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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 and objectives (you must provide information for at least one of the 4 categories below)?

Major Activities:

1. Hydropedology:

A major activity was the development of a new model to predict the location of bedrock outcrops and areas of shallow soil across the Hubbard Brook valley (Fraser et al. 2020). Identifying the areal extent of bedrock outcrops and shallow soils has important implications for understanding spatial patterns in vegetation composition and productivity, stream chemistry gradients, and hydrologic and soil properties of landscapes.

2. Changing Climate

Charles Driscoll and Julia Jones (H.J. Andrews LTER) are leading a cross-site analysis of climate change impacts at LTER sites resulting from a workshop at the 2018 All Scientist Meeting. Five manuscripts are being finalized (Introduction, Forests and Freshwaters, Drylands, Coastal, Marine) for submission as a series to BioScience).

The ongoing Climate Change Across Seasons Experiment (CCASE) was used to evaluate interactions between growing season warming and the ongoing process of nitrogen oligotrophication that has been observed at Hubbard Brook. This experiment warms soils 5 °C above ambient temperatures and induces winter freeze/thaw cycles to simulate projected changes over the next century. We measured rates of net nitrogen (N) mineralization, foliar N, and natural abundance foliar ¹⁵N (δ¹⁵N) in red maple (*Acer rubrum*) trees, and characterized soil microbial communities on these plots

The ongoing DroughtNet experiment began the first year of analysis of post-treatment recovery. This experiment

removed ~50% of throughfall from a plot, simulating a severe drought. In spite of limitations on bringing a field crew to the site, we continued monitoring core response variables including soil moisture, sapflow, and tree growth responses. Because a natural drought affected the area for most of the 2020 growing season, we plan to continue monitoring recovery for at least one additional year.

We analyzed eight years of bi-weekly snowpack and soil frost-depth measurements, and continuous soil climate monitoring to investigate the effects of variation in winter climate on soil microclimate throughout the whole year (Wilson et al. 2020).

3. Eddy flux tower:

We continued measurements at the Bartlett AmeriFlux tower, which has been in operation since 2004. These measurements include fluxes of carbon (C)/water/energy, and phenology. We added a snowpack thermal profile station to measure temperature in 10cm intervals; filling an important gap in our energy budget calculations. Using 2019 data, we conducted an analysis of the agreement between our tower measurements and the NEON BART tower located 100 m to the southeast. We updated the flux tower data this year with gap-filled values so that the data set can be used by the project in a broader suite of analyses.

Work on modeling the impacts of shifts in phenology on ecosystem processes has continued. The current focus is on integrating empirical and model-based analyses to predict how future shifts in phenology will impact C, N and water cycles in the White Mountain region. Data from phenology cameras were used in the multi-site analyses of uncertainty in remotely-sensed phenology (Bórnez et al 2020) and a Bayesian modeling analysis of deciduous forest phenology (Seyednasrollah et al 2020).

4. Changing atmospheric chemistry

This was the 10th year of N and phosphorus (P) fertilization in MELNHE (Multiple Element Limitation in Northern Hardwood Ecosystems). Efforts focused on analysis of the long-term record of leaf litter production and a year of frequent measures of soil respiration, repeating measurements of coarse woody debris in a chronosequence of forest sites, and study of beech bark disease in the MELNHE study.

Long-term effects to determine the source of nitrate in stream water have continued, with a focus on where in the catchment most stream water nitrate originates and the cause of an unexplained streamwater nitrate pulse in 2013 – 2014.

An additional focus has been on rates of N cycling and soil exoenzyme activities at depth, i.e., below 10 or 20 cm depth. We measured rates of gross and net N mineralization and nitrification as well as the potential activities of hydrolytic and oxidative enzymes at five soil depths (forest floor to 50 cm) at sites of varying age (45 and 100 years post-harvest and old growth) at and near Hubbard Brook (Darby et al. 2020).

We had 3 modelling activities over the past year: 1) a decomposition model to investigate the role of deadwood in the imbalance of the N budget; 2) integration of a biogeochemical model (PnET-CN) with a landscape-scale successional model (Landis); 3) translation of the PnET suite of models to the Python coding language to make it accessible to a broader range of users.

5. Changing Biota

We used spaceborne remote sensing to make regional estimates of canopy N, airborne remote sensing to assess mechanisms driving the relationship between canopy reflectance and canopy N/photosynthetic capacity, and to estimate various metrics of tree diversity to compare with stand productivity.

The Ecosystem Demography Model is being used to assess the sources of uncertainty in near-term forecasts and to forecast the potential impacts of hemlock woolly adelgid and emerald ash borer at Hubbard Brook. A major mechanistic focus in this model is the importance of mycorrhizal fungi on ecosystem processes such as soil respiration and decomposition rates of different leaf species.

We were able to continue the collection of data and development of models to explain interannual variation in the phenology of leaf-out and leaf senescence. We continued studies of spring ephemerals, soil invertebrates, and mycorrhizae in plots with and without ash trees.

We completed our third summer of drone missions over selected ash-containing sectors of Hubbard Brook with data acquisition on multiple dates during and after leaf expansion. These data are being used to develop computer-assisted identification, mapping, and enumeration of canopy ash trees via machine learning algorithms.

We continued bioacoustic monitoring for birds and bats (for the 6th year). This has produced the first contribution of

acoustic data from Hubbard Brook into the Environmental Data Initiative (Symes et al. 2021).

Due to COVID, we were largely unable to conduct valley-wide animal surveys via point-counts, but we were able to do one caterpillar survey that extended a time series of annual data that has been uninterrupted since 1985.

We completed a synthesis of tree allometric data obtained across stand age for forests within and near Hubbard Brook (Levine et al. 2020). Results from this analysis inform an in-progress upgrade of forest biomass quantification across Hubbard Brook Valley. We also contributed our hard-to-obtain allometric data to the global Plant Trait Database (Kattge et al. 2020).

We continued new work (begun in 2018) on stream ecology in the Hubbard Brook Valley. Our objective is to build a time series dataset for weekly stream algal biomass, instream decomposition, organic matter standing stocks, and emerging aquatic insects. We are also working to calculate autotrophic assimilation of nitrate using sensors and to synthesize all stream macroinvertebrate work at Hubbard Brook from 1965-present.

Due to COVID, data from 26 Hubbard Brook wildlife cameras were recovered only once, in late June 2020. Camera image occurrence and occupancy data were used to validate a habitat suitability prediction model.

We were able to complete a full, three-month field season of stream salamander sampling in 2020. We completed intensive capture-mark-recapture (CMR) surveys on three study streams..

