Northeastern States Research Cooperative (NSRC) FY2024
USDA FS Award #: 23-DG-11242311-0240

Interim Progress Report
Period ending December 31, 2024

Administration and Information Transfer

The Northeastern States Research Cooperative (NSRC; https://nsrcforest.org/) is a research-granting program administered collaboratively by the USDA Forest Service Northern Research Station, the Rubenstein School of Environment and Natural Resources at the University of Vermont, the Department of Natural Resources and the Environment at the University of New Hampshire, the Center for Research on Sustainable Forests at the University of Maine, the State University of New York College of Environmental Science and Forestry, and the Hubbard Brook Research Foundation.

NSRC's goal is to foster research that is relevant and beneficial to the people who live within the Northern Forest boundaries, work with its resources, use its products, visit it, and care about it. The specific objectives of the NSRC are to:

1. Facilitate a multi-partner platform for the Northern Forest to inform research priorities and recruit a strategic roster of research and Indigenous forest knowledge projects.
2. Support high priority scientific research through efficient research administration, data archiving and sharing, and annual financial and technical monitoring and reporting.
3. Share and foster dialog to increase knowledge and impact of research.

Summary of progress in 2024

Between January 1, and December 31, 2024, NSRC:

- Conducted outreach and communications activities to increase the visibility of the NSRC with people who live within the Northern Forest boundaries, work with its resources, use its products, visit it, and care about it.
- Monitored and tracked all research and IFKF projects.
- Organized a special session at the 2024 Forest Ecosystem Monitoring Cooperative conference in Burlington, Vermont, highlighting research from 2020 and 2021 projects to over 50 people.
- Rebranded NSRC with activities including updated colors, a new logo, and a redesigned NSRC website. The new website is set to launch in the Spring/Summer of 2025.
- Initiated collaboration with the Northern Research Station communications team.
- Modified reporting workflows to include more robust review of research progress based on information contained in annual reports.

The objectives and tasks described in the NSRC 2023 proposal narrative are on schedule and described below.

1. Facilitate a multi-partner platform for the Northern Forest to inform research priorities and recruit a strategic roster of research and Indigenous forest knowledge projects.
   - EAC formed–Complete.
   - EAC meets and recommends priorities for research—Complete.
   - Successful RFP process—Complete. 2 RFPs were released through this award.
     - **The general fund** received 49 research project proposals requesting $14 million in funding; 17 grants were awarded totaling nearly $4.5 million of federal funding and close to $2 million of matching funding.
     - **The IFKF** received 10 proposals requesting $3.2 million in funding; 6 grants awarded totaling nearly $2 million in funding.
   - Research projects awarded—Complete, view all of the projects on our website and in Table 1 below.

- IFKF projects awarded—Complete, view all of the projects on our website

2. Support high priority scientific research through efficient research administration, data archiving and sharing, and annual financial and technical monitoring and reporting.
   - Annual technical and financial reporting—Ongoing. In 2024, the NSRC management team modified reporting mechanisms to include more robust reviewal of research proposal activities and actual activities as well as more direct reports.
   - Research outputs, to include scholarly and public-facing publications and activities—Ongoing. In 2024, this award supported 4 scholarly articles, 8 presentations, and at least 5 other products (see appendix A). Additionally, these research projects have supported 12 graduate students and 14 undergraduate students in 2024.
   - Project data archived with the FEMC— Ongoing. An NSRC collection with available data is accessible on the FEMC website.

3. Share and foster dialog to increase knowledge and impact of research.
   - Communications outputs—New NSRC logo, FEMC conference special session, print publications, press releases, and project specific communications materials.
   - NSRC website with current list of projects, research outputs—Communications team is in the process of updating the website. The current website is used by PIs and partners to find projects, RFP information, and publications.
   - Engagement with partners and the public—Ongoing

On February 1, 2024, NSRC announced 17 grants totaling nearly $4.5 million of federal funding and close to $2 million of matching funding. This is the largest single year of research funding NSRC has provided.

Table 1: Regional Research and Indigenous Forest Knowledge Fund projects funded through NSRC 2023 (23-DG-11242311-020)

Project	PI, Lead Institution
2024 NSRC GENERAL FUND	
Social, economic, and ecological dimensions of forest management for climate change adaptation and resilience	Erin Simons-Legaard, University of Maine
Using a functional trait approach to inform assisted migration for climate adaptation in the Northern Forest region	Heidi Asbjornsen, University of New Hampshire
Satellite monitoring of eastern white pine (EWP) health through assessing the forest structure	Parinaz Rahimzadeh-Bajgiran, University of Maine
The effects of seed dispersal and seedling establishment limitations on climate-driven tree species range shifts in the northeastern U.S.	Martin Dovciak, SUNY-ESF
Tools for rehabilitative silviculture to enrich habitat and restore productivity in degraded hardwood stands	John Foppert, Paul Smith's College
Assessing the future Northern Forest through the lens of seedling survival and sapling recruitment	Lucas Harris, University of Vermont
Northern Forest historical atlas project	Daniel Hayes, University of Maine
Assessing eDNA as a monitoring tool for forest arthropod biodiversity and pests	Jason Johnston, University of Maine at Presque Isle
Sustainable co-production of bioplastics and hydrochar from forest residue biomass	Ankita Juneja, SUNY-ESF

Private forest landowner engagement in forest management programs for carbon sequestration	Danielle Kloster, SUNY-ESF
Post-release non-target impacts of hemlock woolly adelgid biocontrol	Angela Mech, University of Maine
Decadal-scale trends in northern forest carbon storage in relation to nutrient availability and rising carbon dioxide	Scott Ollinger, University of New Hampshire
Assessing fire-dependency in natural red pine forests of the Northeast	Simon Pendleton, Plymouth State University
Digital species-site-suitability systems for regenerating northern forests.	Michael Premer, University of Maine
A predictive scaling framework of forest structure and functional diversity in a non-equilibrial world	Sydne Record, University of Maine
Mapping canopy height model and aboveground biomass of northeastern forests annually at 25 m resolution through remote sensing data fusion and machine learning	Bahram Salehi, SUNY-ESF
*Long-term monitoring of rare plant populations in the Adirondack alpine	Kayla White, Adirondack Mountain Club
2024 IFKF PROJECTS	
Ecosystem responses to the interacting forces of bridge improvements and beavers	Benjamin Simpson, Penobscot Nation
**Integrating advanced geospatial analysis and Indigenous forest knowledge for protecting ash species	Parinaz Rahimzadeh-Bajgiran, University of Maine
**Managing for tomorrow's Panawahpskek Forests today: An integrative approach to submerchantable competition control	Carolyn Ziegra, Appalachian Mountain Club
Partnership with Abenaki for conservation and restoration of the threatened, declining butternut tree, an ecologically and culturally important hardwood	Sean Hoban, The Morton Arboretum
Restoring tribal relations and forest knowledge	Les Benedict, Saint Regis Mohawk Tribe
**WaYS to utilize Indigenous knowledge and technology	tish carr, Wabanaki Youth in Science (WaYS)

* the project is completed. The final report for each research project will be attached to the final award report and in Appendix B.
** indicates the subaward was finalized late in 2024, allowing little progress from the research project during this reporting period.

Next reporting period

During the next reporting period, NSRC will continue monitoring progress on research projects, launch the new NSRC website, and develop more communications materials related to project findings and researchers.

The main portion of this annual report is composed of summaries of progress for the administration project, ongoing research projects, and IFKF projects.

Ongoing Research Projects

SEED: Social, Economic, and Ecological Dimensions of Forest Management for Climate Change Adaptation and Resilience

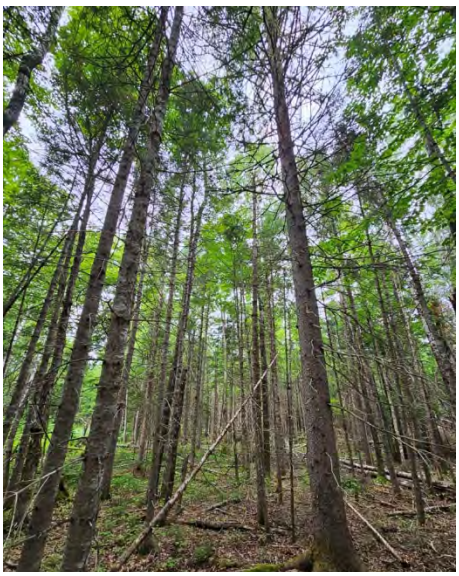

Figure 1: University of Maine graduate student Dustin McCloskey visited potential SEED study sites on the Penobscot Experimental Forest with the Research Team in the fall of 2024.

Principal Investigator: Erin Simons-Legaard, University of Maine

Summary of progress in 2024

- In Year 1 of the project, the team recruited a graduate student (Dustin McCloskey) who will lead the social science analysis and assess adaptive potential of conventional silvicultural treatments performed at the Penobscot Experimental Forest (PEF).
- Cameron McIntire, U.S. Forest Service, State, Private and Tribal Forestry; John Kabrick, U.S. Forest Service, Northern Research Station; and Loic D'Orangeville, University of New Brunswick joined the Research Team.
- The project hosted co-production meetings for both the Research Team and Advisory Panel for project co-development. Organizations represented on the Advisory Panel included the American Forest Management; Appalachian Mountain Club; Baskahegan Company; Baxter State Park; Maine Bureau of Parks and Lands; Maine Department of Inland Fisheries and Wildlife; New England Forestry Foundation; Penobscot Indian Nation, Department of Natural Resources; Seven Islands Land Company; U.S. Fish and Wildlife Service; U.S. Forest Service, National Forest System; and Vermont Department of Forests, Parks, and Recreation.
- Work was started on a comprehensive review of existing literature from other regions of North America concerned with the climate-adaptivity potential of conventional and alternative forest management practices. Results will be used to draft an assessment matrix that relates adaptability characteristics (resistance, resilience, and transition) to silvicultural treatments and regeneration methods.
- Initial forest, wildlife, and soils inventory methods are in development or have been piloted. Additional overstory inventories were completed to supplement existing data on the PEF and proposed study design was overlain on soil and productivity layers. Field reconnaissance was conducted to confirm suitability and adjust experimental unit boundaries.

Problems or changes

- PI Jeanette Allogio left her position for other employment; Erin Simons Legaard joined the Research Team as PI and brings expertise on modeling, scaling, and wildlife habitat assessment.

Plans for 2025

- In Year 2 surveys will be conducted before and after field tours designed to introduce participants to the SEED project and sites selected for treatment. Half of the field tour participants will receive training (objectives, benefits derived, etc.) before the field tour. Surveys will be submitted for IRB approval this spring and will begin recruiting participants over the summer and fall.
- Experimental unit and plot installation will be completed. Initial on-the-ground inventories of forest conditions across ~300 acres at the Penobscot Experimental Forest will be conducted in the summer of 2025. Timber marking and first entry harvests will be conducted the following winter so long as inventories are completed and all necessary measurements are finished.
- Collaboration with partners to source seed from southern genotypes of northern forest species will continue, with nursery coordination for species requiring two field seasons of growth before planting.

Figure 2: The proposed SEED study area contains a range of site conditions and stand structures typical of those practitioners encounter in northern conifer forests and will be useful for testing adaptive silviculture treatments. Photo by Laura Kenefic, USFS

Description of alignment with or collaboration with USFS, other partners, or the public

- Multiple co-PIs and Advisory Panel members are from the U.S. Forest Service and other federal, state, private, and non-governmental organizations. The work by the graduate student will determine the adaptive potential of treatments in the foundational study at the Penobscot Experimental Forest, leveraging that Forest Service project and providing value added to a conventional silviculture experiment. Silvicultural treatments are currently being developed in collaboration with Forest Service researchers and staff with input from the Advisory Panel (listed above).
- U.S. Forest Service staff are providing technical support, methods development, and planning the upcoming field season to complete inventories for pre-harvest data in collaboration with University researchers and student and temporary employees.

