



**Northeastern States Research Cooperative (NSRC) FY2023
USDA FS Award #: 23-DG-11242311-0240**

**Interim Progress Report
Period ending December 31, 2025**

Table of Contents

Administration and Information Transfer	2
<i>Summary of Progress in 2025</i>	3
<i>Collaboration with USDA Forest Service</i>	5
<i>Next Reporting Period</i>	5
<i>Products</i>	6
Ongoing Research Projects	11
<i>Using a Functional Trait Approach to Inform Assisted Migration for Climate Adaptation in the Northern Forest Region</i>	11
<i>The Effects of Seed Dispersal and Seedling Establishment Limitations on Climate-Driven Tree Species Range Shifts in the Northeastern United States</i>	15
<i>Tools for Rehabilitative Silviculture to Enrich Habitat and Restore Productivity in Degraded Hardwood Stands</i>	20
<i>Assessing the Future Northern Forest Through the Lens of Seedling Survival and Sapling Recruitment</i>	23
<i>Northern Historical Atlas Project</i>	25
<i>Assessing eDNA as a Monitoring Tool for Forest Arthropod Biodiversity and Pests</i>	28
<i>Sustainable Co-production of Bioplastics and Hydrochar from Forest Residue Biomass: A Novel Hybrid Conversation Approach</i>	30
<i>Private Forest Landowner Engagement in Forest Management Programs for Carbon Sequestration</i>	32
<i>Understanding the Landscape for Species of Greatest Conservation Need by Uniting Coarse- and Fine-filter Strategies for Conservation</i>	33
<i>Post-Release Non-Target Impacts of Hemlock Woolly Adelgid Biocontrol</i>	35

<i>Decadal-scale Trends in Northern Forest Carbon Storage in Relation to Nutrient Availability and Rising Carbon Dioxide</i>	38
<i>Assessing Fire-Dependency in Natural Red Pine Forests of the Northeast</i>	41
<i>Digital Species-Site-Suitability Systems for Regenerating Northern Forests</i>	45
<i>Integrating Advanced Geospatial Analysis and Indigenous Forest Knowledge for Protecting Ash Species</i>	47
<i>Satellite Monitoring of Eastern White Pine (EWP) Health through Assessing the Forest Structure</i>	50
<i>A Predictive Scaling Framework of Forest Structure and Functional Diversity in a Non-Equilibrium World</i>	53
<i>Mapping Canopy Height Model and Aboveground Biomass of Northeastern Forests Annually at 25-m Resolution Through Remote Sensing Data Fusion and Machine Learning</i>	57
<i>SEED: Social, Economic, and Ecological Dimensions of Climate Adaptive Silviculture</i>	59
<i>Partnership with Abenaki for Conservation and Restoration of the Threatened, Declining Butternut Tree, an Ecologically and Culturally Important Hardwood</i>	62
<i>Restoring Tribal Relations and Forest Knowledge</i>	65
<i>Effects of Road Crossing Construction on The Aquatic Community of a Beaver-Influenced Landscape</i>	68
<i>Managing for Tomorrow's Panawahpskek Forests Today: An Integrative Approach to Submerchantable Competition Control</i>	70

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. Develop a multi-stakeholder 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 dialogue regarding research findings and synthesis to stakeholders through multiple communication channels.

Between January 1 and December 31, 2025, NSRC:

- Rebranded and launched a new website: www.nsrcforest.org.
- Conducted outreach and communications activities to increase the visibility of 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 Indigenous Forest Knowledge Fund (IFKF) projects.

- Organized a special session at the 2025 Forest Ecosystem Monitoring Cooperative conference in Burlington, Vermont, highlighting research from Fiscal Year (FY) 2023 projects to over 50 attendees.
- Presented and/or exhibited at the New York Society of American Foresters (SAF), New England SAF, National SAF, and the Northern Hardwood conferences.

Summary of Progress in 2025

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

Objective 1: Develop a multi-stakeholder platform for the Northern Forest to inform research priorities and recruit a strategic roster of funded research projects.

- External Advisory Committee (EAC) formed—Complete.
- EAC meets and recommends priorities for research—Complete.
- Successful Request for Proposals (RFP) process—Complete. 2 RFPs were released for this award.
 - **The general fund** received 49 research project proposals requesting \$14 million in funding; 19 grants were awarded¹ totaling over \$4 million in federal funding and close to \$2 million of matched funding.
 - **The IFKF** received 10 proposals requesting \$3.2 million in funding; 5 grants were awarded totaling nearly \$1.7 million in federal funding.
- Research project awarded—Complete. [View all the projects on the NSRC website](#) and in table 1 below.
- IFKF projects awarded—Complete. [View all IFKF projects on the NSRC website](#) and in table 1 below.