Specific Objectives:	
Significant Results:	<div>1. Hydopedology:<p>The new model to predict the location of bedrock outcrops and shallow soil across the Hubbard Brook valley resulted in a 79% accuracy of interpreting deep soil locations and 84% accuracy in distinguishing areas of shallow soil (Fraser et al. 2020). This model will be useful for expanding digital hydopedological mapping for the entire Hubbard Brook watershed since these shallow soils exert control on lateral soil development.</p><div>2. Climate Change</div><p>Results from the CCASE experiment (papers by Harrison et al. 2020) showed that growing season warming led to increased rates of transpiration up to 727%, even when trees were exposed to increased frequency of soil freeze/thaw cycles in winter. The combination of growing season warming and winter soil freeze/ thaw cycles altered the depth from which trees take up water. Growing season warming may counteract the trend toward nitrogen oligotrophication in northern hardwood forests by increasing rates of net mineralization and nitrogen availability for trees. Soil microbial communities shifted with changes in soil temperatures (Garcia et al. 2020).</p><p>The elevation/aspect gradient analyses of the effects of variation in winter climate on soil microclimate throughout the whole year found that snowpacks with lower seasonal snow water equivalents resulted in more soil temperature variation and deeper soil frost but had no effect on variation in soil moisture (Wilson et al. 2020). Seasonal snow water equivalent of the snowpack influenced the date of rapid soil warming in the spring, which in turn influenced both summer soil moisture and an index of annual cumulative soil heat.</p><p>Comparison of measurements from the Bartlett AmeriFlux tower with the the NEON BART show that energy, water, and CO2 fluxes, the measurements were well-correlated between the two towers (Figure 1). However, for CO2 we found that wavelet analysis indicated much lower spectral energy for the NEON measurements. We therefore cannot yet conclude that the continuity between our AmeriFlux measurements and the NEON measurements is robust enough to permit us to discontinue our own measurements.</p><p>Seyednasrollah et al. (2020) used hierarchical Bayesian state-space modeling to investigate the controls on phenological transitions in deciduous forests. We found that green-up is more sensitive to temperature at warmer sites, but fall is more sensitive to moisture availability. If the climate continues to change as currently projected, we predict that the timing of spring will exhibit more dramatic swings in onset, but the timing of autumn will likely become less sensitive to moisture availability in the next 50 years.</p><p>Richardson et al (2021) used samples collected in Bartlett NH to investigate how leaf optical properties change as leaves mature over the 8 weeks following leafout (Figure 2). The shape and magnitude of mid-infrared (MIR) reflectance spectra changed markedly with development, and MIR spectral differences among species became more pronounced and unique as leaves matured. Our results point to the potential for using MIR spectroscopy to better understand species-level differences in cuticular development and composition.</p></div>

Data from the new snowpack thermal profile that was added at the flux tower were analyzed with a machine-learning algorithm to understand the probable drivers of evapotranspiration (ET). We found that C flux, net radiation, and vapor pressure deficit to be most important. High ET days appear to be associated with high pressure systems and cold frontal passages.

3. Changing atmospheric chemistry

Analysis of results from MELNHE showed that after 8 years of NxP fertilization tree growth was limited by N in young forests and by P in mid-successional forests. Separating ecto- from arbuscular-mycorrhizal tree species revealed nutrient co-limitation of AM species in mature forest.

Long-term effects to determine the source of nitrate in stream water found that the majority of the nitrate in comes from bedrock-controlled hotspots of nitrate production, often higher up in the watershed. Analysis of GIS data layers of mapped instream barriers and previously collected water quality data have shown the impact of these features on nutrient concentrations.

The analyses of rates of N cycling and soil exoenzyme activities at depth found that as expected, rates of N cycling and potential enzyme activities per unit soil mass correlated strongly with soil carbon (C) concentration, and these parameters declined exponentially with increasing soil depth (Darby et al. 2020). After normalization per unit soil organic matter, N cycling rates and specific enzyme activities generally decreased little with depth within the mineral soil (Figure 3). Gross N mineralization rates correlated with specific activities of those enzymes that hydrolyze cellulose and N-rich glucosamine polymers, but not those that degrade protein or more complex C compounds. Hence, gross N cycling appears to be associated with the N released during microbial N recycling, rather than from decomposition of soil organic matter. Across the three stands, the youngest had a larger ratio of N- to-phosphorus-acquiring enzyme activities, indicating a greater N demand in younger than older forests. For all three stands, mineral soil below 10 cm contributed 30–53% of total gross and net N cycling per unit area to 50 cm depth. These results support the inclusion of often-ignored mineral subsoils and microbial N recycling in both ecosystem N budgets and in model simulations.

4. Changing biota

Work on the importance of mycorrhizal fungi on ecosystem processes found that rates of soil respiration were higher in plots dominated by arbuscular mycorrhizal (AM)-associated trees than in plots dominated by ectomycorrhizal (ECM)-associated trees (Figure 4) (Lang et al. 2020). These differences are likely explained by the slightly higher nitrogen concentrations and deeper organic horizons in soil within AM plots. Studies of decomposition rates of different leaf species found that intact mycorrhizae accelerated leaf decomposition regardless of the functional identity of the mycorrhizae (Lang et al. 2021) (Figure 5). Our results highlight the importance of mycorrhizal associations to C cycling processes.

Bioacoustic monitoring for birds and bats produced the first contribution of acoustic data from Hubbard Brook into the Environmental Data Initiative (Symes et al. 2021).

The 2020 caterpillar survey picked up a conspicuous increase in caterpillars from what have been historically low levels for the last 8-10 years.

After three years of a new data collection effort on stream ecology, we have found that algal biomass accrues throughout the summer in all streams, but only in habitats protected from flood scour. Over three years, peak algal biomass has varied considerably among watersheds and years. We are particularly interested in understanding how winter snow and ice dynamics alter spring algal biomass accrual (and ecosystem productivity). Stream insect emergence peaks in the spring with the magnitude varying with algal biomass across years. We also measured a surprising autumn emergence peak in most streams in one year and are examining what causes these peaks.

Data from Hubbard Brook wildlife cameras have positively identified 16 different mammal species, including the pine marten, a species of concern in New Hampshire. Detection rates/activity levels for January – June 2020 were highest for coyotes, followed by red fox, and moose and deer.

We published four papers on salamanders in 2020. These papers show that (1) salamanders that live in the riskiest habitats disperse the farthest, (2) salamanders can impose strong top-down effects on stream invertebrate communities, (3) the biomass of stream biofilms increases with light availability, nutrient availability, and lower acidity. We also published a review paper on how increasing climate variability will affect metamorphic species.

Key outcomes
or Other
achievements:

The Information Management System at HBR continues to address these primary 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 HBR website, the EDI data portal, and DataONE. Ongoing data package development addresses time-series additions to our core data sets and the addition of new data sets. The HBR data catalog contains over 210 data packages ranging from single year studies to longterm data collections. Seventy two new data packages have been added in this LTER funding cycle, in addition to the long-term datasets that are revised annually. Core long-term datasets include 20 data packages containing data collected for more than 50 years, and another 30 covering a timespan of more than 20 years. The HBR data catalog on <https://hubbardbrook.org> is structured to provide local browse/search capabilities, with metadata and data access linked directly to the EDI dataset landing page. All HBR datasets include the LTER Data Access Policy, and are considered Type I, with a goal of release to the general public within 2 years from the time of collection.