Products

Published abstract:

- Breigenzer, Peter; Kenefic, Laura S.; Rogers, Nicole; Allogio, Jeanette; Butnor, John; Heckman, Katherine; King, David; Roach, Skylar; Sachdeva, Sonya; Straub, Crista; Wason, Jay. 2024. SEED: Silvicultural, economic, and ecological dimensions of climate adaptation silviculture in northern conifers. Presented at the New England Society of American Foresters Annual Winter Meeting, 28 March 2024, Burlington, VT. In: News Quarterly 85(2): 16. https://nesaf.org/wp-content/uploads/2024/04/2024_April_NQ.pdf

Using a functional trait approach to inform assisted migration for climate adaptation in the Northern Forest Region

Principal Investigator: Heidi Asbjornsen, Professor, University of New Hampshire

Summary of Progress in 2024

Data collection and analysis

- Foliar samples were collected from Thompson Farm, Durham, NH and Harvard Forest during the summer of 2024. Species sampled include white pine, red oak, white oak, yellow birch and shagbark hickory.
- Site surveys were conducted for the mountain sites, Moosilauke, Madison, Bigelow, and Killington to assess species abundances along the elevation gradient and site access. The team also assessed Yale-Myers Forest and Burham Lot, a UNH property.
- Tree increment cores were samples from Thompson Farm and Harvard Forest during the fall of 2024.
- Researchers submitted research permit applications for all mountain sites in the fall of 2024 and received permits from the WMNF and the GMNF to sample on Mount Madison, Abraham and sections of Killington, the Maine Department of Agriculture to sample on Old Speck and Bigelow and Vermont State to sample on Jay, Mansfield and sections of Killington. The team is still waiting for permits from Dartmouth to sample from Mount Moosilauke and New York State to sample on Whiteface.
- Methods are being developed for measuring traits on leaf samples and tree cores. This involves optimizing the lab processes to get the best possible data as the procedure is sometimes different for each study species (white oak, red oak, sugar maple, shagbark hickory, yellow birch, white pine, balsam fir, red spruce)

Communications and Outreach

- Anders. E. Adaptation of Northern Forest Tree Species to a Warmer, Drier Future. Oral Presentation, Forest Ecosystem Monitoring Cooperative (FEMC) Annual Conference, December 2024.

Problems or Changes

- The team had some difficulty assessing bark thickness as the bark gauge used broke easily with some force. To measure bark thickness, different methods will be used this spring once it gets warmer.
- The team also found that measuring cuticle thickness was difficult on frozen leaves. The leaves become more fragile after being frozen and thawed which caused them to rip when the cross sections were attempted.
- After reviewing the species composition and access to Cannon Mountain, the team may exclude this site. There are few sugar maples and yellow birches to sample along the transects. Additionally, the sites are close to many trails which will make it difficult to do foliar sampling with a shotgun. To compensate, the project will likely add a UNH property Burham Lot located near Cardigan Mountain.

Next Reporting Period

Data Collection and Processing

- January -June
    - Continue methods development and complete measuring trait data from foliar samples and tree cores including, stomatal traits, specific leaf area, vein density, cold tolerance, δ13C, leaf nitrogen content, turgor loss point, and growth rates.
    - Refine methods for assessing bark thickness at UNH owned property Thompson Farm, which is also one of the study sites.
    - Continue to survey mountain sites (Jay, Mansfield, Abraham, Old Speck and Whiteface) for accessibility and species abundances.
    - Functional Trait International Summer School to strengthen theory and methods of leaf traits climate adaptation (June15-20th)
- July-August
    - Collect foliar samples from mountain sites. Collect from 5-6 sites depending on weather and other factors.
    - Properly store leaf samples in the freezer (-20 or -80) for analysis in the fall/winter.
- September- December
    - Collect tree cores from sites sampled during the summer once trees finish growing for the season
    - Collect seeds from species that are producing
    - Process foliar samples for trait data
    - Collect twigs for cold tolerance analysis

Communications and outreach

- Society of American Foresters Annual Meeting (October)

Alignment and Collaboration with USFS and stakeholders

The work is closely aligned with the goals of the USFS. The project builds off the Green Mountain National Forest's Range Expansion Seed Collection Project to identify seed collection stands of species predicted to do well in future northeast conditions to be used for the proposed "climate adaptation tree planting" in the Telephone Gap Integrated Resource Project. The collaboration with the USFS will increase the research and application of assisted migration in the northeast.

Name	Affiliation	Role
John Butnor	US Forest Service	Co-PI, assisting with cold tolerance measurements
James Donahey	US Forest Service	Collaborator, providing knowledge on seed collection

Satellite Monitoring of Eastern White Pine (EWP) Health through Assessing the Forest Structure

Principal Investigator: Parinaz Rahimzadeh, Ph.D. Associate Professor, School of Forest Resources, University of Maine, Orono, Maine

Summary of progress in 2024

This project started in April 2024. The goal of this study is to assess eastern white pine (Pinus strobus L.; EWP) health through the analysis of canopy structural parameters and health indicators providing an evaluation of tree vitality and forest condition. The objectives of this project are 1) to improve estimating live crown ratio (LCR), leaf area index (LAI) for EWP-dominated stands using satellite remote sensing imagery and 2) to develop a health index map for EWP for Maine, Vermont and New Hampshire.

Fieldwork spring/summer 2024

In spring 2024, 14 field sites in Maine, New Hampshire and Vermont were identified through consultation with the project co-PIs and collaborators and a total of 119 10*10 m plots were established. Field data were collected from May to July 2024. The ground data on tree density (total number of trees in a plot), canopy height, live crown ratio (LCR) and leaf area index (LAI) were recorded in the field. The plots sampled in the field were EWP-dominated; however, understory herbs, scrubs, or small trees were often present. Ground data were collected within replicated plots, wherein a varied number of plots (5-12) was established per site based on site area and EWP occurrence with an average of 8 plots per site. The canopy height was measured using the laser range finder. LiCOR 2200 TC Plant Canopy Analyzer (LI-COR, Inc., Lincoln, NE) was used to measure LAI. In addition, Digital Hemispherical Photographs (DHP) were taken to estimate the LAI. The LCR data were collected through a visual assessment for each tree within a plot based on the proportion of canopy fraction of green foliage to the total tree height according to Das et al., (2024).

Data analysis and modeling

Since summer 2024, the field data are being processed. Also, remote sensing data including Sentinel-2 and Sentine-1 imagery for the three states have been collected and are being processed. These data are being used for modeling various canopy structural attributes such as LAI and LCR.

Problems or Changes

The original PI of the project left the University of Maine in July 2024 and Dr. Parinaz Rahimzadeh became the PI of the project. A graduate student is working on the project instead of the postdoc Dr. Das under her supervision.

Plans for 2025

The team will develop predictive models to produce high-resolution LAI, LCR, and health maps for Maine, Vermont, and New Hampshire. These maps are expected to reveal spatial variability in forest

health, providing a scalable framework for monitoring EWP resilience and informing sustainable management under future climate conditions.

Description of alignment with or collaboration with USFS, other partners, or the public

This project is closely collaborating with USFS and Maine Forest Service (MFS) and products are designed to be directly used for EWP health monitoring by USFS and MFS. Dr. Cameron McIntire (USFS, New Hampshire), and Aaron Bergdahl from the MFS, Augusta are co-PIs of the project. Dr. Cameron McIntire has supported the project by helping us identify and access sites in New Hampshire and Vermont. Aaron Bergdahl and Dr. William Livingston (SFR, UMaine) helped us with identifying appropriate sampling locations in Maine. They helped with data collection and reviewed the techniques being used.

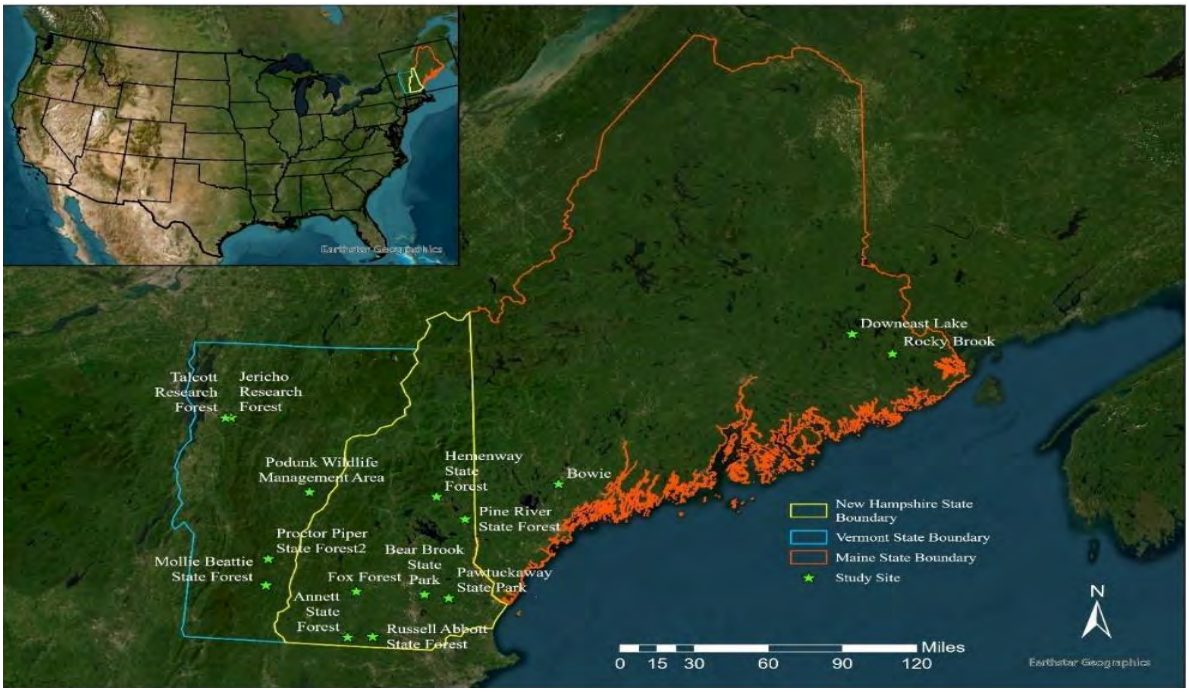

Figure 3: Study Area: green dots show the locations of field data collection sites in Maine, New Hampshire and Vermont, US

The effects of seed dispersal and seedling establishment limitations on climate-driven tree species range shifts in the northeastern United States

Principal Investigator: Martin Dovciak, Ph.D. (mdovciak@esf.edu; SUNY College of Environmental Science and Forestry)
Co-Principal Investigator: Nathan G. Kiel, Ph.D. (ngkiel@esf.edu; SUNY College of Environmental Science and Forestry)

Summary of progress

The team has made excellent progress in the first stage of this project. In the fall, a Master's position was advertised and received over 100 inquiries and applications. One student was offered and accepted the position. They began coursework and onboarding at SUNY ESF in January. The team has also begun working with an undergraduate student on developing their Honor's thesis project in alignment with the research objectives. In preparation for the 2025 field experiments, the project has begun purchasing materials, including seeds of sugar maple, American beech, and balsam fir for seed addition experiment. Finally, the team has conducted new analyses with previously collected data to determine the roles of seed dispersal and seedling establishment in tree regeneration dynamics and upslope species migrations on mountains in the Northern Forest. This manuscript is planned for submission to a high-impact, peer-reviewed ecology journal by March 2025.

Changes or problems

One notable change is the above new analyses and manuscript. Originally, only new data collection was proposed, with deliverables materializing in the coming years. However, an existing dataset was leveraged to begin addressing the project's research objectives. Beyond this, the team had to adjust the seed addition experiment protocols. The original plan was to include red spruce as a focal species, but no seeds of this species were available for purchase from regional suppliers or government agencies, and seed collection next fall concurrent with the addition experiment is not logistically feasible.

Plans for 2025

Several main components of the project will take place in 2025. Microclimate data loggers (TOMST TMS-4) will be purchased and instrumented across elevation and light environment on ten mountains in New York, Vermont, New Hampshire, and Maine. Afterwards, seed addition experiments will be conducted on five of these mountains spanning the above states to determine the influence of substrate and granivory on seedling establishment. At the same sites, seed traps will be deployed to quantify species-specific dispersal rates across elevation. This latter component is occurring one year earlier than originally planned in part to subsequently utilize these field-collected seeds for a greenhouse study in 2026. One additional project aligned with the research objectives will be developed and led by the new Master's student, and the undergraduate honor's thesis project will be designed and implemented.

Collaborations

New or continued existing collaborations have been established at several institutions in the first months of the project that will be critical to its success. These include with Laura S. Kenefic at the U.S. Forest Service Northern Research Station, Louis J. Lamit at Syracuse University, Jordon C. Tourville with the

Appalachian Mountain Club, and Jay W. Wason at the University of Maine. Further collaborations with additional partners and institutions will continue to be explored in 2025 and beyond, including with regional state agencies and land trusts.