Objective 2: Support high priority scientific research through efficient research administration, data sharing, and annual financial and technical monitoring and reporting.

- Annual technical and financial reporting—Ongoing.
- Research outputs, to include scholarly and public-facing publications and activities—Ongoing. This award supported the development of 16 scholarly articles (4 of the 16 currently in review), 31 presentations, and 12 other communications materials during this reporting period (see “Products” below). Additionally, these research projects supported at least 17 graduate students and 11 undergraduates.
- Project data archived with the Forest Ecosystem Monitoring Cooperative (FEMC)—Ongoing. An NSRC collection with available data is accessible [on the FEMC website](#).

Objective 3: Share and foster dialog regarding research findings and synthesis to stakeholders through multiple communication channels.

- Communications outputs—New NSRC logo, FEMC conference special session, print publications, press releases, and project specific communications materials.

¹ This total includes a project that was split across two awards (FY23 and FY24) to maximize available funds supporting research. All deliverables and progress updates for that project are in the FY24 report.

- NSRC website with current list of projects, research outputs—The current website is used by PIs and partners to find projects, RFP information, and publications.
- Engagement with partners and the public—Ongoing, key partners include the USFS, the universities in the Northern Forest, and members of the EAC.

Table 1: Regional Research and Indigenous Forest Knowledge Fund projects funded through NSRC 2023 (23-DG-11242311-0240)

PI / Institution	Lead Institution	Project Title	Project Status
General Fund NSRC 2023 Research Projects			
Asbjornsen, Heidi	University of New Hampshire	Using a functional trait approach to inform assisted migration for climate adaptation in the Northern Forest Region	Ongoing
Clark, Peter	University of Vermont	Restoration and climate adaption potential of red spruce in the Northern Forests	Ongoing *
Dovciak, Martin	SUNY-ESF	The effects of seed dispersal and seedling establishment limitations on climate-driven tree species range shifts in the northeastern U.S.	Ongoing
Foppert, John	Paul Smith's College	Tools for rehabilitative silviculture to enrich habitat and restore productivity in degraded hardwood stands	Ongoing
Harris, Lucas	University of Vermont	Assessing the future Northern Forest through the lens of seedling survival and sapling recruitment	Ongoing
Hayes, Daniel	University of Maine	Northern Forest Historical Atlas Project	Ongoing
Johnston, Jason	University of Maine at Presque Isle	Assessing eDNA as a monitoring tool for forest arthropod biodiversity and pests	Ongoing
Juneja, Ankita	SUNY-ESF	Sustainable Co-production of Bioplastics and Hydrochar from Forest Residue Biomass: A Novel Hybrid Conversion Approach	Ongoing
Kloster, Danielle	SUNY-ESF	Private forest landowner engagement in forest management programs for carbon sequestration	Ongoing
Kron, Peter	Vermont Center for Ecostudies	Understanding the Landscape for Species of Greatest Conservation Need by Uniting Coarse- and Fine-filter Strategies for Conservation	Ongoing **
Mech, Angela	University of Maine	Post-release non-target impacts of hemlock woolly adelgid biocontrol	Ongoing
Ollinger, Scott	University of New Hampshire	Decadal-scale trends in northern forest carbon storage in relation to nutrient availability and rising carbon dioxide	Ongoing
Pendleton, Simon	University of New Hampshire	Assessing fire-dependency in natural red pine forests of the Northeast	Ongoing
Premer, Michael	University of Maine	Digital Species-Site-Suitability Systems for Regenerating Northern Forests	Ongoing

Rahimzadeh, Parinaz	University of Maine	Satellite Monitoring of Eastern White Pine (EWP) Health through Assessing the Forest Structure	Ongoing
Record, Sydne	University of Maine	A predictive scaling framework of forest structure and functional diversity in a non-equilibrium world	Ongoing
Salehi, Bahram	SUNY-ESF	Mapping Canopy Height Model and Aboveground Biomass of Northeastern Forests Annually at 25 m Resolution through Remote Sensing Data Fusion and Machine Learning	Ongoing
Simons-Legaard, Erin	University of Maine	Social, Economic, and Ecological Dimensions of Forest Management for Climate Change Adaptation and Resilience	Ongoing
White, Kayla	Adirondack Mountain Club	Long-term Monitoring of Rare Plant Populations in the Adirondack Alpine	Complete ***
NSRC 2023 Indigenous Forest Knowledge Fund (IFKF) Projects			
Hoban, Sean	Morton Arboretum	Partnership with Abenaki for conservation and restoration of the threatened, declining butternut tree, an ecologically and culturally important hardwood	Ongoing
Rahimzadeh, Parinaz	University of Maine	Integrating Advanced Geospatial Analysis and Indigenous Forest Knowledge for Protecting Ash Species	Ongoing
Raspitha, Jessica	Saint Regis Mohawk Tribe	Saint Regis Mohawk Tribe- Restoring Tribal Relations and Forest Knowledge	Ongoing
Simpson, Ben	Penobscot Nation	Ecosystem responses to the interacting forces of bridge improvements and beavers	Ongoing
Ziegra, Carolyn	Appalachian Mountain Club	Managing for Tomorrow's Panawahpskek Forests Today: An Integrative Approach to Submerchantable Competition Control	Ongoing