In 2020, we transitioned to the EML Assemblyline for R workflow to support data package development and management (developed by the Environmental Data Initiative; EDI). In addition, HBR-IM has developed a metadata template (a spreadsheet that is filled in by IM or data contributors), and an accompanying R script that extracts all elements from the spreadsheet and feeds information into the EML Assemblyline workflow. Although there are several workflow approaches adopted within the LTER community, this choice was made based on the solid EDI support for the code supporting this workflow, and support from EDI staff and training materials. The workflow is also easily adopted for non LTER datasets, and EDI training/staff has supported LTER researchers in curating data that they have collected beyond the scope of HBR-LTER. A final nudge in this direction was in response to the Covid-19 pandemic – the transition to remote work increased data submissions, while also limiting physical access to the server that the previous workflow relied upon. The EMLAssemblyline workflow environment is organized in a modular form, with all dataset components existing within an individual file folder (metadata templates, data entities, and EMLAssemblyline R script). Transition to this workflow added independence in the remote work environment, and has substantially increased the speed with which HBR-IM can generate data packages.

Website: The HBR website (<http://hubbardbrook.org>) is the primary means by which HBR information is disseminated. Although this website is only several years old, we are in the process of migrating the website to Wordpress on a cloud-based platform. The advantages of this move are numerous, and are responsive to the HBR mid-term review, which suggested the use of cloud-based services where possible/affordable. A highly customized website and associated database was necessary prior to the availability of EDI and associated API's to generate site-specific data catalogs. We leverage this resource by providing browse/search/filter capabilities on the HBR website, while using the data access and delivery functions provided by EDI.

The current website provides the following functionality:

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

HBR-IM Activities/Projects:

- *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 semantics working group and the non-tabular data working group.
- *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* - Virtual meeting; August 10, 2020
Ecological Society of America (ESA) Annual Meeting - Virtual Meeting; August 2020

*** 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. In 2020 we were forced to drastically reduce our on-site activities and only hosted 3 graduate students and 4 undergraduates for extended stays.

Despite the limitations on in-person programs this past year, the site did enhance our school-year student training by initiating a new program run by the Hubbard Brook Research Foundation (HBRF), called the Young Voices of Science. HBRF is a non-profit group dedicated to synthesis, outreach, education, and support of facilities associated with the HBR-LTER. This program, run remotely, hosted 21 students from 11 institutions its inaugural fall cohort. The program is designed to give graduate and undergraduate students in environmental fields training and experience with public engagement early in their careers. The students attended five expert-led Zoom workshops: 1) Introduction to the STEM Ambassador Program, 2) Creative Writing and Opinion Pieces, 3) The Art of Storytelling, 4) Engaging with Policymakers, and 5) Empathy and Science Communication. The students are now in the outreach phase of the program—designing outreach projects of their own, with one-on-one support from HBRF staff. We expect to invite a second cohort of students in late winter, 2021.

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. 2020 activities included:

- Coordinating a “Zoom a scientist” program connecting Hubbard Brook scientists with classrooms. Four Hubbard Brook scientists participated and presentations included amphibians, invasive pests, birds, and the Hubbard Brook LTER children’s book.
- Supporting and maintaining data lessons on the Hubbard Brook website, including developing two new lessons and updating a third.
- Presenting at teacher training workshops
- Continuing ongoing work with partners on two 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.

*** Have the results been disseminated to communities of interest? If so, please provide details.**

Despite the challenges of the COVID pandemic, the Hubbard Brook community maintained their commitment to meeting with one another through their regular Committee of Scientists (COS) meetings, held four times a year, and adapted to a remote format in 2020. The July meeting included the 57th such annual meeting for the project, composed of two half-days of ongoing and proposed Hubbard Brook research presentations from senior investigators, post-docs, and both graduate and undergraduate students, as well as a half-day COS meeting.

The Hubbard Brook Research Foundation (HBRF) leads Hubbard Brook’s public engagement with science (PES) 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 2020, regional stakeholder initiatives included:

- Holding a stakeholder symposium focused on the Ice Storm Experiment held in Concord, NH. Attendees included meteorologists, arborists, landowners, and utility workers. A research brief was prepared for the event and can be viewed at <https://hubbardbrook.org/articles/ice-storm-manipulation-experiment-northern-hardwood-forest>
- Developing a science center exhibition about the Hubbard Brook Ice Storm Experiment for the McAuliffe-Shephard Discovery Center in Concord, NH.
- Developing an External Advisory Committee for the USDA’s Northeastern States Research Cooperative to create a mechanism for stakeholders, including state land managers, small private landowners, large private land managers, Federal land managers, and wildlife professionals to give shape to research funding goals in northeastern forests.
- Presenting to the USDA Forest Service’s Northeast-Midwest State Foresters’ Alliance Forest Resources Planning Committee Meeting on integrating stakeholder engagement into Hubbard Brook research.
- Participating in a panel discussion on encouraging research-practice partnerships in informal science education and science communication at the Association of Science and Technology Centers (ASTC) conference with the Center for the Advancement of Informal Science Education (CAISE).
- Convening a workshop for Conservation Commissioners in New Hampshire focusing on the concept of indicators of community and ecological resilience developed by the group leading the NSF-funded Public Engagement with Science project on community and ecological resilience.
- Convening a Hubbard Brook Stakeholder Advisory Council in May 2020 to share progress on the community and ecological resilience synthesis project, including scientific presentations about ecological resilience at Hubbard Brook and discussions about stakeholder interests and concerns related to community and ecological resilience.
- Holding a science briefing for U.S. congresswoman Annie Kuster via Zoom in August.

Releasing a public synthesis report about winter climate change, based on a multi-year regional synthesis study and a series of stakeholder roundtable dialogues: Confronting Our Changing Winters: <http://multimedia.hubbardbrook.org/confronting-our-changing-winters>

- Partnering with Northern Woodlands magazine to share science stories from the Hubbard Brook LTER, including a feature video: The Birds of Hubbard Brook: <https://northernwoodlands.org/resilient-forest/part-3-the-birds-of-hubbard-brook>

In addition, the HBRF coordinates regular internal and external outreach efforts focused on community building within our existing networks. In 2020 we maintained Hubbard Brook’s suite of science communication programs, including updates to the Hubbard Brook website (full redesign coming in 2021), a multimedia storytelling site, a system of regular press releases, a suite of e-newsletters, and a strong social media campaign (i.e., Facebook, Twitter). We regularly publish two newsletters, in addition to more ad-hoc social media dialogue:

- Our internal e-newsletter, called the Hubbard Brook Monthly, is 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.
- Hubbard Brook Research Foundation news, a quarterly newsletter, focused on science, education, and outreach updates from the Hubbard Brook community to interested residents and visitors to the White Mountains and Northern Forest regions, including decision-makers, partners, and supporters.