Products at present

No products have been delivered yet, but the below manuscript is in preparation and will be submitted within the next two months.

Kiel, N. G., Tourville, J. C., Wason, J. W., & Dovciak, M. (In preparation). Environment-mediated neighborhood effects influence tree recruitment across a montane temperate-boreal forest transition. Planned submission to Journal of Ecology, March 2025.

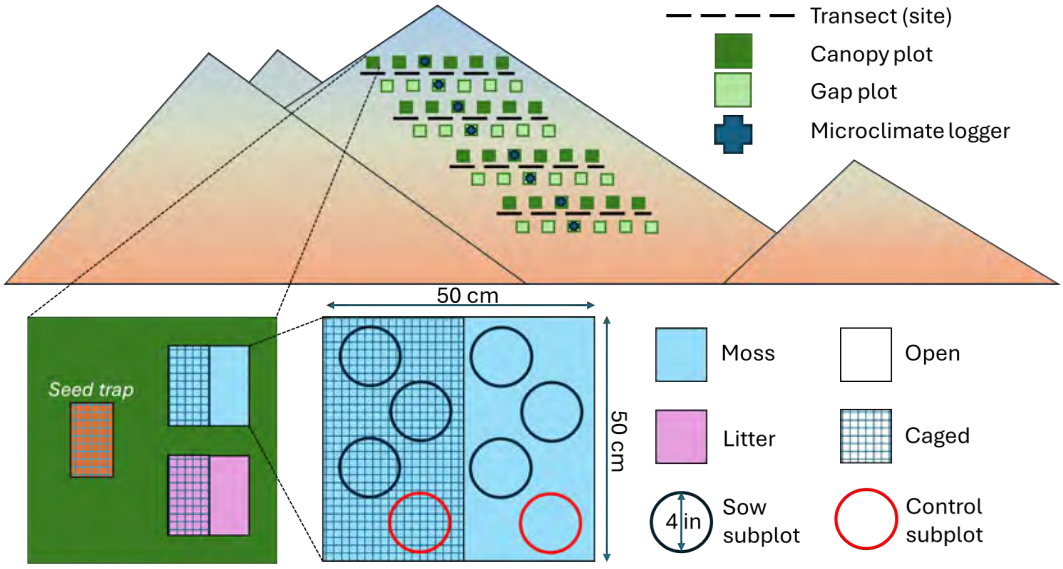

Figure 4: Study design schematic for the 2025 field season

Tools for rehabilitative silviculture to enrich habitat and restore productivity in degraded hardwood stands

Principal Investigator: John Foppert, Paul Smith's College

Summary of progress

Progress has been satisfactory along multiple dimensions of the project. Fieldwork for the two most inflexible and time sensitive empirical components of the project—wildlife habitat use monitoring and harvest cost data collection—began in 2024 on schedule.

Co-PI Lizz Schuyler deployed eight acoustic monitors for a one-month period in the spring to sample for ruffed grouse drumming; conducted two midsummer songbird point counts with Collaborator Suzanne Treyger; conducted time constrained herpetofauna surveys in July; and in September conducted deer density pellet transects with six Paul Smith's undergraduate students volunteers.

Figure 5: Co-PI Lizz Schuyler installing an acoustic monitor in an untreated portion of the rehabilitation demonstration project site

Figure 6: Wood frog observed during herpetofauna survey in the demonstration site

PI John Foppert and Co-researcher Alex George developed a preharvest stand inventory methodology that was implemented by Research Technician Tyler Richardson and four Paul Smith's undergraduate student assistants. Over 700 variable radius plots were sampled. Foppert, George, and Richardson also developed a harvest time-use monitoring protocol and collected GPS machine location data and observational time-use data during the implementation of the rehabilitative treatment in December.

With support from Co-researcher Neal Maker, Foppert also developed a conceptual framework for spatially optimizing rehabilitative silvicultural treatments and presented that framework at the Symposium for Systems Analysis in Forest Resources, an international scientific conference held in Hondarribia, Spain, in May. Maker and Foppert began exploring crop-tree selection modeling methods and refining the underlying ecological and economic models that approach will rely on.
A virtual all-team kick-off meeting was held over the summer and arrangements were made for an in-person all-team meeting at Paul Smith's College in 2025.

Problems or changes

No significant problems were encountered. One of the eight acoustic monitors failed to properly record data, but the others all worked properly. Scheduling challenges prevented the kick-off meeting from taking place in person, so that meeting was held virtually and the in-person meeting has been rescheduled for 2025, which will give the project team more opportunities to explore preliminary data together. Minor

changes occurred in the project staffing, as co-PI Lizz Schuyler left the faculty of Paul Smith's College for a leadership position in a state agency. She is continuing her role in the project as a contractor and some budget resources were reallocated to support a part-time field technician role to assist with fieldwork.

Plans for 2025

In 2025, another round of habitat use data and operational time-use data will be collected and begin processing and analyzing data collected in 2024. The team will continue to develop and refine crop-tree selection optimization modeling and spatial treatment optimization tools and submit the first manuscript. Landscape and region-scale modeling studies will begin in 2025. The entire project team will come together for a multi-day, in-person workshop and site visits.

USFS collaboration

USFS Researcher Nate Anderson has advised and supported this project on research design and data collection and will play a larger role as the work moves toward analysis and interpretation.

Figure 7: Paul Smith's College Logging Crew equipment and landing during feathered-edge habitat enhancement treatment; regenerative treatment visible in the background

Assessing the future Northern Forest through the lens of seedling survival and sapling recruitment

Principal investigator: Lucas B. Harris, University of Vermont

Collaborators: Anthony W. D'Amato (University of Vermont), Melissa A. Pastore (USFS), John Sinclair (USFS), Christopher W. Woodall (USFS)

Summary of progress in 2024

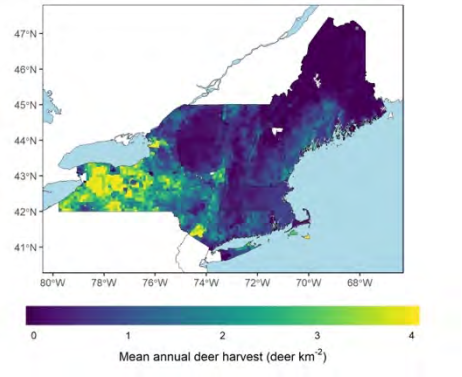

Figure 8: Mean annual harvest density of white-tailed deer, compiled using publicly available town-level records. This layer is being used as a regional indicator of browsing pressure on tree seedlings, in conjunction with snow depth and land cover metrics.

This project began in July and started by gathering and processing geospatial datasets to form the basis of the analyses of tree seedling survival and sapling recruitment. Just as this project began, the team published an article on implications of observed sapling recruitment patterns for future forest carbon stocks (Harris et al., 2024) that provides an additional foundation for Part I of the project. Data was processed on land cover, climate and terrain that will be used throughout the project. As proposed, the team also developed geospatial indicators of browsing pressure by white-tailed deer including town-level harvest records, which have not been previously used to assess browse impact on tree seedlings. The team used browse impact scores assessed in the field to evaluate each indicator. Based on this encouraging preliminary work, the team developed a standalone analysis of the regional effects of deer browse on tree regeneration and plans to submit a manuscript on this topic over the coming weeks. Data was gathered and analyzed for the work on the regional implications of sapling recruitment patterns, including investigating trends over time in recruitment composition, changing climate risk and functional trait scores.

Problems or changes

Because the project began in July 2024 instead of March 2024 as proposed, the timeline has been pushed back four months. The work is on schedule considering this adjustment. The team has also added a standalone analysis of deer browse impacts on tree regeneration, which goes beyond the work that was proposed but aligns with management concerns of the USFS and other stakeholders.

Plans for 2025

The manuscript on regional impacts of deer browse on tree regeneration will be submitted within the next month to Forest Ecology and Management. Work will continue on the analysis of sapling recruitment patterns and its implications (Part I), with the goal of submitting a manuscript in the late winter or early spring. As the team completes these analyses, a webpage will be developed to share maps and charts in an easy-to-use format. Concurrently, the proposed analysis will be conducted on seedling survival and its implications for management (Part II). The team will present this work at the New England Society of American Foresters meeting, the Ecological Society of America meeting and the Forest Ecosystem Monitoring Cooperative conference. By the end of 2025, the team plans to have the analysis of seedling survival submitted for publication so that work can begin on scaling up insights from the seedling size class inventory (Part III).

Description of alignment with or collaboration with USFS, other partners, or the public

The team presented preliminary results from the project at the Forest Inventory and Analysis (FIA) Science Symposium on November 20th, in a special session focused on forest change at the wildland-urban interface. Researchers also presented the work on deer browse impacts at the Forest Ecosystem Monitoring Cooperative conference on December 12th.

Publications

Harris, L. B., Woodall, C. W., & D'Amato, A. W. (2024). Sapling recruitment as an indicator of carbon resiliency in forests of the northern USA. Ecology and Evolution, 14, e70077. https://doi.org/10.1002/ece3.70077. Completed just prior to the start of this project but forms an additional foundation for the work on sapling recruitment.

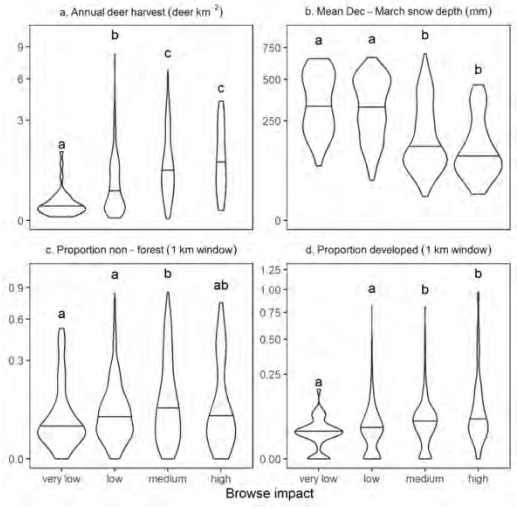

Figure 9: Violin plots comparing browse impact assessed at the plot level (n = 750) with geospatial proxies of deer browsing pressure across the Northeast. Horizontal lines indicate median values. Letters indicate significant differences among BIC

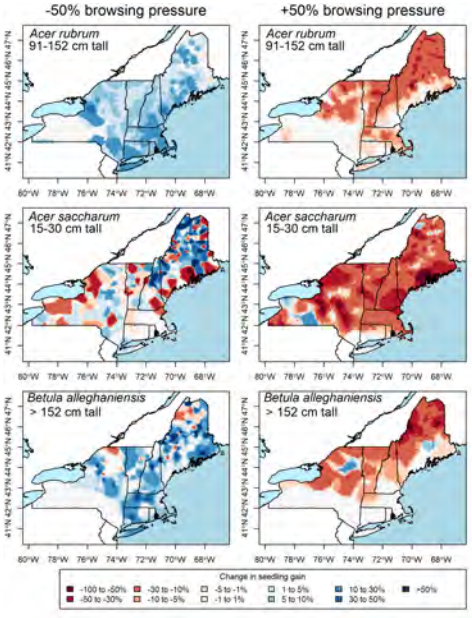

Figure 10: Predicted change in likelihood of regeneration success (gains in abundance) under 50% reduced and 50% increased deer browsing pressure for three tree species and seedling height classes

Northern Forest Historical Atlas Project

Principal Investigator: Daniel Hayes, University of Maine

Summary of progress in 2024

This is a new, two-year project with a start date for the period of performance on May 15, 2024. The team has begun work to digitize and analyze the James W. Sewall Company archive of historical aerial photography as a resource for the NSRC region's researchers, land managers, educators, and broader public. The initial scanning and orthophoto mosaic workflow development so far covers 9.7 million acres of Maine and Northern New Hampshire with high-resolution historical imagery, made publicly available through a digital atlas. The team generated orthophoto mosaics from over 5,000 photos with resulting mean spatial resolutions of 0.47 m and mean spatial accuracies of 0.55 m across this portion of the region.