* Indicates the project was split between two awards (FY 23 and FY 24). All deliverables and progress updates are found within the FY24 report.

**Indicates the award was funded during the FY24 Request for Proposals (RFP).

***Indicates the project concluded during a previous reporting cycle. The final report for each research project will be attached to the final award report.

Collaboration with USDA Forest Service

Deahn DonnerWright serves as the Forest Service liaison with NSRC. She contributes expertise to all aspects of NSRC activities, including the development and implementation of research projects and IFKF research competitions, participation in the EAC as an observer, and coordination and management activities.

Next Reporting Period

During the next reporting period, NSRC will work on activities related to objectives 2 and 3 and ensure the successful completion of each research project by the end of the award. This annual

report is composed of summaries of progress for the administration project, ongoing research projects, and IFKF projects.

Products

Scholarly Articles

1. Bergl, D.D., Carbone, M.S., Hollinger, D., Liu, Y., Lucas, B., Ollinger, S.V., Ouimette, A.P., Templer, P., Richardson, A.D. Increasing Respiration Weakens the Carbon Sink over Two Decades in a Temperate Deciduous Forest. *Global Change Biology Communications*. In Review.
2. Eichenwald, A. M., Grady, J. M., Knott, J. A., Read, Q. D., Rodriguez, J. M., & Record, S. (2025a). The impact of disturbance on tree size distributions in the United States. *Global Ecology and Biogeography*, 34, e70102. <https://doi.org/10.1111/geb.70102>
3. Eichenwald, A. M., Grady, J. M., Knott, J. A., Read, Q. D., Rodriguez, J. M., Weinstein, B., Orwig, D. A., & Record, S. (2025b). Leveraging remote sensing and theory to predict tree size abundance distributions across space. *Global Ecology and Biogeography*, 34, e70085. <https://doi.org/10.1111/geb.70085>
4. Gawali, S., Kumar, D., & Juneja, A. (2026). *Potential of mixed hardwood forest residues from Northeastern United States for the production of different biobased products*. *Biomass Futures*. Manuscript submitted for publication. (Manuscript No. BMF-D-26-00017)
5. Harris, L. B., Pastore, M. A., & D'Amato, A. W. (2025). Effects of browsing by white-tailed deer on tree regeneration vary by ontogeny and palatability in forests of the northeastern USA. *Forest Ecology and Management*, 593, Article 122906. <https://doi.org/10.1016/j.foreco.2025.122906>
6. Harris, L. B., Pastore, M. A., & D'Amato, A. W. (in review). Shifting balance between natural mortality and harvesting in forests of the northeastern USA. *Canadian Journal of Forest Research*.
7. Harris, L. B., Pastore, M. A., & D'Amato, A. W. (in revision). Tree regeneration trends in forests of the northeastern USA and their implications for resilience and restoration. *Ecological Applications*.
8. Kiel, N. G., Tourville, J. C., Wason, J. W., & Dovciak, M. (2025). *Tree seedling abundance mediated by local neighborhood effects and microsite conditions* (Version 1). Environmental Data Initiative. <https://doi.org/10.6073/pasta/a380a7a53f1954d6b4735b2103531db6> (Accessed 2025-12-24)
9. Kiel, N. G., Tourville, J. C., Wason, J. W., & Dovciak, M. (2026). Conspecific adult dominance interacts with microsite factors to influence forest regeneration patterns across elevation. *Journal of Biogeography*, 53(1), e70153. <https://doi.org/10.1111/jbi.70153>
10. Kumar, M., Cheatham, R., Hossain, M. S., Reza, T., Volk, T. A., Juneja, A., & Kumar, D. (2025). Sustainable valorization of forest waste hydrolysis residues to solid biofuel: Insights into conversion mechanisms and fuel properties. *Energies*, 18(23), 6156. <https://www.mdpi.com/1996-1073/18/23/6156>
11. Liu, Y., Stoy, P., Chu, H., Hollinger, D.Y., Ollinger, S.V., Ouimette, A.P., Durden, D.J., Sturtevant, C., Lucas, B. and Richardson, A.D., 2026. A tale of two towers: comparing NEON

and AmeriFlux data streams at Bartlett Experimental Forest. *Agricultural and Forest Meteorology*, 378, p.110939.