Diversity, Equity, and Inclusion initiatives at the HBR-LTER

The leadership at Hubbard Brook prides itself on not only producing excellent research but on training and supporting students and younger scientists. We realize that historically, our approach has left marginalized people without access to the opportunities we provide, and some people feeling unwelcome or unsupported when they do interact with our project. We are addressing this as a community and are currently participating in a broad, HBR-wide dialogue on how to make our site better reflect the diversity of backgrounds and perspectives in our country, both through active recruitment and student support. This effort is lead by the HBR site representatives on the LTER network’s Diversity, Equity, and Inclusion (DEI) committee.

In 2020, our efforts included a community-wide dialogue and brainstorming session at the annual cooperators' meeting in July, resulting in the formation of a Hubbard Brook DEI working group, which holds regular monthly meetings. The Hubbard Brook DEI group has undertaken the following tasks, beginning in 2020

- Updating the complaints procedure at Hubbard Brook.
- Developing a mechanism for anonymous feedback.
- Establishing a field gear bank to better equip summer field students who might not arrive fully prepared for rigorous fieldwork.
- Drafting a Land Acknowledgement.
- Working with the ESA's SEEDS program to bring a field trip to Hubbard Brook.
- Reporting back and soliciting feedback and ideas from the Committee of Scientists at our winter project meeting. Winter breakout group topics included: increasing social interaction, inclusive recruiting for this field season, inclusive recruiting of Pis, indigenous knowledge and building a regional Tribal coalition, enabling anonymous feedback, and establishing a shared code of conduct.

* 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.

Other highlights for 2021 include preparing a renewal proposal and continuintg to develop efforts on diversity, equity and inclusion.

Supporting Files				
	Filename	Description	Uploaded By	Uploaded On
(Download)	Hubbard Brook narrative 2020 - Figures.pdf	Figures	Peter Groffman	02/25/2021

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Products

Books

Book Chapters

Alber, M., A. Blair, C. T. Driscoll, H. Ducklow, T. Fahey, W. R. Fraser, J. E. Hobbie, D. M. Karl, S. E. Kingsland, A. Knapp, E. Rastetter, T. Seastedt, G. Shaver and R. B. Waide (2020). Sustaining Long-Term Ecological Research: Perspectives from Inside the LTER Program. *The Challenges of Long Term Ecological Research: A Historical Analysis. Submitted to the series Archimedes: New Studies in the History and Philosophy of Science and Technology* Waide, R. B. and S. E. Kingsland, (eds.). Springer. Chapter 4. Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes ; ISBN: 978-3-030-66932-4.

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Inventions

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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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Other Publications

van Doorn, N.S., L.A. Roman, et al. (1 of 17 co-authors). (2020). *Urban tree monitoring: a field guide*. General Technical Report NRS-GTR-194. USDA Forest Service. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

(1 of 19 co-authors). Roman, L.A, van Doorn N.S., et al. (2020). *Urban tree monitoring: a resource guide*. General Technical Report PSW-GTR-266. USDA Forest Service. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Patent Applications

Technologies or Techniques

Thesis/Dissertations

Shan Shan. *Controls of nutrient limitation on resource allocation belowground*. (2020). Miami University. 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

Shijie Guo. *GIS-Based Wildlife Activity and Habitat Modeling using wildlife cameras: A study of the Hubbard Brook Moose*. (2020). Vassar College. Acknowledgement of Federal Support = No

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

Lang, Ashley K.. *Mycorrhizal fungi as drivers of soil carbon dynamics in northern temperate forests.*. (2020). Dartmouth College. 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 or Other Internet Sites

WaterViz
<https://waterviz.org/>

WaterViz for Hubbard Brook represents the nexus between the hydrologic sciences, visual arts, music, and information design.

Hydrologic data, captured from a small watershed at the Hubbard Brook Experimental Forest in the White Mountains of New Hampshire using an array of environmental sensors, is transmitted to the internet and used to drive a computer model that calculates all components of the water cycle for the catchment *in real time*. These data, in turn, drive artistic visualizations and sonifications of the water cycle, reflecting the hydrologic processes occurring at that moment in time.

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Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Groffman, Peter	PD/PI	1
Ayres, Matthew	Co PD/PI	1
Fisk, Melany	Co PD/PI	1
Templer, Pamela	Co PD/PI	1
Asbjornsen, Heidi	Co-Investigator	0
Bailey, Scott	Co-Investigator	2
Battles, John	Co-Investigator	2
Bernhardt, Emily	Co-Investigator	1
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	2
Johnson, Chris	Co-Investigator	1
Kelsey, Eric	Co-Investigator	1
Lavallee, Anthea	Co-Investigator	2
Lovett, Gary	Co-Investigator	1
Lowe, Winsor	Co-Investigator	1
Matthes, Jaclyn	Co-Investigator	1
McGuire, Kevin	Co-Investigator	1
Ollinger, Scott	Co-Investigator	1
Pardo, Linda	Co-Investigator	2
Richardson, Andrew	Co-Investigator	1
Rosi, Emma	Co-Investigator	1
ter Hofstede, Hannah	Co-Investigator	1
Vadeboncoeur, Matthew	Co-Investigator	1
Yanai, Ruth	Co-Investigator	1
Chiasson, Clara	Other Professional	3
Garlick, Sarah	Other Professional	2
Martin, Mary	Other Professional	10
Swartz, Leah	Other Professional	0
Thorne, Sarah	Other Professional	0
Wilson, Geoff	Other Professional	10
Gewirtzman, Jonathan	Technician	1
Heather, Malcom	Technician	1
Koppers, Mary	Technician	8
LeMoine, Jim	Technician	1
LoRusso, Nicholas	Technician	6
Martel, Lisa	Technician	3
Michael, Seitz	Technician	3
Montesdeoca, Mario	Technician	2
Stewart, Anthony	Technician	2
Vollmer, Hannah	Technician	1
Wooster, Tammy	Technician	3
Burakowski, Elizabeth	Staff Scientist (doctoral level)	0
Ouimette, Andrew	Staff Scientist (doctoral level)	2
Zhou, Zaixing	Staff Scientist (doctoral level)	2