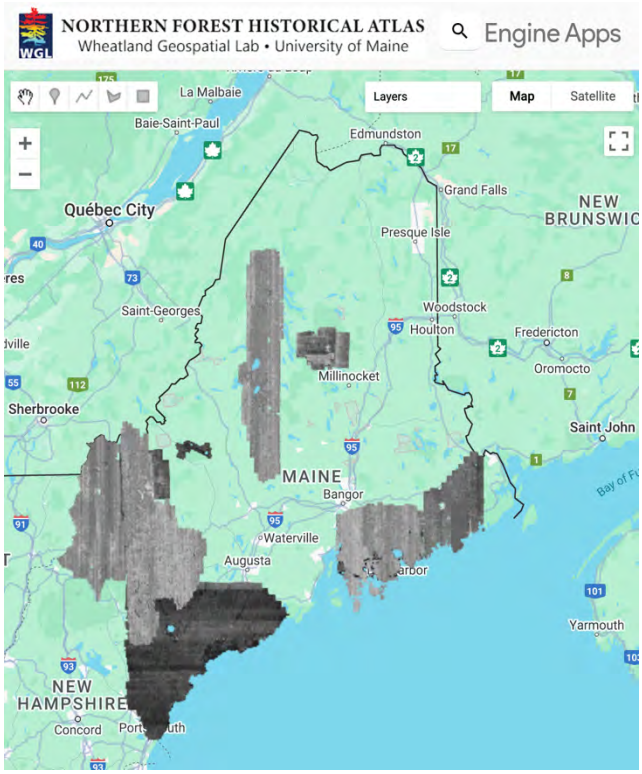

Figure 11: A collection of 11 orthophoto mosaics generated from imagery captured between 1943 and 1968, made available through the Northern Forest Historical Atlas web map.

Additionally, historical digital surface models (DSMs) produced through photogrammetric reconstruction are being used as historical canopy height models (CHMs) that explore canopy height change and biomass dynamics. A novel image classification approach is being developed for mapping historical land cover and forest types using panchromatic imagery. By digitizing a set of companion forest stand type maps drawn by Sewall's surveyors, there is access to a wealth of historical training and validation data for classification modeling. The University of Southern Maine's Osher Map Library is collaborating to digitize these historical type maps and many other Sewall Collection surveys that will be catalogued.

Problems or changes

Digitization of the Sewall photos has proven to be a slower process than hoped, but ultimately as was expected. While the whole collection of 700,000 negatives does not need to be scanned to complete these research objectives, many colleagues and collaborators are eager to see as much historical photo coverage as possible. The only photogrammetry scanner available to us proved to be an older and less automated scanner (Vexcel Ultrascan 5000), however the scanning quality and speed remains significantly higher than manual photo scanning option. Consequently, the team is adapting to utilize additional digitized photo collections, including from the Maine Geological Survey, USGS, and USDA.

Plans for 2024

In the next project year, the project plans to expand on the digitization and classification mapping work to grow the spatial coverage of the historical atlas across the NSRC region. This will allow the team to advance the research with other collaborators on specific projects, including the mapping of pre- and post-disturbance forest conditions in Maine's Acadia National Park (1947 fire) and Baxter State Park (1970s spruce budworm outbreak).

Alignment and collaboration

The team continues to work on a weekly basis with UMaine's Special Collections Director Greg Curtis and staff Paul Smitherman at UMaine's Fogler Library to execute photo digitization. Additionally, they are expanding collaborations with the Osher Map Library collaborators who manage companion Sewall Collection spatial information. The team is working with researchers and resource managers at Acadia National Park and Schoodic Institute to expand the remote sensing record of the Acadia region by building decadal orthophoto mosaics of the region dating back to 1944. The project is collaborating with researchers Sarah Nelson and Jordon Tourville at the Appalachian Mountain Club to explore treeline migration in alpine areas across the Northeast.

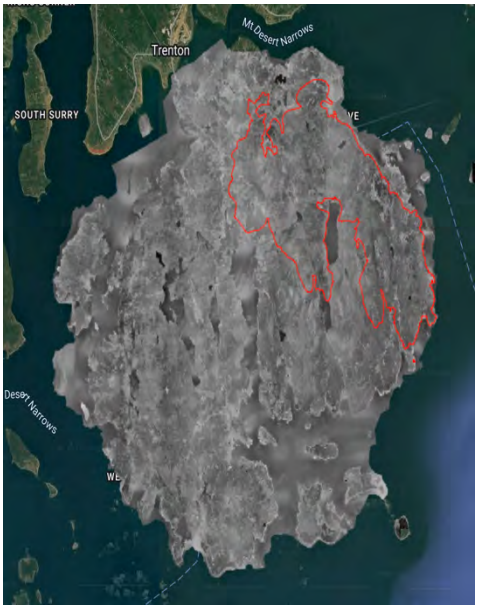

Figure 12: 1944 Orthophoto mosaic of Mount Desert Island with 1947 Great Fire extent shown

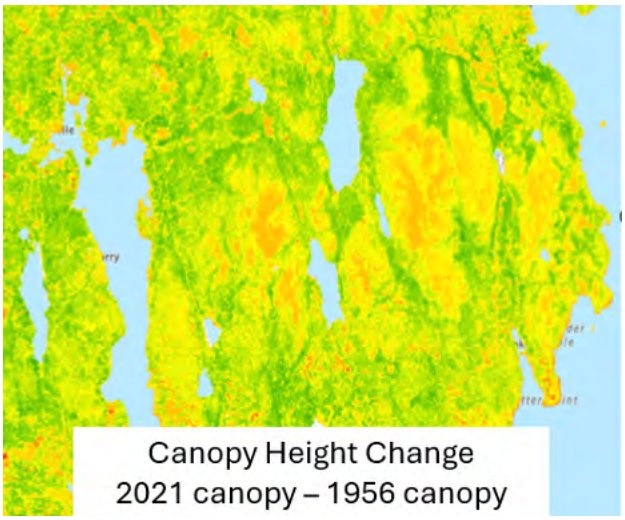

Figure 13: Canopy Height Change Model of Mount Desert Island using digital surface models derived from 1956 historical aerial imagery.

Links

Grandin, Trevor. (2024) Past, Present, and Future: Historical Aerial Photography. Schoodic Institute. Podcast.

Hartin, Shelby. (2024) UMaine researcher will digitize thousands of historical photos to understand changes in the Northern Forest Region. Orono: University of Maine News.

Assessing eDNA as a monitoring tool for forest arthropod biodiversity and pests

Principal Investigator: Jason Johnston, Ph.D., Professor of Wildlife Ecology, University of Maine at Presque Isle

Summary of progress in 2024

Since June of 2024, the team has successfully launched field sampling efforts, completed initial laboratory work, and developed bioinformatics code for the eDNA analysis. Determining sampling locations, gaining landowner permissions, and initial planning occupied June in advance of the field sampling effort during July. Multiple large and small landowners provided access to sampling sites, along with public access points. Thus, they sampled a wide geography for both leaf litter and river/stream sampling sites. They focused on several known areas of recent Emerald Ash Borer establishment, in addition to other samples in spruce/fir managed forest – 50 samples were collected. Lab filtration techniques were fine-tuned and to date 30 samples have been filtered, to be followed by DNA extraction and PCR this winter. Using other similar data to develop the DNA sequence analysis pipeline, the team has developed a substantial amount of code in line with published methods to analyze DNA sequences, i.e. quality control steps and reference database curation; taxonomic identification of experimental sequences is the next step to complete. The PI, two co-PIs and 3 undergraduates have worked on the project, and a 4th undergraduate will start work in the coming weeks.

Figure 14: University of Maine at Presque Isle undergraduate, Bailey LaPlante with a recently collected leaf litter sample from a mixed fir stand in Ashland, ME that is a pheromone trap sampling site for spruce budworm (Choristoneura fumiferana)

Problems or changes

There have been no changes and no serious problems yet. The only challenge faced is gaining permission to one large landowner's holdings which is extensive and ecologically important (especially based on current spruce budworm trends) for this project's goals. However, the team finally has a meeting with them in early February.

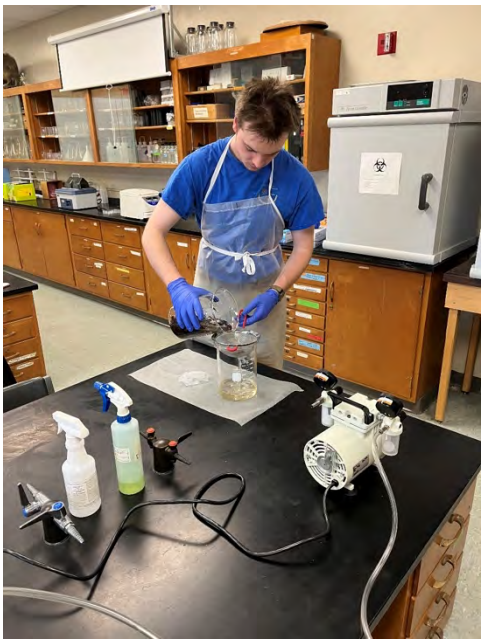

Figure 15: University of Maine at Presque Isle undergraduate, Ben Snow, pre-filtering a leaf litter sample as part of the environmental DNA

Plans for 2025

During February - May 2025 the team will continue laboratory work, development of coding, and finalize plans for field sampling. Field sampling from mid-June through early August will occur throughout priority areas of Aroostook County, the North Maine Woods, and over near the Quebec border, including in areas where target pest species are increasing and also where they are known to be low in numbers or not established. Laboratory analyses of 2025 samples will continue into the fall. Once DNA sequence data are available final analyses will be conducted. At this point, a clearer approach to developing an open-source pipeline or software to facilitate broader incorporation of these methods will be developed.

Description of alignment with or collaboration with USFS, other partners, or the public

There has not been alignment or collaboration with these partners. However, the team participated in the annual Maine Cooperative Forestry Research Unit trip which focused on an area of recent budworm emergence that is also within the proposed sampling area. This allowed us to connect with foresters from all the major commercial holders, state foresters, and other faculty and undergraduates.

Sustainable Co-production of Bioplastics and Hydrochar from Forest Residue Biomass: A Novel Hybrid Conversion Approach

Principal Investigator: Ankita Juneja, State University of New York College of Environmental Science and Forestry (SUNY ESF), Syracuse, New York

Summary of the progress in 2024

This project uses a mix of three hardwoods as representative of forest residue biomass (FRB) mix- cherry (Prunus serotina), ash (Fraxinus americana), and sugar maple (Acer saccharum). A large batch (5 kg d.b.) of each of three species were collected. The moisture content of the FRB was brought down to <10% by drying it at 45 °C in convective oven dryer for 24 hours to prevent any microbial growth during storage. The dried FRB chips were ground in Wiley Mill using a mesh screen to maintain uniform particle size of 2 mm. The ground FRB were mixed in equal proportions (1:1:1) (mixed FRB) and stored in refrigerator at 4 °C until further use.

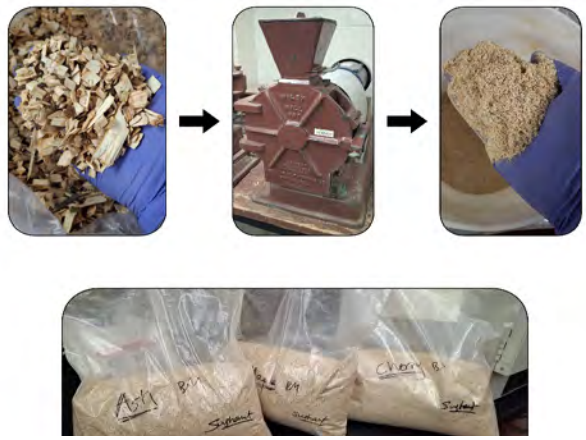

Figure 16: Biomass collection and post-processing using Wiley mill to obtain ground (2 mm) FRB

The chemical composition of FRB was determined by wet chemistry using standard laboratory analytical procedures (LAPs) from National Renewable Energy Laboratory (NREL). The composition of mixed FRB was 35.44% cellulose, 29.91% hemicellulose, 27.64% lignin, and 9.31% extractives. The compositions of separate hardwood samples were also performed to check the variability.

The ground mixed FRB was pretreated using hot water at 195 ℃ for 13 min with 13.5% solid loading in a high-pressure Parr reactor. The resulting slurry was processed using a laboratory-scale disk mill mechanical refining method. Post mechanical refining, the pretreated biomass was subjected to enzymatic hydrolysis with 10% solid loading (w/v), 50 mL working volume, enzyme (Cellic® Ctec2 and Htec2) loading of 30 FPU/g biomass, 50 °C for 72 hours. Post-hydrolysis, liquid and solid fractions were separated out using vacuum filtration. Samples were collected at various time intervals and sugar concentrations were determined using HPLC analysis (results pending). The experiments for PHB production using the hydrolysate generated in a flask scale are underway.