12. Ouimette, A.P., Hastings, J.H., D'Amato, T., Battles, J.J., Ducey, M., Foster, J.R., Fuss, C., Goodale, C., Johnson, C., Lang, A., Ollinger, S.V., 2026. Can Coarse Woody Material Account for the Nitrogen Imbalance at Hubbard Brook Experimental Forest, New Hampshire, USA? *Biogeochemistry*. In Press.
13. Wehner, D. W. (2026). An uphill battle: Seed dispersal and mycorrhizal constraints on the climate-driven upslope migration of tree species in the northeastern U.S. *Mitchelliana*, 37(1), 11–13.
14. Sullivan, F.B., Hastings, J.H., Ollinger, S.V., Ouimette, A., Richardson, A.D. and Palace, M., 2026. Parsing the Relative Contributions of Leaf and Canopy Traits in Airborne Spectrometer Measurements. *Remote Sensing*, 18(2), p.355.
15. Yadav, G., Rahimzadeh-Bajgiran, P., Das, P., & Weiskittel, A. (in review). Automating leaf area index (LAI) estimation in the field and at landscape scale using image processing techniques and remote sensing (submitted to a peer-reviewed journal and it is currently under review)
16. 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. and Laflower, D., 2025. Integrating nitrogen and carbon cycling into LANDIS-II/PnET-Succession to improve forest landscape modeling: methods and sensitivity analyses. *Ecological Modelling*, 510, p.111285.

Conferences and Presentations

1. DelBove, M., Doner, L., Pendleton, S., & Doiron, O. (2025). *Reconstructing Holocene wildfire activity in the White Mountain Region using paleolimnology* [Conference presentation abstract PP23E-1012]. AGU Fall Meeting, New Orleans, LA, December 15–19, 2025.
2. Dionis, J., Kotulak, A., Contosta, A., Ouimette, A., Blommel, C., Hastings, J., Tetreault, E., Vandewater, V., Ollinger, S.V., 2025. Assessing Shifts in Carbon Allocation Over Two Decades in a Mixed Northern Hardwood Forest. Poster presentation at the American Geophysical Union Annual Meeting, New Orleans, LA, December 15-19.
3. Dionis, J., 2025. Is rising atmospheric CO₂ and nutrient limitation driving changes in carbon allocation in northeastern temperate forests? Talk at the UNH Department of Natural Resources Spring Seminar.
4. Doiron, O., Doner, L., Pendleton, S., & DelBove, M. (2025). *12,000 years of environmental change in New England: A dual-site paleolimnological study* [Poster presentation]. Geological Society of America Annual Meeting, San Antonio, TX, October 17–22, 2025.
5. East, A. M., Eichenwald, A. M., & Record, S. (2025). *Multimodal crown segmentation across spatial resolutions* [Poster presentation]. American Geophysical Union Annual Meeting, New Orleans, LA.
6. Guiterman, C. (2025). *Historical wildland fire in the northeastern U.S. as reconstructed from tree rings* [Invited seminar]. Albany Pine Bush Preserve Science Lecture Series, Albany, NY.
7. Guiterman, C., Marshall, J., & Stambaugh, M. (2025). *Historical fire in the Northeast as viewed from tree rings* [Conference presentation]. Northeast Association of Fish & Wildlife Agencies Conference, Bartlett, NH.