Baillargeon, Kaitlyn	Graduate Student (research assistant)	3
Benton, Joshua	Graduate Student (research assistant)	1
Blumenthal, Noah	Graduate Student (research assistant)	1
Bower, Jenny	Graduate Student (research assistant)	3
Butler, Samuel	Graduate Student (research assistant)	1
Cochrane, Maddy	Graduate Student (research assistant)	4
Hastings, John	Graduate Student (research assistant)	3
Jevon, Fiona	Graduate Student (research assistant)	1
Kernan, Ciara	Graduate Student (research assistant)	1
Kreitinger, Elizabeth	Graduate Student (research assistant)	6
Lang, Ashley	Graduate Student (research assistant)	1
Mejia, Catalina	Graduate Student (research assistant)	5
Mike, Mahoney	Graduate Student (research assistant)	0
Pennino, Amanda	Graduate Student (research assistant)	3
Studer, Elizabeth	Graduate Student (research assistant)	5
Teets, Aaron	Graduate Student (research assistant)	6
Thellman, Audrey	Graduate Student (research assistant)	6
Valipour, Mahnaz	Graduate Student (research assistant)	2
Alexander, Young	Non-Student Research Assistant	0
Amy, Giovati	Non-Student Research Assistant	0
Claudia, Victoroff	Non-Student Research Assistant	0
Dillon, Gretchen	Non-Student Research Assistant	0
Kovari, Stephen	Non-Student Research Assistant	2
Sunghoon, Hong	Non-Student Research Assistant	0
Cox, Avery	Undergraduate Student	5
Edwards, Tyler	Undergraduate Student	5
Frost, Tanner	Undergraduate Student	3
Nieto, Marisy	Undergraduate Student	3
Pappas-Byers, Bronwyn	Undergraduate Student	1
Rothenberg, Anna	Undergraduate Student	1
Stockman, Sarah	Undergraduate Student	3
Tracewell, Jaime	Undergraduate Student	4
Wentzell-Brehme, Sage	Undergraduate Student	3
Kambhampaty, Abby	High School Student	0
Martinez, Victoria	Research Experience for Undergraduates (REU) Participant	2

Olson, Pratt	Research Experience for Undergraduates (REU) Participant	3
McCartney, Brenda	Other	0
Rubenstein, Maribeth	Other	6

Full details of individuals who have worked on the project:

<p>Peter M Groffman Email: pgroffman@gc.cuny.edu Most Senior Project Role: PD/PI Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Project management and ecosystem nitrogen cycling research.</p> <p>Funding Support: This grant and the City University of New York.</p> <p>Change in active other support: No</p> <p>International Collaboration: No International Travel: No</p>
<p>Matthew P Ayres Email: matthew.p.ayres@dartmouth.edu Most Senior Project Role: Co PD/PI Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Overall coordination of the following project areas: 2.3.5 Climate change, N availability, and forest food webs; 2.4.4 The incipient loss of Fraxinus from HBR; and 2.5.3 Spatial patterns of animal populations. Oversight of undergraduate research assistants, technicians, and Dartmouth graduate students for above project areas.</p> <p>Funding Support: This award and home institution.</p> <p>Change in active other support: No</p> <p>International Collaboration: No International Travel: No</p>
<p>Melany C Fisk Email: fiskmc@miamioh.edu Most Senior Project Role: Co PD/PI Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Interactions among N, P, and C; nutrient limitation of plant productivity and soil processes.</p> <p>Funding Support: This award and home institution.</p> <p>Change in active other support: No</p> <p>International Collaboration: No International Travel: No</p>
<p>Pamela H Templer Email: ptempler@bu.edu Most Senior Project Role: Co PD/PI Nearest Person Month Worked: 1</p> <p>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. I am leading a collaboration among scientists around the globe to synthesize atmospheric and stream nitrogen data from ILTER sites around the globe.</p>

<p>Funding Support: Funds from other federal grants.</p> <p>Change in active other support: No</p> <p>International Collaboration: Yes, Austria, China, Finland, France, Germany, Italy, Japan, Latvia, Norway, Poland, Spain, Sweden, Switzerland</p> <p>International Travel: No</p>
<p>Heidi Asbjornsen Email: heidi.asbjornsen@unh.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 0</p> <p>Contribution to the Project: Project management, data analysis and interpretation associated with the DroughtNet project</p> <p>Funding Support: Northeastern States Research Cooperative; New Hampshire Agricultural Experiment Station; University of New Hampshire – Iola Hubbard Climate Endowment</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Scott W Bailey Email: swbailey@fs.fed.us Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Lead researcher and field coordinator on the hydropedology study. 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.</p> <p>Funding Support: This grant and U.S. Forest Service</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>John J Battles Email: jbbattles@berkeley.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Co-lead scientist for long-term monitoring of primary productivity, forest composition and tree demography. Co-chair of the Science Coordinating Committee.</p> <p>Funding Support: This award</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Emily Bernhardt Email: emily.bernhardt@duke.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1</p> <p>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 Victoria Martinez. Advised undergraduate student Tyler Edwards who worked on counting emerged stream insect samples.</p> <p>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.</p> <p>International Collaboration: No</p> <p>International Travel: No</p>

<p>Denise Burchsted Email: dburchsted@keene.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Mapping instream disturbances and natural dams in the Hubbard Brook valley and quantifying their geomorphic and stream chemistry impacts.</p> <p>Funding Support: This award</p> <p>International Collaboration: No International Travel: No</p>
<p>Lynn Christenson Email: lychristenson@vassar.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Coordinate project and supervise all aspects of field work, data collection and data analysis.</p> <p>Funding Support: Other sources</p> <p>International Collaboration: No International Travel: No</p>
<p>Natalie L Cleavitt Email: nlc4@cornell.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 11</p> <p>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</p> <p>Funding Support: This award and Cornell University</p> <p>International Collaboration: Yes, Canada International Travel: No</p>
<p>Charles T Driscoll Email: ctdrisco@syr.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Designs and coordinates project, conducts data analysis and model simulations, works with students, technicians and other investigators.</p> <p>Funding Support: NSF DEB 1637685 (NSF Award #1457675)</p> <p>International Collaboration: Yes, China International Travel: No</p>
<p>Timothy J Fahey Email: tjf5@cornell.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Co-lead scientist for long-term monitoring of primary productivity, forest composition and tree demography.</p> <p>Funding Support: This award</p> <p>International Collaboration: No International Travel: No</p>
<p>Christine Goodale</p>