Plans for 2025

1. To scale up the fermentation process to a 3-L bioreactor
2. To optimize the production of bioplastic (PHB) considering two critical parameters – dissolved oxygen (DO) and feed rate of sugar (from hydrolysis) into the bioreactor.
3. To utilize the lignin-rich solid fraction generated after hydrolysis for hydrothermal carbonization (HTC) to obtain hydrochar.

4. To develop TEA and LCA modeling framework to optimize the process for both economic and environmental benefits using multi-criteria approaches.

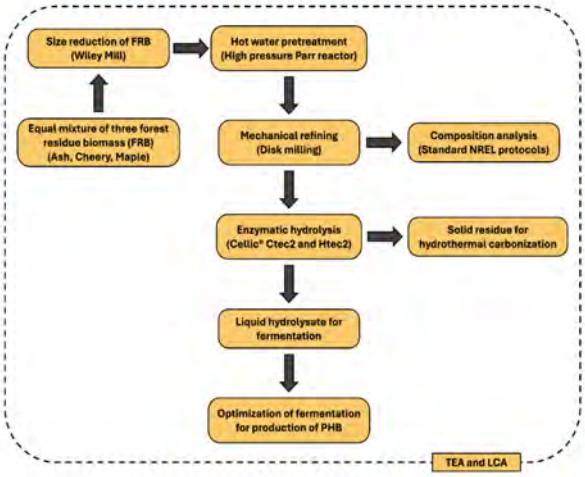

Figure 17: Overview of the flow of the complete process for FRB conversion for PHB production

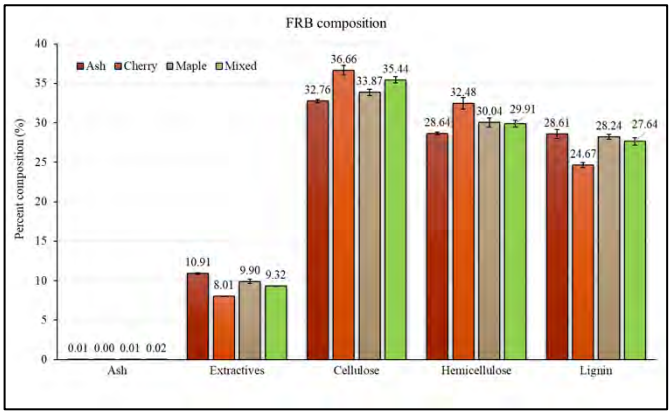

Figure 18: Composition analysis of three hardwoods and their mixture

Private forest landowner engagement in forest management programs for carbon sequestration

Principal Investigator: Danielle Kloster, SUNY College of Environmental Science and Forestry

Summary of Progress

In 2024, the team successfully recruited a doctoral student (Elysia Palmieri) to work on the project. She is currently engaged in literature review of forest carbon management and landowner engagement in forest management programs. Based on her dissertation plans, she is also incorporating a consideration of sense of place and its role in landowner engagement. She has started drafting a landowner survey, in consultation with the PI and co-PIs. Team members attended the Regional Conservation Partnership Annual Meeting (PI Kloster and PhD student Palmieri) and the Adirondack Fall Forestry Roundtable (PI Kloster) to build partnerships with relevant stakeholders.

Plans for 2025

In Spring 2025, PhD student Palmieri, in consultation with PI Kloster and co-PI Caputo, will finish drafting the landowner survey. The survey will aim to answer Question 1: What motivations do forest landowners have to engage in existing forest management programs to increase carbon sequestration on their land? What barriers exist to this engagement? The survey will address reasons for owning land, previous and planned forest management, awareness of and engagement in forest management programs, interest in potential future programs, and demographic information. While drafting the survey, PhD student Palmieri, PI Kloster, co-PI Beier, and co-PI Volk will be working on identifying landowners to target with the survey. Landowners will be selected to be able to partially answer Question 3 (which will be more fully explored in the focus groups in 2026): How do the barriers, motivations, and willingness to engage differ between landowners falling under the disadvantaged community criteria and those not? Between landowners of different parcel sizes? By past management, or other parcel or landowner characteristics? To capture different landowner/property types, researchers will use various maps, property values data, and parcel-level carbon stock data from co-PI Beier. The team will complete pre-testing and obtain IRB approval for the survey by the beginning of Summer 2025. They plan to complete the survey printing, mailing, and follow-up during Summer 2025 and begin data input, to be completed in Fall 2025.

Description of alignment with or collaboration with USFS, other partners, or the public

Co-PI Caputo is a research forester at the Family Forest Research Center (USFS) and is collaborating with PI Kloster and PhD student Palmieri on the landowner survey draft.

Post-Release Non-target Impacts of Hemlock Woolly Adelgid Biocontrol

Principal Investigator: Angela Mech, University of Maine

Summary of progress

a) Interviews for a Ph.D. position were conducted and a new graduate student joined the Forest Entomology Lab at the University of Maine in August 2024 – the main part of their dissertation will be in regard to the research funded here.

b) Meetings were had with members of the Maine Forest Service to go over potential locations for the 3 treatment sites: (1) sites with un-infested hemlock, (2) sites with hemlock + hemlock woolly adelgid (HWA), and (3) sites with hemlock + HWA + biological control releases. All sites will also have white pine and the native pine bark adelgid (PBA) (Fig. 1).

c) Trips were made to determine which sites would be ideal for the research

d) Lari-Leuco containers are being built for the rearing out of adelgid predators

Figure 19: (A) Eastern hemlock branch infested with hemlock woolly adelgid (Adelges tsugae) and (B) eastern white pine infested with pine bark adelgid (Pineus

Plans for 2025

Multiple aspects of this project will be initiated in 2025.

1) Selection of sites will be finalized by March 2025
2) At each site, adelgid-infested trees (hemlock and white pine) will have insect rearing sleeves attached to prevent any predators from attacking, while a paired branch on the same tree will be left with no sleeve. Adelgid counts will be conducted at multiple times to estimate the top-down pressures in the sites.
3) Infested twigs at each site will be collected and brought back to the lab to be placed in the Lari-Leuco containers. These will capture any Laricobius beetle larvae and/or Leucotaraxis fly adults that have been feeding on adelgid prey.
4) In early fall, soil emergence tents will be set up at each site to collect emerging beetle predator adults.

Collaboration with USFS, partners, and the public

The team will work with Dr. Nathan Havill (USFS) for all adelgid predator identifications. They will continue to work with Colleen Teerling and Allison Kanoti (Maine Forest Service) with site establishment and to obtain historical HWA biological control release data.

Decadal-scale trends in northern forest carbon storage in relation to nutrient availability and rising carbon dioxide

Principal Investigator: Scott V. Ollinger, University of New Hampshire

Summary of progress in 2024

This project examines how rising CO_2 affects nitrogen (N) availability and, in turn, wood growth and carbon storage by resampling plots at Bartlett Experimental Forest (BEF) first measured 25 years ago. In the first year, the team put a large effort into reoutfitting the plots (n=23) by constructing and deploying 221 soil respiration collars and 184 leaf litter baskets. Measurements from the collars and baskets will be critical for testing the hypothesis that increasing ecosystem respiration reflects a shift towards belowground plant carbon allocation as trees attempt to offset reductions in N availability.

The team recruited two master's students, and Co-I Ouimette will serve on the students' committees. The students were involved in reestablishing plots and making initial measurements of soil respiration, collecting leaf litter, and inventorying plots, which included measuring tree diameter on more than 2000 trees.

Researchers also began analyzing Forest Inventory and Analysis (FIA) data and satellite remote sensing (RS) products to assess if patterns of declining wood growth at BEF are widespread across the Northern Forest region. Preliminary analysis suggests variability by region and species, but evidence for declining aboveground wood growth (FIA data), despite a general increase in GPP (RS products).

Plans for 2025

2025 will be a fieldwork-intensive year, with efforts being led by students. The team will resume soil respiration measurements this spring and plan to make measurements every 3-4 weeks throughout the snow-free portion of the year.

An undergraduate student is analyzing long-term trends in wood growth at 12 of the plots measured annually around the AmeriFlux tower as part of her Undergraduate Senior Capstone. She will be examining how growth rates and trends may differ by functional group (broadleaf vs. needleleaf), mycorrhizal associations (AM vs. ECM), and wood type (ring porous vs. diffuse porous). She plans to present her results at the UNH Undergraduate Research Conference in April.

Lastly, the team anticipates submitting abstracts for the graduate students and Research Scientist to present results from the project at several regional and international conferences/meetings, including the Hubbard Brook Cooperators Annual Cooperators' Meeting, the Forest Ecosystem Monitoring Cooperative Conference, and the American Geophysical Union Annual Meeting.

Description of alignment with or collaboration with USFS, other partners, or the public

Despite extensive research on forest productivity and carbon sequestration in the Northern Forest region, researchers still do not have a sense of whether these variables are expected to increase or decrease in the coming years. Resolving this question and better understanding the how rising CO_2 is interacting with other stressors is critical to stakeholders of the region, including the USFS, who are concerned about wood production and carbon sequestration by northern forest ecosystems. The potential to combine historical measurements from +25 years ago with new measurements and model predictions provides the research team with a unique opportunity to address these questions and help plan for more resilient forests in the future. The project has both regional and national significance and will increase the precision with which forest managers can assess current and future forest growth, an area of high importance to the economic vitality of the region.

Additionally, this project builds on long-term measurements from two AmeriFlux towers (Bartlett and Howland) which are operated by the USFS (Co-I Ouimette). Bartlett is also part of the National Ecological Observatory Network and all the measurements will be complementary to NEON data collection.

Products:

- Liu, Y., Stoy, P., Housen, C., Hollinger, D., Ollinger, S., Ouimette, A., Durden, D., Sturtevant, C., Lucas, B., Richardson, A. A tale of two towers: comparing NEON and AmeriFlux data streams at Bartlett Experimental Forest. Submitted to *Global Change Biology* (In review).
- Zhou, Z., Gustafson, E.J., Ollinger, S.V., Ouimette, A.P., Miranda, B.R., Duveneck, M.J., Foster, J.R., Sturtevant, B.R., Bronson, D.R., Laflower, D. Integrating nitrogen and carbon cycling into LANDIS-II/PnET-Succession to improve landscape modeling: methods and sensitivity analyses. Submitted to *Ecological Modelling* (In review).

Proposals:

- Mathes, J., **Ollinger, S.,** Ouimette, A., Green, M. Characterizing the impacts of meteorological extremes and nitrogen limitation on temperate forest carbon cycling. *NASA Carbon Cycle Science* (Pending).
- Mathews, S., **Ollinger, S.** Kannenberg, S., Gougherty, A., Rehm, E., Ouimette, A. From leaves to landscapes: Integrating leaf scale physiology with macroscale models to improve understanding of tree responses to climate. *NSF Organismal Response to Climate Change* (Pending).
- Frey, S., **Ollinger, S**., Wymore, A., Blumstein, M., Mathes, J. Nutrients in Ecosystems for Cross-disciplinary Understanding of Shifting Stoichiometry. *NSF Biology Integration Institutes* (Pending).

Assessing fire-dependency in natural red pine forests of the Northeast

Principal Investigator: Dr Simon Pendleton, Plymouth State University
Co-PI: Dr Lisa Doner, University of Colorado Boulder; Christopher Guiterman

Summary of progress in 2024

During summer, 2024 the team began multiple field work campaigns:

- PI Guiterman and team members collected tree-ring fire-scar samples from 15 sites in the Saco-Swift River watershed study area totaling close to 100 trees, the samples were dried and processed in the laboratory and cross-dating has commenced. Including finalizing dates from prior collections (2022-2023) in the study area, the team now has a tree-ring chronology extending to the 1590s, and fire scars dated back to the 1730s.
- PIs Pendleton and Doner, along with NEPARS REU and Plymouth State University (PSU) students, retrieved two, 3-m-long, side-by-side sediment cores from a perched bog on Middle Mountain (adjacent to the above tree sampling area).
- PI Pendleton trained PSU students and completed sedimentary charcoal analyses on cores from a bog near S Moat Mountain (west of Conway, NH).
- Charcoal and grain-size analyses are underway on a 7-m-long lake sediment core from Cone Pond, Thornton, NH. Collaborative REU projects and those associated funds supplemented NRSC funds to create a chronology with 10 AMS C14-dates and a Pb210-dated surface core. This allowed us to establish a modern-to-glacial age model for Cone Pond and place the charcoal data, and pre- existing pollen data, in historical context. Initial charcoal counts from the Cone Pond sediment core indicates the presence of charcoal. NEPARS REU student Alex Hynes authored and presented a poster on this work at the University at Albany - State University of New York, Aug 1.