8. Hubbard, K., Murphy, C., Simpson, B., & Zydlewski, J. (2025). *Effects of road crossing construction on the aquatic community of a beaver-influenced landscape* [Conference presentation]. 155th Annual Meeting of the American Fisheries Society, San Antonio, TX, August 11.
9. Hubbard, K., Murphy, C., Simpson, B., & Zydlewski, J. (2026). *Effects of road crossing construction on the aquatic community of a beaver-influenced landscape* [Conference presentation]. Atlantic Salmon Ecosystems Forum, Bangor, ME, January 13.
10. Hynes, A., Doner, L. A., & Pendleton, S. (2025). *Fire and the forest: Sedimentary charcoal records of paleo-wildfires in New England* [Conference presentation abstract #407208]. GSA Joint Northeastern/North-Central Meeting.
11. Johnston, J. (2025, April). *A bioinformatics toolset for processing eDNA* [Conference presentation]. UMPI University Day.
12. Kiel, N. G. (2025). *Slow vs. abrupt pathways of climate-driven forest change* [Invited presentation]. Biology Department, Utica University, Utica, NY.
13. Kiel, N. G. (2025). *Slow vs. abrupt pathways of climate-driven forest change* [Invited presentation]. Cary Institute of Ecosystem Studies, Millbrook, NY.
14. Kiel, N. G. (2025). *Slow vs. abrupt pathways of climate-driven forest change* [Invited presentation]. Department of Biology, SUNY Geneseo, Geneseo, NY.
15. Kiel, N. G. (2025). *Slow vs. abrupt pathways of climate-driven forest change* [Invited presentation]. Department of Biology, Syracuse University, Syracuse, NY.
16. Kiel, N. G. (2025). *Slow vs. abrupt pathways of climate-driven forest change* [Invited presentation]. Section of Natural Resources and the Environment, Cornell University, Ithaca, NY.
17. Kiel, N. G., Tourville, J. C., Wason, J. W., & Dovciak, M. (2025). *Overstory tree neighborhood effects interact with microsite factors to impede or facilitate upslope range shifts* [Poster presentation]. Ecological Society of America Annual Meeting, Baltimore, MD, August 10–15.
18. Killea, F. (2025). *Managing for compositional diversity in American-beech dominated stands: A tribal collaboration* [Poster presentation]. Northern Hardwoods Conference, Syracuse, NY. <https://docs.google.com/document/d/16foFjBk6h1qUAj0v-nKIcObWPOSr8IxZ/edit>
19. Kotulak, A., Dionis, J., Frey, S., Ouimette, A., Blommel, C., Hastings, J.H., Tetreault, E., Vandewater, V., Ollinger, S.V., 2025. Long-Term Patterns of Forest Productivity and Nitrogen Availability in a Northeastern Temperate Forest. Poster presentation at the American Geophysical Union Annual Meeting, New Orleans, LA, December 15-19.
20. Kotulak, A., 2025. Long-term changes in forest C allocation, N availability, and mediation by mycorrhizal fungi. Talk at the UNH Department of Natural Resources Spring Seminar.
21. McCloskey, D., Kenefic, L., Simons-Legaard, E., Rogers, N., Sachdeva, S., & Roach, S. (2025). *Climate adaptivity outcomes of conventional silviculture in northern conifer forests* [Poster presentation]. New England Society of American Foresters Winter Meeting, Devens, MA. https://nesaf.org/wp-content/uploads/2025/04/NQ_apr_2025.pdf
22. McCloskey, D., Kenefic, L., Simons-Legaard, E., Rogers, N., Sachdeva, S., & Roach, S. (2025). *Managing mixedwood forests for the future: Outcomes from long-term silviculture* [Poster presentation]. Northern Hardwoods Conference, Syracuse, NY. <https://docs.google.com/document/d/16foFjBk6h1qUAj0v-nKIcObWPOSr8IxZ/edit>

23. McCloskey, D., Kenefic, L., Simons-Legaard, E., Rogers, N., Sachdeva, S., & Roach, S. (2025). *Conventional silviculture and climate adaptivity: Outcomes from 70 years of data in northern conifer forests* [Poster presentation]. Society of American Foresters National Convention, Hartford, CT.
24. Moore, V., Pendleton, S., Hastings, E., Doner, L., Doiron, O., Talon, G., Hynes, A., & Coleman, M. (2025). *13,000 years of wildfire history in the Cone Pond watershed* [Conference presentation]. NH-LIFT Summit, Jefferson, NH, August 19–20.
25. Moore, V., Pendleton, S., Doner, L., Talon, G., Hastings, E., Doiron, O., Hynes, A., & Coleman, M. (2025). *Entire Holocene fire activity in the White Mountains, NH reconstructed through sedimentary charcoal* [Conference presentation abstract PP23E-1011]. AGU Fall Meeting, December 15–19, 2025.
26. Pendleton, S., Doner, L., Guiterman, C., Neely, J., Moore, J., DelBove, M., Doiron, O., Hastings, E., Hynes, A., Gifford, A., Talon, G., & Coleman, M. (2025). *Tree rings and mud: An ongoing collaborative reconstruction of historical fire regimes in northern New Hampshire* [Conference presentation]. Forest Ecosystem Monitoring Cooperative Conference, Burlington, VT, November 20, 2025.
27. Ramsay, B., White, C., & Johnston, J. (2025). *A bioinformatics toolset for processing eDNA* [Poster presentation]. UMPI University Day, April.
28. Salehi. Poster presentation at the National Association of American Foresters conference in Hartford, Connecticut, in October 2025.
29. Yadav, G., Rahimzadeh-Bajgiran, P., & Das, P. (2025). *Remotely sensed canopy structural parameters as indicators for eastern white pine health* [Conference presentation]. AGU Fall Meeting, New Orleans, LA.
30. Yadav, G., Rahimzadeh-Bajgiran, P., & Das, P. (2025). *Automating Eastern white pine health assessment through modeling canopy structural parameters* [Conference presentation]. Northeastern Forest Pest Council 87th Annual Meeting, Middlebury, VT.
<https://www.northeasternforestpestcouncil.org/previous-meetings>
31. Bergdahl presented the project at the New York Nut Growers Association meeting.