<p>Email: clg33@cornell.edu</p> <p>Most Senior Project Role: Co-Investigator</p> <p>Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Co-chair Science Coordinating Committee, Co-lead project on denitrification and environmental change and N bank; support leaf chemistry, sensors, and various stable isotopic measurements. Mentor graduate (Elizabeth Kreitinger, Catalina Mejia) and undergraduate students (REU Whitney Denison, Sr Honor thesis Nathaniel Fisher).</p> <p>Funding Support: NSF-1655818, this award, and Cornell University</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Mark Green</p> <p>Email: mbg78@case.edu</p> <p>Most Senior Project Role: Co-Investigator</p> <p>Nearest Person Month Worked: 2</p> <p>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.</p> <p>Funding Support: US Forest Service</p> <p>International Collaboration: Yes, Japan</p> <p>International Travel: No</p>
<p>Chris Johnson</p> <p>Email: cejohns@syr.edu</p> <p>Most Senior Project Role: Co-Investigator</p> <p>Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Research on soil chemistry and biogeochemistry.</p> <p>Funding Support: N/A</p> <p>International Collaboration: Yes, Sweden</p> <p>International Travel: No</p>
<p>Eric Kelsey</p> <p>Email: ekelsey2@plymouth.edu</p> <p>Most Senior Project Role: Co-Investigator</p> <p>Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Led activities to understand water and energy budgets, and evapotranspiration at the flux tower site, including data analysis and sensor maintenance at flux tower. Installed snowpack thermal-profile sensor and supervised research technician, Dan Evans.</p> <p>Funding Support: This LTER grant, Plymouth State University</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Anthea Lavallee</p> <p>Email: alavallee@hbresearchfoundation.org</p> <p>Most Senior Project Role: Co-Investigator</p> <p>Nearest Person Month Worked: 2</p> <p>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.</p> <p>Funding Support: This award, Forest Service Joint Venture agreement 15-JV-11242307-064, NSF ASIL Award for Public Engagement with Science</p> <p>International Collaboration: No</p> <p>International Travel: No</p>

Gary M Lovett

Email: lovettg@caryinstitute.org

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: In his final year as the Lead Principal Investigator, Dr. Lovett was responsible for the overall organization of the project and all related reporting and planning. In addition, Dr. Lovett conducted LTER-related research at Hubbard Brook

Funding Support: This grant and Cary Institute

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 is using long-term Hubbard Brook vegetation data to simulate and forecast ecosystem dynamics at the Hubbard Brook Experimental Forest. 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. This work supported three undergraduate reserachers in the 2020-2021 academic year.

Funding Support: This LTER grant, Wellesley College

International Collaboration: No

International Travel: No

Kevin McGuire

Email: kevin.mcquire@vt.edu

Most Senior Project Role: Co-Investigator

Nearest Person Month Worked: 1

Contribution to the Project: Conducts research on hydrology and hypedopedology, 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. Supervising one Ph.D. student on this project.

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

<p>Contribution to the Project: Carbon and nitrogen cycling, remote sensing, eddy flux, ecosystem modeling and regionalization, project oversight and reporting.</p> <p>Funding Support: Home institution and other grants</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Linda H Pardo Email: linda.pardo@usda.gov Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 2</p> <p>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.</p> <p>Funding Support: This grant and U.S. Forest Service</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Andrew Richardson Email: andrew.richardson@nau.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1</p> <p>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.</p> <p>Funding Support: Northern Arizona University faculty salary</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Emma J Rosi Email: rosie@caryinstitute.org Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Co-oversight of stream sampling. Supervises Heather Malcom and Tammy Wooster at Cary Institute who collect and analyze stream samples. Advised Audrey Thellman, PhD student at Duke, who works on the seasonal dynamics in stream algae. Advised REU student Victoria Martinez who measured examined long-term dynamics of pH and stream insects in NH streams.</p> <p>Funding Support: Institutional support</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Hannah ter Hofstede Email: Hannah.ter.Hofstede@dartmouth.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1</p> <p>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.</p> <p>Funding Support: This grant and Dartmouth University</p> <p>International Collaboration: No</p> <p>International Travel: No</p>

<p>Matthew A Vadeboncoeur Email: matt.vad@unh.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1</p> <p>Contribution to the Project: field logistics, data collection, and data analysis assocaited with drought experiment, forest ecophysiology, and MELNHE.</p> <p>Funding Support: Northeastern States Research Cooperative; New Hampshire Agricultural Experiment Station; University of New Hampshire – Iola Hubbard Climate Endowment; NSF EAR 1562127</p> <p>International Collaboration: No International Travel: No</p>
<p>Ruth D Yanai Email: rdyanai@syr.edu Most Senior Project Role: Co-Investigator Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Ruth coordinates the MELNHE project (Multiple Element Limitation in Northern Hardwood Ecosystems), which is one of the manipulative experiments of the Hubbard Brook LTER. 2020 was the tenth 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 year we completed a Bayesian analysis of precipitation volumes for all the monitored watersheds and made progress on a Monte Carlo analysis of runoff and solute export from Watershed 3.</p> <p>Funding Support: State University of New York</p> <p>International Collaboration: No International Travel: No</p>
<p>Clara Chiasson Email: cchiasson@hubbardbrookfoundation.org Most Senior Project Role: Other Professional Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Outreach and Communications Manager for the Hubbard Brook Research Foundation.</p> <p>Funding Support: NSF ASL award #1713204</p> <p>International Collaboration: No International Travel: No</p>
<p>Sarah Garlick Email: sarahgarlick@gmail.com Most Senior Project Role: Other Professional Nearest Person Month Worked: 2</p> <p>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.</p> <p>Funding Support: NSF ASL award #1713204</p> <p>International Collaboration: No International Travel: No</p>
<p>Mary Martin Email: mary.martin@unh.edu Most Senior Project Role: Other Professional Nearest Person Month Worked: 10</p> <p>Contribution to the Project: Information Manager</p> <p>Funding Support: This award, and US Forest Service Cooperative Agreement</p> <p>International Collaboration: No</p>

International Travel: No
Leah Swartz Email: leah.swartz@mso.umd.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: 0 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: wilson@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
Jonathan Gewirtzman Email: jgewirtz@bu.edu Most Senior Project Role: Technician Nearest Person Month Worked: 1 Contribution to the Project: Jonathan is responsible for assisting with field and laboratory work at Hubbard Brook and Boston University, respectively. Funding Support: Other sources 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: 8 Contribution to the Project: Field sampling and laboratory analysis of soils. Funding Support: N/A International Collaboration: No International Travel: No
Jim LeMoine Email: jim.le.moine@nau.edu Most Senior Project Role: Technician Nearest Person Month Worked: 1 Contribution to the Project: Assistance with maintenance of flux tower data Funding Support: Northern Arizona University 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
Seitz Michael Email: meseitz@syr.edu Most Senior Project Role: Technician Nearest Person Month Worked: 3 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