Plans for 2025

- Laboratory processing and fire-history chronology building from the extensive 2024 tree-ring collections.
- New tree-ring collections targeting areas where sediment cores are being collected
- Sediment core retrieval – In early January, the team will evaluate and probably core Black Spruce Bog, in Tamworth, NH. If safe lake ice conditions persist later into the spring, the team will also core proposed locations in the Saco watershed.

Figure 5: Research team collecting fire scar samples at Rattlesnake Mountain

- Sedimentary charcoal and particle-size analyses – PSU PIs and students will complete the charcoal and particle-size records for both Cone Pond and Middle Mountain during the spring and summer of 2025. Black Spruce bog charcoal analyses will be started in summer or fall of 2025. NEPARS REU student Alex Hynes will present preliminary results from the Cone Pond charcoal

and sedimentary XRF analyses at the 2025 GSA Joint Northeastern and North-Central and Section Meeting, Erie, PA, in March.

- In Spring, 2025, PI Doner will begin pollen preparation and microscopic charcoal, pollen and spore analyses on samples immediately before, during and after inferred fire events identified in the cores from Cone Pond, Middle Mountain Bog, and (hopefully) Black Spruce Bog.

Description of alignment with or collaboration with USFS, other partners, or the public

The project has continued collaboration with the White Mountain National Forest. The team is working with current and former staff on permitting and access requirements, but also to further the Forest Services' own goals of gaining a better understanding of past fire regimes to inform current and future fire use as a management tool.

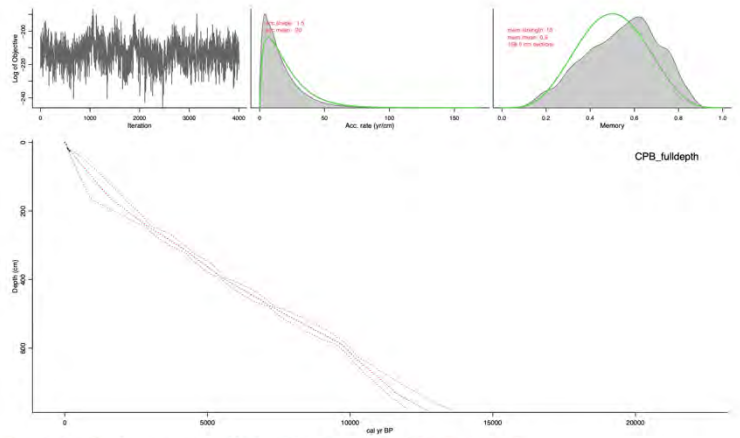

Figure 4: Cone Pond sediment core age depth model constructed from Pb-210 and ^{14}C ages.

Products

- PSU student paper article by Alison Kaiser - PSU professors researching fire management practices in the White Mountain National Forest
- Talon, Gabriel D. (2024). Cone Pond Charcoal Analysis for Fire History and Climatic Conditions; Past and Future. University of Maine, Ecology and Environmental Sciences Capstone Project
- Gifford, Aiden, Guiterman, Chris, Neely, John, Crawford, Michael, and Lougee, Jeff (2024). Fire history of the Green Hills Preserve, North Conway, New Hampshire. Poster, The Northeast-Midwest Prescribed Fire Science and Management Workshop, Albany, NY. August 19-22, 2024.
- Guiterman, Chris (2024). WHY do we burn? Historical motivation for prescribed fire in the Northeast. Plenary introduction, The Northeast-Midwest Prescribed Fire Science and Management Workshop, Albany, NY. August 19-22, 2024.

Digital species-site-suitability systems for regenerating northern forests

Principal Investigator: Michael Premer, University of Maine

Summary of Progress

During the first project year, the (Co)PIs advertised for a PhD student and held several meetings to discuss logistics, planning, and methodology. A preliminary study was successfully conducted on a pilot area of the project (Maine) with 3 species (Picea spp.) of interest to test methodologies and generate workflows and was presented at the North American Forest Ecology Workshop and the Northeastern/Southern Forest Mensuration Conference. Soil databases for the entire Northern Forest were curated and processing of digital elevation models for topographic variables was initiated. To date, a total of 28 raster files of climatic, topographic, and meteorological variables have been generated for the northern forest (NF) region and will be used as covariates in the generation of digital soil maps and estimates of species suitability.

Problems or changes

The only challenge to date is recruiting a qualified PhD student. The (Co)PIs advertised widely and held initial interviews during the first project year yet have not yet secured a student for completing the project. Considering this, the team requests a 1-year no-cost extension and may consider filling the role with a MSc student to meet project objectives within the defined timeframe.

Plans for 2025

The team plans to highlight the project goals and proof of concept from the recent progress in Maine at the New England Society of American Foresters meeting in Devens, Massachusetts in March 2025. They will re-circulate the open position with professional networks with an updated project description to recruit top-quality candidates. In the meantime, they will continue with curating and processing available data to form monthly estimates of evapotranspiration for 1990-2020. With the hopes of successfully recruiting a student to start in the fall of 2025, the student will begin coursework and generating data summaries for future analyses.

Description of alignment with or collaboration with partners

With the completion of the prototype for several species across Maine (Picea spp.), the team has deployed several geospatial raster products for testing by collaborators, Seven Islands Land Company, and JD Irving. Feedback from the products will be used to enhance the approach for the entirety of the NF region.

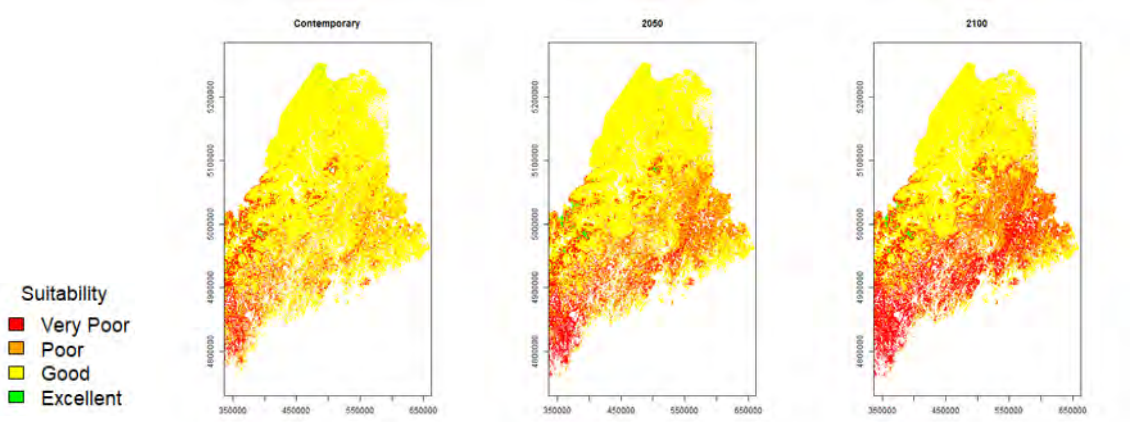

Figure 22 – Proof of concept results for site-suitability of white spruce (red=very poor, orange=poor, yellow=good, green=excellent) in current conditions (left panel), projected to 2050 (middle panel) and 2100 (right panel) under Representative Concentration Pathways of 4.5.

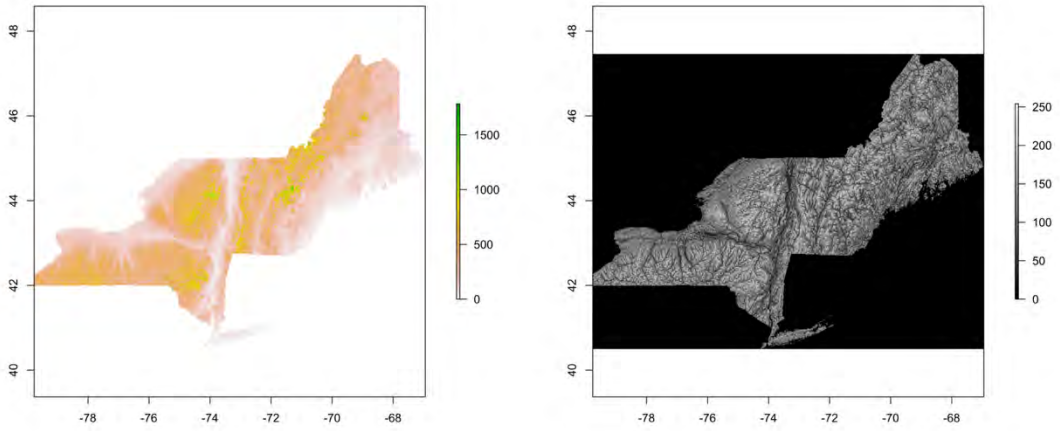

Figure 23 *– The raw digital elevation model (left panel, meters, 28m resolution) of the Northern Forest area is used to process a series of 30 additional topographical and meteorological variables to date, including Wind Exposure Index (right panel) where greater values correspond to greater wind exposure from all directions.*

A predictive scaling framework of forest structure and functional diversity in a non-equilibrial world

Principal Investigator: Sydne Record, Associate Professor of Landscape Conservation, Department of Wildlife, Fisheries, and Conservation Biology, University of Maine (Lead Institution)
Co PI: Jonathan Knott (co-PI), Northern Research Station, United States Forest Service

Summary of progress

The core goals of this proposal are to incorporate disturbance through time and RS into a scaling framework of forest structure and functional diversity to build better predictive tools for estimating carbon stocks and wildlife habitat connectivity. In fall 2024, a graduate student, Alyson East, was brought on the project.

The project has made great progress towards objective 1 (spatio-temporal modeling of forest structure combining ecological theory with United States Forest Service (USFS) Forest Inventory and Analysis (FIA) data and remotely sensed (RS) disturbance data). The team submitted a paper entitled, "The impact of disturbance on tree size distributions in the United States," to the peer-reviewed journal Global Ecology and Biogeography that is in major revision. Researchers analyzed size-abundance distributions (slopes) in >180,000 FIA plots for both disturbed and undisturbed forests, examining changes in slope associated with disturbances, stand age, and maximum tree height. The team found that disturbances specifically targeting smaller trees (e.g., animal grazing, ground fire) result in predictable, shallower shifts in size-abundance slopes, whereas disturbances less likely to target specific tree sizes (simultaneous ground and crown fires) do not shift slopes in predictable patterns (Fig. 1a). Maximum tree height and stand age were also reliable predictors of size-abundance slopes (Fig. 1b-c). Disturbances result in predictable changes to forest size-abundance slopes. As climate change and increased disturbance frequencies produce younger and shorter forests, future size-abundance slopes are expected to be steeper than those in undisturbed forests. Immediately after a disturbance, however, the team predicts a temporary flattening in the size-abundance relationship.

Problems or changes

The project had originally proposed fitting the models for objective 1 with covariates from gridded products capturing climate, topography, and disturbance. The team had to pivot away from that given the recent pause on new agreements for using the actual geographic coordinates of the USFS FIA plot locations (Goeking et al. 2024). Fortunately, all models have been fit using the in-situ data reported within the FIA database on stand age and canopy height, so no need to match other gridded data products in fitting models for objective 1. For making predictions in space for objective 2, the team can use canopy height and stand age estimates from remote sensing data that can align with the inputs for the models from objective 1.

Plans for 2025

In 2025, the project will focus more on objectives 2 (using remote sensing canopy data inputs with the objective 1 models to make predictions across space) and 3 (using objective 2 outputs to calculate connectivity metrics between conserved and working lands). Researchers will segment tree crowns for the northern forest using two remote sensing data products (National Agricultural Inventory Program (NAIP) and Maxar commercial satellite images). The project proposed to use NAIP data, which are at ~1-2 m resolution, but segmentation will be done on <1m resolution data to see if that works better at characterizing crowns. The Maxar data from NASA can be processed to be at a sub-meter resolution, so the team plans to segment both NAIP and Maxar data and compare them to ground-truthed, in-situ field data collected by the Maine Adaptive Silviculture Network (MASN). To work towards objective 3, the team will schedule meetings with partners (i.e., the Northeast Wilderness Trust and the Maine Department of Agriculture, Conservation, and Forestry) identified in the proposal to ensure that the connectivity metrics calculated between conserved and working lands in the Northern forest are relevant to management to ensure the translation of the science.