Other Products

1. Maine Public Feature - [Maine Calling Feature](#).
2. Premer Website [Prototype](#)
3. Eichenwald, A.M., J.M. Grady, A.M. East, N. D. Charney, and S. Record. In major revision. ScalingFromSky package: An R package to infer forest structure from remote sensing data. *Methods in Ecology and Evolution*. <https://anonymous.4open.science/r/ScalingFromSkypackage-7CB2/README.md>
4. Akwesasne Cultural Exchange Camp [summary article](#) prepared by the SRMT Center for Media and Communications for inclusion in the Kanenna'ké:ne/ Fall 2025 Community Newsletter. (PDF Page 8, Print pages 14-15)
5. [LinkedIn Post](#)

2025 Summer Program Student Final Projects affiliated with the project “Restoring Tribal Relations and Forest Knowledge

6. A story map on Non-Indigenous Relatives’ Impact on Wabanaki Traditions by Apemesim Galipeau, Pensobscot Nation.
7. A field guide titled, Wabanaki Cultural Crafts and Forest Knowledge Guide, by Sierra Lank, Passamaquoddy Tribe at Motahkomikuk.
8. A poster presentation on Shifting Changes in Moose in Maine, prepared and presented by Frank Milano IV, Passamaquoddy Tribe at Motahkomikuk.
9. A poster presentation on Wolahkakoniw: It is plentiful, it is a good crop, focusing on food sovereignty, prepared and presented by Taliah Doughty, Passamaquoddy Tribe at Sipayik.
10. A slide show presentation on Returning Native Species to the Thousand Acres Reclaimed by the Onondaga Nation, prepared and presented jointly by Riley Thornton and Kenji Frazier, both from Onondaga.
11. A presentation and hands-on demonstration focused on Insect Biodiversity, lead by Cora Thompson, Akwesasne Mohawk.
12. A video presentation on the Wildfire Risk in Akwesasne, prepared and presented by Ty David, Akwesasne Mohawk.

Ongoing Research Projects

Using a Functional Trait Approach to Inform Assisted Migration for Climate Adaptation in the Northern Forest Region

Principal Investigator: Heidi Asbjornsen (University of New Hampshire, hiw3@usnh.edu)

Summary of Progress in 2025

Foliar samples were collected from Mount Madison, NH; Mount Mansfield, VT, Burnham lot (UNH property), Yale-Myers Forest, CT during the summer of 2025. Species sampled include white pine, red oak, sugar maple, yellow birch, balsam fir and red spruce. On mountain sites trees were collected from the highest and lowest elevations where they were found.

Data was measured on specific leaf area, turgor loss points and stomatal measurements for broadleaf species. For sugar maple we also assessed leaf vein density. Leaf samples are being prepared for isotope analysis to obtain $\delta^{13}\text{C}$ and leaf nitrogen content. Acorns were collected from Harvard Forest, Yale-Myers Forest, Burnham Lot, and Hogsback in the fall of 2025 and sent to the National Seed Lab in GA for germination trails and seed weight measurements.

Research permit applications were submitted for all mountain sites in the fall of 2025 to collect foliar samples in the summer of 2026 and seeds in the fall of 2026. Permits from the WMNF and the GMNF were granted to collect seeds on Mount Madison and collect foliar samples and seeds on sections of Killington, the Maine Department of Agriculture to collect foliar samples and seeds on Old Speck and Vermont State to sample collect seeds on Mansfield and collect foliar samples and seeds on parts of Killington. Permits from Dartmouth to sample from Mount Moosilauke are pending.

The PhD student on this project, Emily Anders, attended a Functional Trait Course from June 15–20, 2025 at Université Laval, Québec, Canada. The course was led by professors, Bill Shipley, Eric Garnier, Francesco de Bello, Juan Posada, and Alison Munson. Emily strengthened her understanding on the theory and methods of measuring leaf functional traits for this NSRC project.