<div><div>Mario Montesdeoca Email: mmontesd@syr.edu Most Senior Project Role: Technician Nearest Person Month Worked: 2</div><div>Contribution to the Project: Coordinates field and laboratory activities. Oversees data management.</div><div>Funding Support: NSF DEB 1637685 (NSF Award #1457675)</div><div>International Collaboration: No International Travel: No</div></div>
<div><div>Anthony Stewart Email: ajs0428@uw.edu Most Senior Project Role: Technician Nearest Person Month Worked: 2</div><div>Contribution to the Project: Maintain environmental sensors and process data</div><div>Funding Support: NSF-1655818, this award</div><div>International Collaboration: No International Travel: No</div></div>
<div><div>Hannah Vollmer Email: hvollmer@hubbardbrookfoundation.org Most Senior Project Role: Technician Nearest Person Month Worked: 1</div><div>Contribution to the Project: Educator and Field/Maintenance Technician, Hubbard Brook Research Foundation</div><div>Funding Support: Forest Service</div><div>International Collaboration: No International Travel: No</div></div>
<div><div>Tammy Wooster Email: woostert@caryinstitute.org Most Senior Project Role: Technician Nearest Person Month Worked: 3</div><div>Contribution to the Project: Collects stream algae and insects</div><div>Funding Support: This award</div><div>International Collaboration: No International Travel: No</div></div>
<div><div>Elizabeth Burakowski Email: elizabeth.burakowski@gmail.com Most Senior Project Role: Staff Scientist (doctoral level) Nearest Person Month Worked: 0</div><div>Contribution to the Project: Ecosystem-climate interactions, modeling</div><div>Funding Support: Other sources</div><div>International Collaboration: No International Travel: No</div></div>
<div><div>Andrew Ouimette Email: andrew.ouimette@unh.edu</div></div>

<p>Most Senior Project Role: Staff Scientist (doctoral level)</p> <p>Nearest Person Month Worked: 2</p> <p>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.; Development of deadwood C and N cycling model.</p> <p>Funding Support: Other sources</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Zaixing Zhou</p> <p>Email: zaixingzhou@gmail.com</p> <p>Most Senior Project Role: Staff Scientist (doctoral level)</p> <p>Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Ecosystem modeling, simulation of C and N cycling, development of PnET-CN and PnET-SOM.; integration of PnET-CN and Landis</p> <p>Funding Support: This grant and other sources</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Kaitlyn Baillargeon</p> <p>Email: b2014@wildcats.unh.edu</p> <p>Most Senior Project Role: Graduate Student (research assistant)</p> <p>Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Biodiversity studies, remote sensing</p> <p>Funding Support: Other sources</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Joshua Benton</p> <p>Email: joshuabenton@vt.edu</p> <p>Most Senior Project Role: Graduate Student (research assistant)</p> <p>Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Examining shallow groundwater flow direction and flux</p> <p>Funding Support: Virginia Tech and another NSF grant</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Noah Blumenthal</p> <p>Email: blumennm@miamioh.edu</p> <p>Most Senior Project Role: Graduate Student (research assistant)</p> <p>Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Nutrient limitation of aboveground growth</p> <p>Funding Support: This award and Miami University</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Jenny Bower</p> <p>Email: Jennifer.bower@uvm.edu</p> <p>Most Senior Project Role: Graduate Student (research assistant)</p>

<p>Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Examining mineral weathering and solid phase chemistry across lateral gradients using a whole-regolith approach</p> <p>Funding Support: UVM and another NSF grant</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Samuel Butler Email: butlersj@miamioh.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Nutrient limitation of belowground processes</p> <p>Funding Support: This award and Miami University</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Maddy Cochrane Email: madaline.cochrane@umconnect.umd.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 4</p> <p>Contribution to the Project: Conducting studies on salamander responses to changes in headwater stream hydrology. Dissertation in progress, University of Montana</p> <p>Funding Support: This grant and University of Montana</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>John Hastings Email: jhc33@wildcats.unh.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Remote sensing, biodiversity, soil N data analysis</p> <p>Funding Support: Other sources</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Fiona Jevon Email: fiona.v.jevon.gr@dartmouth.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 1</p> <p>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.</p> <p>Funding Support: Stipend provided by Dartmouth College.</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Ciara Kernan Email: Ciara.E.Kernan.GR@dartmouth.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 1</p>

<p>Contribution to the Project: Conducting studies on bat ecology at Hubbard Brook. Ph.D. Dissertation in progress, Dartmouth College.</p> <p>Funding Support: Stipend provided by Dartmouth College. Dissertation research supported by research assistants and infrastructure.</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Elizabeth Kreitinger Email: eak59@cornell.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 6</p> <p>Contribution to the Project: Collect and interpret denitrificaiton data</p> <p>Funding Support: NSF-1655818, this award, and Cornell University</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Ashley K Lang Email: ashley.k.lang.gr@dartmouth.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Conducting studies of soil ecology in northeastern hardwood forests, bats within study. Ph.D. dissertation in progress, Dartmouth College.</p> <p>Funding Support: Dartmouth College stipend.</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Catalina Mejia Email: cm953@cornell.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 5</p> <p>Contribution to the Project: Collect and interpret denitrificaiton data</p> <p>Funding Support: NSF-1655818, this award, and Cornell University</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Mahoney Mike Email: mike.mahoney.218@gmail.com Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 0</p> <p>Contribution to the Project: Led a field sampling effort for beech bark disease.</p> <p>Funding Support: This award</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Amanda Pennino Email: penninoa@vt.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Investigating weathering fluxes as solute sources to streams.</p>

<p>Funding Support: This grant, another NSF grant and Virginia Tech</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Elizabeth A Studer Email: elizabeth.a.studer.gr@dartmouth.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 5</p> <p>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.</p> <p>Funding Support: Dartmouth University stipend</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Aaron Teets Email: aft49@nau.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 6</p> <p>Contribution to the Project: Research on vegetation phenology, and impact of phenology on ecosystem processes related to C and H2O</p> <p>Funding Support: This award and Northern Arizona University</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Audrey Thellman Email: audrey.thellman@duke.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 6</p> <p>Contribution to the Project: Ran stream algae samples and investigating seasonal patterns of stream ecology</p> <p>Funding Support: Funded by NASA FINESST fellowship and Duke University</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Mahnaz Valipour Email: mvalipou@syr.edu Most Senior Project Role: Graduate Student (research assistant) Nearest Person Month Worked: 2</p> <p>Contribution to the Project: Research on simulation of the hydrologic and biogeochemical effects of forest harvesting.</p> <p>Funding Support: NSF DEB 1637685 (NSF Award #1457675)</p> <p>International Collaboration: No</p> <p>International Travel: No</p>
<p>Young Alexander Email: alexyoung.116@gmail.com Most Senior Project Role: Non-Student Research Assistant Nearest Person Month Worked: 0</p> <p>Contribution to the Project: Weighed and applied fertilizer.</p> <p>Funding Support: This award</p>

International Collaboration: No
International Travel: No

Giovati Amy
Email: agiovati@syr.edu
Most Senior Project Role: Non-Student Research Assistant
Nearest Person Month Worked: 0

Contribution to the Project: Weighed and applied fertilizer.

Funding Support: This award

International Collaboration: No
International Travel: No

Victoroff Claudia
Email: cnvictor@syr.edu
Most Senior Project Role: Non-Student Research Assistant
Nearest Person Month Worked: 0

Contribution to the Project: Weighed and applied fertilizer.