Products

Github repository for all reproducible code from paper that is in major revision at Global Ecology and Biogeography: https://github.com/ForestScaling/The-Impact-of-Disturbance-History-on-Size-Abundance-Scaling-Patterns-in-Forests.

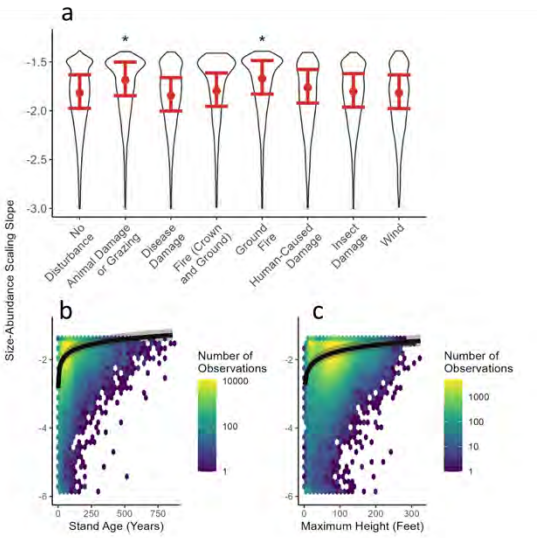

Figure 24. a) Visualized conditional effects output from Bayesian models fit to both FIA microplot and subplot data. Error bars are the posterior median and 95% credible interval. Despite the wide range in possible size-abundance slopes, the team found that animal grazing/damage and ground fires resulted in shallower slopes. The tail of the violin plot reaches to ~-6 but is cut off to better highlight the error bars. Disturbance types classified as different from plots with no disturbance are highlighted with an asterisk. The wide range in slopes is partly due to the effect of b) stand age and c) maximum tree height, which are logarithmically related to the size-abundance scaling slope.

References

Goeking, S.A., C.W. Woodall, R. Bush, and LS. Heath. 2024. Collaboration can preserve the integrity of gold standard carbon data from forest inventories. Proceedings of the National Academy of Science, 121(38): e2409263121.

Mapping Canopy Height Model and Aboveground Biomass of Northeastern Forests Annually at 25 m Resolution through Remote Sensing Data Fusion and Machine Learning.

Principal Investigator: Dr. Bahram Salehi, SUNY-ESF

Summary of progress in 2024

The project commenced as scheduled in June 2024. Below is a summary of the progress made over the past 7 months:

- A PhD student was recruited at the project's onset and became an integral part of the team.
- Conducted a comprehensive literature review and collected satellite data, including LiDAR, optical, and SAR datasets.
- Preprocessed the satellite data and refined the GEDI spaceborne LiDAR data for analysis.
- Developed machine learning techniques in Google Earth Engine and Python to generate Canopy Height Models (CHM) based on ecoregional classifications.
- Produced the CHM for the entire northeastern forest region, validated the maps at selected sites using FS-FIA plots, and presented the findings at the 2024 ASPRS (American Society for Photogrammetry and Remote Sensing) International Symposium. Link to presentation recording:https://drive.google.com/file/d/1x4pSaO7afnA37MtCRG07i0vbZwbpdxaO/view?usp=sharing

Plans for 2025

- Enhance the CHM model by integrating UAVSAR data, a simulation of NASA's upcoming NISAR satellite.
- Develop aboveground biomass (AGB) maps for the study area.
- Test and validate both CHM and AGB models using US-FS FIA plots in collaboration with the FS-Northern Research Station FIA team.
- Hold meetings with project collaborators, sharing the CHM and AGB maps to gather feedback and refine the products.
- Publish 1-2 journal papers and deliver 1-2 conference presentations.
- Prepare additional proposals to secure further funding for the project.

Description of alignment with or collaboration with USFS, other partners, or the public

The team has been collaborating with the USFS Northern Research Station FIA program to validate and test the CHM maps using FIA plots. Since the FIA plot coordinates are not available to us, they have assisted with the validation process without disclosing the confidential plot coordinates. In 2025, the team will engage with the remaining project collaborators to continue this work.

Products

Link to presentation recordings at 2024 ASPRS International Symposium (Virtual)
https://drive.google.com/file/d/1x4pSaO7afnA37MtCRG07i0vbZwbpdxaO/view?usp=sharing

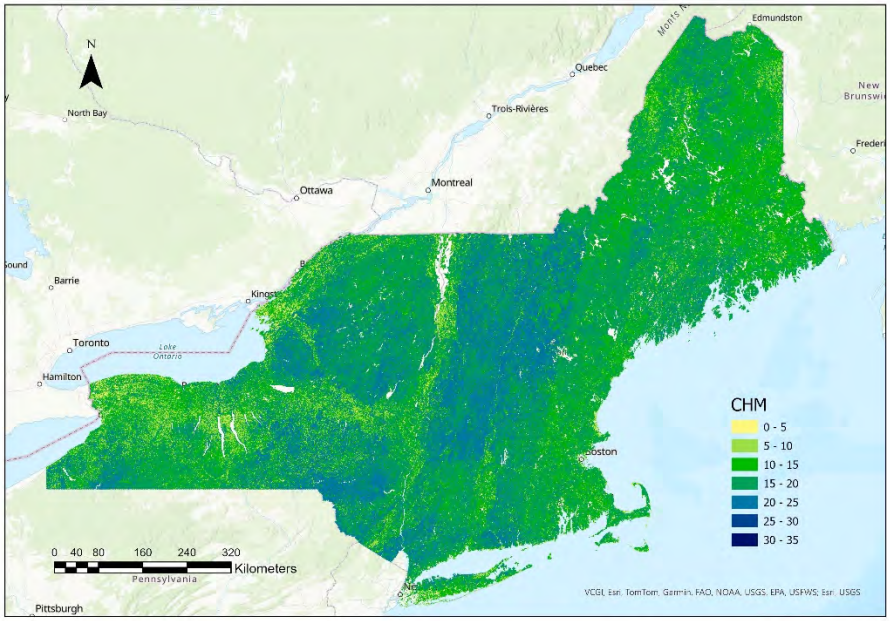

Figure 25. The projects first output: A preliminary map of Forest canopy height model (CHM) for the entire northeastern forests region

Ecosystem responses to the interacting forces of bridge improvements and beavers

Principal Investigator: Benjamin Simpson, Penobscot Nation DNR
Benjamin.simpson@penobscotnation.org
Co-PI: Joseph Zydlewski, Maine Cooperative Fish and Wildlife Research Unit, University of Maine josephz@maine.edu; Christina Murphy, Maine Cooperative Fish and Wildlife Research Unit, University of Maine Christina.murphy@maine.edu

Project Abstract

The Penobscot River is the ancestral home of the Penobscot Nation, draining nearly one-third of the State of Maine. In 2024, PIN will replace two barriers (access road crossings) in Birch Stream with the goal of migratory fish recovery and long-term benefits of increasing available cold-water, resilient habitats within the Penobscot River watershed. The study will examine the aquatic community responses before and after improvements, including beaver activity, food webs, and fish movement. Researchers will monitor water temperature, water availability, beaver activity, fish passage and aquatic invertebrate communities to characterize the ecological changes to beaver dominated habitat in response to increased aquatic connectivity at road crossings. This work will be conducted at two bridge sites before and after reconstruction. Evaluation of the study will include the traditional metrics of academic progress and the successful completion of a master's thesis at the University of Maine. Understanding how ecosystem engineers like beavers are interacting with changing infrastructure will help us to manage beaver activity and understand potential tradeoffs to work aimed at aquatic connectivity. Overall, this will help understand the benefits of these improvements in Tribal infrastructure as well as improving the habitats of culturally significant species of fish and wildlife.

Figure 26: Current beaver impoundment located at one proposed bridge improvement site.

Progress in 2024

A graduate student from the University of Maine, Kyle Hubbard, was brought on board to conduct the majority of the fieldwork on this project. The short time in 2024 after receiving this grant was spent in the planning of the overall project. The timeline for the bridge construction is still up in the air and could happen in the fall of 2025 or the spring of 2026.

Plans for 2025

The team will begin the bulk of the fieldwork this year as soon as the ice has melted in the study area. Researchers will begin to collect fish passage data using electrofishing methods as well as collecting data related to water quality, turbidity, insect communities and water temperature. The team will also begin to capture beavers and fit them with GPS transmitters. This work will be conducted before each bridge has been reconstructed to get baseline data of the environment as it is now.

Collaboration

The team consists of PI Benjamin Simpson from the Penobscot Nation Department of Natural Resources and Co-PI Joe Zydlewski and Christina Murphy from the Maine Cooperative Fish and Wildlife Research Unit at the University of Maine. The project will also be working with Fisheries Program Manager Daniel McCaw from the Penobscot Nation Department of Natural Resources and Cody Dillingham, Fish Biologist from the Penobscot Nation Department of Natural Resources. Benjamin will lend his expertise to the overall project including the capture and monitoring of beavers. Joe and Christina will manage the graduate student and oversee the fisheries side of the project. Dan and Cody will also lend their expertise in the bridge construction oversight and any fish work they are able to contribute to the project.

Partnership with Abenaki for Conservation and Restoration of the Threatened, Declining Butternut Tree, an Ecologically and Culturally Important Hardwood

Principal Investigator: Sean Hoban, The Morton Arboretum

Summary of progress in 2024:

In August 2024, Sean Hoban and Emma Leavens of The Morton Arboretum visited Vermont to meet with Martin Kratt, Dale Bergdahl, and Abenaki Chief Brenda Gagne. The visit included an initial convening of all partners at the Abenaki Tribal Council office followed by 2 days visiting butternut field sites on Isle La Motte, Goshen, Crown Point Historic Site, and Charlotte Park Wildlife Refuge. During the 2024 growing season, Martin Kratt surveyed a large population of butternuts on Isle La Motte, placed deer fence around young trees which are most vulnerable to deer rub, added vole protection where vole presence was visible, and removed brush where it was obstructing the growth of butternut trees. He also grew seedlings of individuals likely to be pure butternuts so that they can be shared with partners, primarily the Abenaki, to be planted at ecologically appropriate sites for restoration or cultural appreciation. Dale Bergdahl coordinated with potential partners around Vermont and New York regarding other sites to survey as well as participation in Abenaki education projects. Chief Gagne promoted upcoming butternut work among her community members, researched traditional and historical stories about butternut among Abenaki elders, planned a first meeting of project partners with Circle of Courage participants, and provided guidance and insight on indigenous teaching methods and content for educational programs. Team members met on zoom monthly to plan educational events with Circle of Courage, site visits and surveys to complete in 2025, and internships for students in forestry and tree research.

Figure 27: Sean Hoban, Dale Bergdahl, and Emma Leavens pose with a particularly large butternut tree on Isle La Motte.

Plans for 2025:

In mid-March, the Abenaki Circle of Courage (COC) education program will host Martin Kratt and Dale Bergdahl for an introductory lesson on butternut trees. Students in COC will then participate in forest

ecology and tree health lessons in spring, summer, and fall. Lessons will include discussions with elders about butternut, ecological concepts and stories, and forestry. Bergdahl, Kratt, and Gagne have plans to visit butternut populations in the spring to assess site conditions and share knowledge. Butternut seedlings from Isle La Motte known to be true butternuts will be distributed for planting at sites selected by the Abenaki and likely at Shelburne Farms and Shelburne Museum. Further genotyping will be performed at Purdue University to determine hybrid status of trees which have not yet been assessed. Data analysis of hybridization will begin by summer 2025. Bergdahl and Kratt will graft scion material from butternuts currently in poor health to preserve their genetic uniqueness with the aim of reintroducing those individuals as healthy saplings. Kratt will continue to survey and deer-fence butternut seedlings in addition to collecting GPS and DBH data. Also, trees will be cored to determine their true age and cohort status. Emma Leavens will likely visit Vermont in summer with a research intern to support surveying. Leavens and Hoban will complete initial analysis of seedling distribution by summer 2025 and determine next data collection (e.g. soil analysis). Leavens and Sean Hoban will mentor an intern during the summer of 2025, Dale Bergdahl will mentor another intern in forestry.

Figure 28: A butternut seedling on Isle La Motte with evidence of deer browse. Seedlings like these are now being protected by cages until they are big enough to withstand damage by deer. Photo by Martin Kratt.