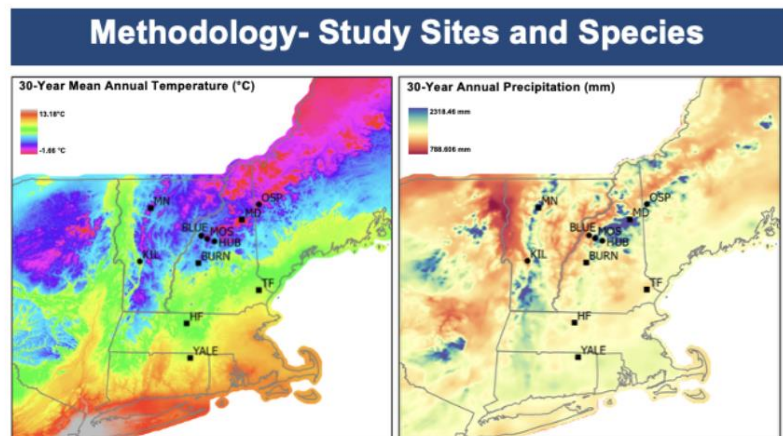


Figure 1. Study sites vary along latitudinal and elevational gradient (0-1200m)⁶. Sites are overlaid with average annual temperature and vapor pressure deficit from 1991-2020⁷. A square indicates that the site was sampled, and a circle indicates that this site will be sampled in summer of 2026.

Problems or Changes

- After reviewing the number of sites available for sampling shagbark hickory and white oak, it was decided to remove these species from the project because of the lack of sufficient sites across a broad enough climate gradient to draw meaningful conclusions about their variation across environmental conditions.
- Two additional sites were included to fill gaps in climate coverage for certain species. In the summer of 2026, there are plans to collect red oak from Hogsback Mountain, NH, and red spruce, balsam fir, red oak, sugar maple, white pine, and yellow birch at Hubbard Brook.
- Due to high variability in tree core data and limited time to revisit sites, this trait was removed from the data collection. For similar reasons, as well as insufficient development of cold tolerance and bark thickness methods, these traits were removed as well.

Plans for 2026

January–June

- Complete processing samples from $\delta^{13}\text{C}$ and leaf nitrogen content.
- Survey sites (Old Speck, Hubbard Brook, Hogsback, Killington) for accessibility and species abundances.

July–August

- Collect foliar samples from 4 mountain sites (Hogsback, Hubbard Brook, Old Speck and Killington) 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 seeds from species that are producing.
- Process foliar samples for trait data.

Communications and outreach

- The PhD student on this project, Emily Anders, will present a proposal defense for this project to her committee and other students in April 2026.

Collaboration or Alignment with USFS, Partners, or the Public

This 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.

Collaboration with the USFS will increase the research and application of assisted migration in the northeast.

Name	Affiliation	Role
John Butnor	US Forest Service; Northern Research Station, Burlington, VT	Co-PI, assisting with data interpretation and concept in plant physiology
James Donahey	US Forest Service; Rochester, VT	Collaborator, providing knowledge on seed collection
Cameron McIntire	US Forest Service; Forest Health Dept. in Durham, NH	Supervisor of PhD student Anders’ Pathways program. Cameron is a plant pathologist with a

		background in plant physiology. Emily's Pathways project focuses on understanding how stressors (climate, pathogens) and their interaction impact plant health.
Nina Lany	US Forest Service; Northern Research Station, North Woodstock, NH	Collaborator. Nina Lany is the lead on long term foliar chemistry research at Hubbard Brook. We plan to collaborate with foliar collection at Hubbard Brook.

Communications & Outreach

- Anders, E, Matthew Vadeboncoeur, John Butnor, Martin Dovciak, Jay Wason, and Heidi Asbjornsen. Using a functional trait approach to inform assisted migration for climate adaptation in the Northern Forest Region, New England Society of American Foresters (NESAF) Annual Conference, March 26, 2025.
- Anders, E., Matthew Vadeboncoeur, John Butnor, Martin Dovciak, Jay Wason, and Heidi Asbjornsen. Using a functional trait approach to inform assisted migration for climate adaptation in the Northern Forest Region, Society of American Foresters (SAF) Annual Conference, October 24, 2025.
- Matthew Vadeboncoeur, John Butnor, Martin Dovciak, Jay Wason, and Heidi Asbjornsen



Figure 2. Sampling methods involve a pole pruner to collect high elevation *P. rubens* and *A. Balsamea* foliage and shotgun sampling to collect *A. saccharum*, *B. alleghaniensis*, *Q. rubra*, and *P. strobus* foliage (left, middle). Acorns collected from *Q. rubra* at Burnham Lot in Grafton, NH (right).



Figure 3. Functional trait measurements are being taken for 6 functionally diverse study species.