Funding Support: This award

International Collaboration: No
International Travel: No

Gretchen Dillon
Email: gretchenadillon@gmail.com
Most Senior Project Role: Non-Student Research Assistant
Nearest Person Month Worked: 0

Contribution to the Project: Laboratory activities including sample processing and quality control.

Funding Support: This award

International Collaboration: No
International Travel: No

Stephen Kovari
Email: stkovari@vassar.edu
Most Senior Project Role: Non-Student Research Assistant
Nearest Person Month Worked: 2

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

Funding Support: Vassar College

International Collaboration: No
International Travel: No

Hong Sunghoon
Email: hoone0416@gmail.com
Most Senior Project Role: Non-Student Research Assistant
Nearest Person Month Worked: 0

Contribution to the Project: Weighed and applied fertilizer.

Funding Support: This award

International Collaboration: No
International Travel: No

<p>Avery Cox Email: averybcox@hotmail.com Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 5</p> <p>Contribution to the Project: Soil ecology</p> <p>Funding Support: This award</p> <p>International Collaboration: No International Travel: No</p>
<p>Tyler Edwards Email: tyler.edwards@duke.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 5</p> <p>Contribution to the Project: Counted and identified emerged stream insects from HB streams.</p> <p>Funding Support: Duke University- Work study and Bernhardt Discretionary, REU from HB LTREB</p> <p>International Collaboration: No International Travel: No</p>
<p>Tanner Frost Email: tanner.frost@unh.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 3</p> <p>Contribution to the Project: analysis of tree cores collected from the DroughtNet experiment</p> <p>Funding Support: University of New Hampshire (Summer Undergraduate Research Fellowship)</p> <p>International Collaboration: No International Travel: No</p>
<p>Marisy Nieto Email: mn103@wellesley.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Summarized data for ED2 modeling</p> <p>Funding Support: This award</p> <p>International Collaboration: No International Travel: No</p>
<p>Bronwyn Pappas-Byers Email: bpappasbyers@vassar.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Identify animals from wildlife camera project images</p> <p>Funding Support: other</p> <p>International Collaboration: No International Travel: No</p>

<p>Anna Rothenberg Email: arothenberg@vassar.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 1</p> <p>Contribution to the Project: Identify animals from wildlife camera project images</p> <p>Funding Support: other</p> <p>International Collaboration: No International Travel: No</p>
<p>Sarah Elizabeth Stockman Email: sstockman@wellesley.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Developed data analysis pipeline for Valleywide Plots</p> <p>Funding Support: This award</p> <p>International Collaboration: No International Travel: No</p>
<p>Jaime Tracewell Email: jt2@wellesley.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 4</p> <p>Contribution to the Project: Developed data analysis pipeline for Valleywide Plots</p> <p>Funding Support: This award</p> <p>International Collaboration: No International Travel: No</p>
<p>Sage Wentzell-Brehme Email: swentzel@wellesley.edu Most Senior Project Role: Undergraduate Student Nearest Person Month Worked: 3</p> <p>Contribution to the Project: Modeled long-term changes in red oak seedling survival</p> <p>Funding Support: This award</p> <p>International Collaboration: No International Travel: No</p>
<p>Abby Kambhampaty Email: abby.kambhampaty@gmail.com Most Senior Project Role: High School Student Nearest Person Month Worked: 0</p> <p>Contribution to the Project: Laboratory activities including sample processing and quality control.</p> <p>Funding Support: This award</p> <p>International Collaboration: No International Travel: No</p>
<p>Victoria Martinez Email: vicmer714@gmail.com</p>

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

Nearest Person Month Worked: 2

Contribution to the Project: Examined long-term data chemistry and insect data collected on NH 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:

Pratt Olson

Email: pmolson@middlebury.edu

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

Nearest Person Month Worked: 3

Contribution to the Project: Pratt collected soils information along transects, as well as detailed profile descriptions and samples, to document the character and occurrence of poorly drained soils (Inceptisols and Histosols) across the whole Hubbard Brook Valley.

Funding Support: This award

International Collaboration: No

International Travel: No

Year of schooling completed: Junior

Home Institution: Middlebury college

Government fiscal year(s) was this REU participant supported: 2020

Brenda McCartney

Email: bmccartney@hubbardbrookfoundation.org

Most Senior Project Role: Other

Nearest Person Month Worked: 0

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: 6

Contribution to the Project: Reporting, HB Cooperators meeting and Outreach as requested, DEI committee member, other administrative 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.

Were other collaborators or contacts involved? If so, please provide details.

- 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
- 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 have contributed to a 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 reaching 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 was the impact on teaching and educational experiences?

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.

2020 activities included:

- Coordinating a “Zoom a scientist” program connecting Hubbard Brook scientists with classrooms. Four Hubbard Brook scientists participated and presentations included amphibians, invasive pests, birds, and the Hubbard Brook LTER children’s book.
 - Supporting and maintaining data lessons on the Hubbard Brook website, including developing two new lessons and updating a third.
- Presenting at teacher training workshops

Continuing ongoing work with partners on two 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.

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 real-time 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 link archive samples with data streams.
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 Information Management System at HBR maintains access to HBR data, with an emphasis on high quality data/documentation and data preservation, enables data discovery/access to the HBR, LTER, and broader scientific communities, and maintains a website to share information on site history, current research, publications, photos, educational materials. HBR data are submitted to the Environmental Data Initiative (EDI) repository, and are discoverable by searching the HBR website, the EDI data portal, and DataONE. The HBR data catalog contains over 210 data packages ranging from single year studies to longterm data collections. Core long-term datasets include 20 data packages containing data collected for more than 50 years, and another 30 covering a timespan of more than 20 years. All HBR datasets include the LTER Data Access Policy, and are considered Type I, with a goal of release to the general public within 2 years from the time of collection.

What is the impact on technology transfer?

The Hubbard Brook Research Foundation (HBRF) leads Hubbard Brook’s public engagement with science (PES) 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 2020, regional stakeholder initiatives included:

- Holding a stakeholder symposium focused on the Ice Storm Experiment held in Concord, NH. Attendees included meteorologists, arborists, land owners, and utility workers. A research brief was prepared for the event and can be viewed at: <https://hubbardbrook.org/articles/ice-storm-manipulation-experiment-northern-hardwood-forest>
- Developing a science center exhibition about the Hubbard Brook Ice Storm Experiment for the McAuliffe-Shephard Discovery Center in Concord, NH.
- Developing an External Advisory Committee for the USDA's Northeastern States Research Cooperative to create a mechanism for stakeholders, including state land managers, small private landowners, large private land managers, Federal land managers, and wildlife professionals to give shape to research funding goals in northeastern forests.

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 into 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.

What percentage of the award's budget was spent in a foreign country?

Nothing to report.

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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.

Change in primary performance site location

Nothing to report.

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