Description of alignment with or collaboration:

Dale Bergdahl is in communication with staff at the University of Vermont, Vermont Department of Forests, Parks, and Recreation and US Forest Service research personnel regarding care and maintenance of the butternut orchard within Green Mountain National Forest. Also, he is in discussions focused on the establishment new cooperative projects. Also, he is in touch with representatives from The Nature Conservancy and the US Fish and Wildlife Service regarding existing butternut populations and current project plantings as well as possible locations for reintroductions. Dr. Hoban is also leading a project on butternut in the Midwest under a separate cooperative agreement with the USFS Forest Health Protection. As part of that grant, numerous butternut samples were obtained from botanic gardens around the country and from two sites in Illinois. Measurements and data collected in this other project, on populations in the Midwest, will provide a comparison case and will help better understand butternut health and butternut hybridization in the Northeast.

Restoring Tribal Relations and Forest Knowledge

Principal Investigator: Les Benedict, Saint Regis Mohawk Tribe, Environment Division: les.benedict@srmt-nsn.gov
Co-Pi. - Jessica Raspitha, Saint Regis Mohawk Tribe, Environment Division: jessica.raspitha@srmt-nsn.gov

Summary of progress in 2024:

Planning for the utilization of the Thompson Island Youth Camp (TIYC) in Akwesasne was confirmed with the Mohawk Council of Akwesasne. The TIYC is one of the locations where inter-tribal cultural exchanges will take place in 2025.

The project was announced and highlighted at the Future of Brown Ash Symposium, Orono, ME, October 8-9, 2024. Information was shared about the purpose of the project and the collaboration that will occur between the northeast tribes, reestablishing historical connections as well as promoting cultural exchanges. The presentation is available upon request.

An intern selection paradigm was created to share with project partners. The paradigm compares native American and contemporary "mentorship" processes. Host nations will be encouraged to utilize models that are the best fit for their respective communities.

The PI and Co-PI met with the Haudenosaunee Environmental Task Force to discuss plans for supporting interns within the Haudenosaunee Nations. The nations are receptive to the concept and agreed to continue with planning for the interns in 2025.

Plans for 2025:

Plans for 2025 involve planning the logistics to recruit, place and provide mentorship of tribal youth within each host nation in the Haudenosaunee and the Wabanaki territories. Recruitment and selection will be according to the respective host nations practices. Financial instruments will be developed to pay for travel costs, cultural camps, transportation, personnel, honoraria, and other costs to support the implementation of the project goals. The outline for 2025 includes:

- Recruitment of tribal youth
- Development of curriculum and elements
    - Cultural exchanges at 2 camps
    - Lining up seminars
    - Assign mentor/mentee
    - Identify specific project and research
- Orient mentors, provide training
- Develop financial commitments
    - Cultural camps
    - Traditional practitioners
- Plan Travel Logistics
- Coordinate Capstone event

    - Travel logistics
    - Identify practicing forest researchers
    - Youth project reports & exchange
- Track Progress
    - Weekly check in with partners
    - Reporting & Documentation

Description of alignment with or collaboration with USFS, other partners, or the public

Collaboration with partners, including USFS and Tribal nations occurred at the Future of Brown Ash Symposium, email and phone exchanges. Recruitment of youth and curriculum development for 2025 will rely heavily on partner exchange which will be accomplished virtually.

Signature

The signing party is the official representative and authorized to act for matters related to the above- referenced grant/agreement.

March 25, 2025

Anne Jefferson
Patrick Professor, Watershed Science and
Planning NSRC Director
University of Vermont and State Agricultural College
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(1) Mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue SW, Washington, D.C. 20250-9410; o
(2) Fax: (833) 256-1665 or (202) 690-7442; or
(3) Email: program.intake@usda.gov.

Appendix A: Products

Scholarly Articles

1. Kiel, N. G., Tourville, J. C., Wason, J. W., & Dovciak, M. (In preparation). Environment-mediated neighborhood effects influence tree recruitment across a montane temperate-boreal forest transition. Planned submission to *Journal of Ecology*, March 2025.
2. Harris, L. B., Woodall, C. W., & D'Amato, A. W. (2024). Sapling recruitment as an indicator of carbon resiliency in forests of the northern USA. *Ecology and Evolution*, *14*, e70077. https://doi.org/10.1002/ece3.70077. *Completed just prior to the start of this project but forms an additional foundation for our work on sapling recruitment.*
3. Gifford, Aiden, Guiterman, Chris, Neely, John, Crawford, Michael, and Lougee, Jeff (2024). Fire history of the Green Hills Preserve, North Conway, New Hampshire. Poster, The Northeast-Midwest Prescribed Fire Science and Management Workshop, Albany, NY. August 19-22, 2024.
4. Record, S., Knott, J. et al. (Submitted) The impact of disturbance on tree size distributions in the United States. *Global Ecology and Biogeography*

Conferences and Presentations

1. Anders. E. Adaptation of Northern Forest Tree Species to a Warmer, Drier Future. Oral Presentation, Forest Ecosystem Monitoring Cooperative (FEMC) Annual Conference, December 2024.
2. Tribal Community Perspectives, PowerPoint Presentation, October 9, 2024.
3. Foppert, J., Maker, N. (2024). A Conceptual Framework for Spatially Optimizing Rehabilitative Silvicultural Treatments. *Symposium for Systems Analysis in Forest Resources.*
4. Harris, L. (2024). Forest Change at the Wildland-urban interface. Special Session. *Forest Inventory and Analysis (FIA) Science Symposium.*
5. Harris, L. (2024). Assessing how effects of browsing by white-tailed deer on tree regeneration vary by species and seedling size across the northeastern USA. *Forest Ecosystem Monitoring Cooperative Conference.*
6. Guiterman, Chris (2024). WHY do we burn? Historical motivation for prescribed fire in the Northeast. Plenary introduction, *The Northeast-Midwest Prescribed Fire Science and Management Workshop.*
7. Kouki, G. 2024. 25 m Resolution Canopy Height Model for the Northeastern U.S. Forests. *ASPRS International Symposium (Virtual)* https://drive.google.com/file/d/1x4pSaO7afnA37MtCRG07i0vbZwbpdxaO/view?usp=sharing
8. Breigenzer, Peter; Kenefic, Laura S.; Rogers, Nicole; Allogio, Jeanette; Butnor, John; Heckman, Katherine; King, David; Roach, Skylar; Sachdeva, Sonya; Straub, Crista; Wason, Jay. 2024. SEED: Silvicultural, economic, and ecological dimensions of climate adaptation silviculture in northern conifers. Presented at the New England Society of American Foresters Annual Winter Meeting, 28 March 2024, Burlington, VT. In: News Quarterly 85(2): 16. https://nesaf.org/wp-content/uploads/2024/04/2024_April_NQ.pdf

Other Products

1. Grandin, Trevor. (2024) *Past, Present, and Future: Historical Aerial Photography.* Schoodic Institute. Podcast.
2. Hartin, Shelby. (2024) UMaine researcher will digitize thousands of historical photos to understand changes in the Northern Forest Region. Orono: University of Maine News.
3. Kaiser, A. (2024) PSU professors researching fire management practices in the White Mountain National Forest. *The Clock.*
4. Talon, Gabriel D. (2024). Cone Pond Charcoal Analysis for Fire History and Climatic Conditions; Past and Future. University of Maine, Ecology and Environmental Sciences Capstone Project
5. Github repository for all reproducible code from paper that is in major revision at Global Ecology and Biogeography: https://github.com/ForestScaling/The-Impact-of-Disturbance-History-on-Size-Abundance-Scaling-Patterns-in-Forests.

Appendix B: Final Reports

Long-Term Monitoring of Rare Plant Populations in the Adirondack Alpine

Principal Investigator: Kayla White, Adirondack Mountain Club

The 2024 Adirondack High Peaks Summit Stewardship program completed the fourth round of sampling for the Alpine Population Study, in conjunction with New York Natural Heritage Program (NYNHP). This study began with initial sampling in 2006/2007, with following rounds of surveying occurring in 2013, and 2018/2019. ADK hired two Botany Field Technicians (seasonal staff) and had one volunteer Botany Intern. They started the field season on May 24th and completed surveying on August 29th. Throughout the summer, Botany Field Technicians Technicians spent time scrambling over rocks, fighting through the krummholz, and visiting remote islands of alpine across the Adirondack High Peaks. In total, they surveyed 373 plots, each five meters by five metes. In these plots, technicians focused on 20 target species, the rare, threatened, and endangered species present in the alpine, as well as keeping an eye out for some species that have not been recently observed. In 2019, we published our findings after completion of the third round of the study. Long-term monitoring is necessary in New York's alpine zone to observe changes to vegetation cover and species present. Depending on changes in the alpine zone, the findings in this research could be indicative of climate change affecting the alpine summits of New York.

Survey plot locations are randomly generated across all geographic areas classified as alpine. By generating polygons over the alpine areas of the High Peaks, we are able to place these random points within the polygons. Below is a breakdown of the number of plots across the mountains surveyed.

Table 2: Study sites and plots

Mountain	Algonquin	Basin	Boundary North	Boundary South	Colden	Dix	Gothics	Haystack	Iroquois
# of Plots	68	8	10	3	6	5	12	39	24
Mountain	Little Haystack	Marcy	NE Colden	NW Algonquin	NW Wright	Saddleback	Skylight	Whiteface	Wright
# of Plots	12	117	3	13	3	5	23	9	13

Because these plots are randomly generated, some of them were not able to be surveyed due to hazardous terrain or improper habitat. Our solution was to also generate 190 overdraw plots. The number of overdraft plots is proportional to the number of base plots distributed across the mountains. When Botany Technicians arrived to a survey site and determined it was an invalid plot location, they selected the closest overdraw plot to their location and surveyed that instead.
Below are the target species, as well as non-target species. The non-target species are those that may have a SH or SX ranking, or have been seen in the alpine areas before, but more data is needed. Botany Field Technicians were not expected to search for the non-target species.

Latin Name	Common Name	Measurement
Agrostis mertensii	Norther Bentgrass	Clumps
Anthoxanthum monticola	Alpine Sweet Grass	Clumps
Betula glandulosa	Glandular Birch	Area
Betula minor	Dwarf White Birch	Stems
Carex arcta	Norther Clustered Sedge	Non Target**
Carex atratiformis	Scabrous Black Sedge	Non Target**
Carex bigelowii	Bigelow's Sedge	Clumps
Carex haydenii	Hayden's Sedge	Non Target**
Carex scirpoidea	Single-Spike Sedge	Clumps
Diapensia lapponica	Diapensia	Clumps/Area
Empetrum atropurpureum	Purple Crowberry	Area
Empetrum nigrum	Black Crowberry	Area
Geocaulon lividum	Purple Commandra	Stems
*Harrimanella hypnoides**	Moss Plant	Non Target**
Huperzia appressa	Mountain Firmoss	Clumps
Kalmia procumbens	Alpine Azalea	Area
Nabalus boottii	Boott's Rattlesnake Root	Individuals
Oreojuncus trifidus	Highland Rush	Clumps
Poa laxa ssp. fernaldiana++	Fernald's Bluegrass	Non Target**
Rhododendron lapponicum	Lapland Rosebay	Stemps
Salix herbacea+	Dward Willow	Stems/Leaves
Salix pyrifolia	Balsam Willow	Non Target**
Salix uva-ursi	Bearberry Willow	Area
Solidago leiocarpa	Alpine Goldenrod	Individuals
Tricophorum cespitosum	Deer's Hair Sedge	Clumps
Vaccinium boreale	Northern Lowbush Blueberry	Area
Vaccinium cespitosum	Dwarf Bilberry	Stems

Expected Products, Outputs, and Possible Outcomes

We have completed the work funded by this grant; the Botany Field Technicians completed the surveying at the end of August and the Summit Steward Coordinator supervised them during that time. Therefore, product 1 (surveying the plots) and product 2 (educating the public while surveying) have been completed. Fieldwork updates were published in the 2024 mid-season and end of season reports to satisfy product 3. Product 4 and 5 (database entry and analysis) will be completed by our research partner Dr. Tim Howard from New York Natural Heritage Program in the spring of 2025. ADK will then submit the final report after that work is completed. Presentations on the field work were made at public lecture events and at the Northeastern Alpine Stewardship Gathering. Additional outreach will be conducted once the data analysis is competed to complete product 6.