No
International Travel: No

Maribeth Rubenstein
Email: rubensteinm@caryinstitute.org
Most Senior Project Role: Other
Nearest Person Month Worked: 3

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

Funding Support: Cary Institute of Ecosystem Studies

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?

USDA Forest Service White Mountain National Forest and Northern Research Station
Boston University
New York University
University of Vermont
Vassar College
Society for the Protection of New Hampshire Forests
Chinese Academy of Sciences
Cornell University
Cary Institute of Ecosystem Studies
SUNY-ESF
University of New Hampshire
University of Michigan
Vassar College
Boston University
Society for the Protection of NH Forests
Lund University (Sweden)
Griffith University (Australia)
Plymouth State University
USDA Forest Service, Northern Research Station
Smithsonian Institution
Wellesley College
Dana Warren, OSU
Bill McDowell, UNH
John Magee, New Hampshire Fish & Game
Eric Berry, St. Anselm's College
Nicolas Belanger, TELUQ, Quebec
Zhangwei Wang, Chinese Academy of Sciences
Dan Evans (PSU technician)
Dr. Fred W. Allendorf, University of Montana, Missoula, MT
Dr. Bret W. Tobalske, University of Montana, Missoula, MT

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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?

LTER resources contribute to ongoing improvements in the physical infrastructure at HBR in three ways:

1) we are refining our realtime environmental sensor network and cross-checking new sensor data with historic analog data sets,

2) we continue to expand the capacity of our physical sample archive and to link archive samples with data streams, and

3) we continue a process of gradual replacement of aging stream weirs.

What is the impact on institutional resources that form infrastructure?

Nothing to report.

What is the impact on information resources that form infrastructure?

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

What is the impact on technology transfer?

Nothing to report.

What is the impact on society beyond science and technology?

Society is confronted with difficult choices about the degree of pollution abatement that is necessary to achieve desirable outcomes in terms of environmental quality. The long-term data sets from HBR-LTER provide among the best objective information available on which to base judgments about the threats of pollution to forest health, soil and water quality, and about the effectiveness of pollution abatement efforts in reducing those threats. Temporal trends can be evaluated against the backdrop of natural variation in reference and manipulated catchments, providing both parameter values and validation data for predictive models. Cost-effective environmental protection depends upon using these models to project the benefits of particular pollution abatement strategies. Hubbard Brook is a cornerstone of such efforts. Our research on the impact of forest pests on U.S. forests was a fundamental resource for a section of the U.S. House of Representatives Farm Bill that seeks to limit the importation of new forest pests into the country. A portion of this amendment was included in the final Farm Bill signed in to law in December 2018. US Customs and Border Protection used this information in deciding to strengthen the enforcement of current regulations regarding importation of forest pests.

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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.

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