Preliminary Results- Stomatal Length (SL) & Stomatal Density (SD)

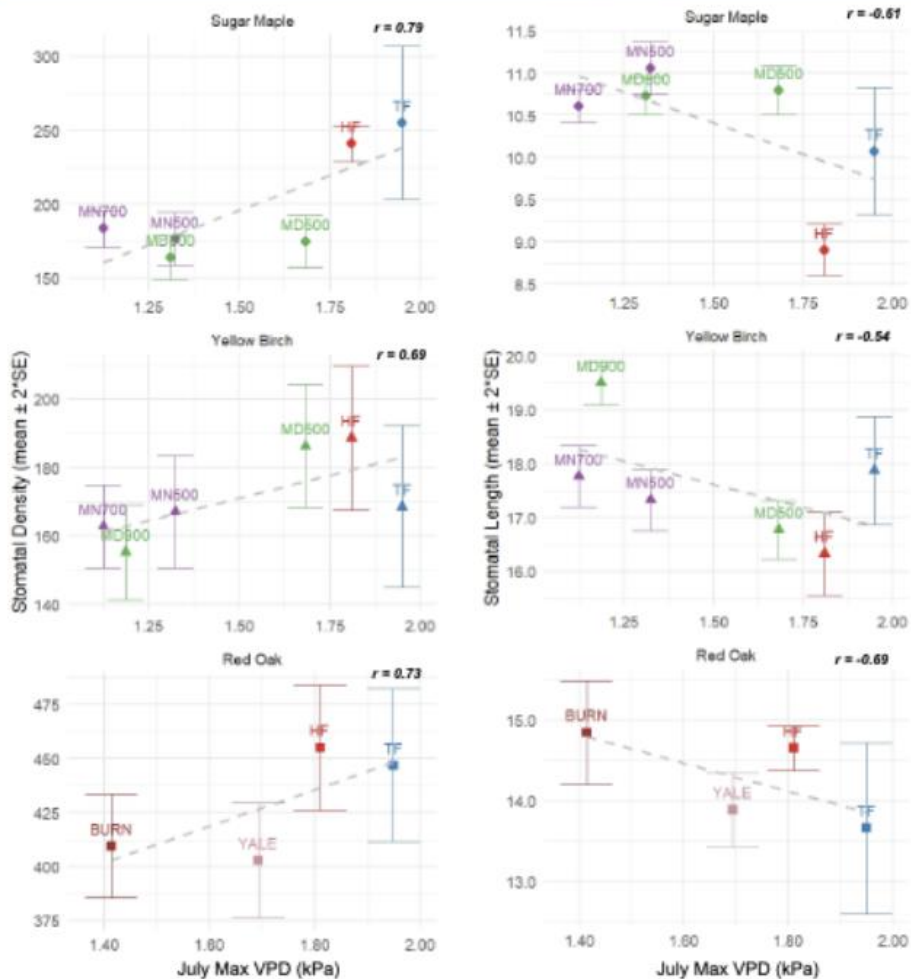


Figure 4. Average SD (count/cm^2) and SL (μm) for three study species across study sites representing a range of July maximum vapor pressure deficit (VPD-kPa). Error bars represent ± 2 standard error of the mean. Generally, we found a positive relationship between SD and VPD and a negative relationship between SL and VPD. The Pearson r correlation coefficient is given for each correlation. In agreement with expectations populations in higher VPD sites have smaller and more densely packed stomata. However, with few sites we have not found significant correlations.

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 (SUNY College of Environmental Science and Forestry; mdovciak@esf.edu)

Progress in 2025

Excellent progress has been made on this suite of sub-projects within the main NSRC project. The manuscript that was in preparation last winter has now been published in *Journal of Biogeography*, with associated data and code deposited with the Environmental Data Initiative according to best practices in Open Research. The findings of this work were also presented as a contributed poster at the 2025 annual meeting of the Ecological Society of America and have been included in five invited seminars given by Kiel at institutions across New York.

The project team has also grown in the last year. In January 2025, a new master's student, Danny Wehner, was accepted and has since made considerable progress on his thesis research. After writing his thesis proposal in the spring, Danny co-led a full summer field season and is currently conducting a greenhouse experiment in collaboration with Louis J. Lamit, an Assistant Professor at Syracuse University. Undergraduate student, Tee Atwater, was onboarded and will complete their honor's thesis by 2027. This summer, Tee joined us in the field in June before setting up a greenhouse experiment at ESF that ran through October. Tee's data are collected and are currently working on report writing and data analyses. Additional details on the above and other projects are outlined in detail below.

Specific progress. After securing proper permitting and purchasing materials in spring, a full field season commenced, spread across ~8 weeks from June to early October. Several greenhouse experiments were initiated. Field data collection took place on mountains in four northeastern U.S. states (NY, VT, NH, and ME; Figure 8) to understand the relative roles of **seed dispersal** and **seedling establishment limitations** (specifically, microclimate, substrate, granivory, and soil mycorrhizal fungi) on upslope range shifts of dominant Northern Forest tree species. This work is guided by several overarching research questions.

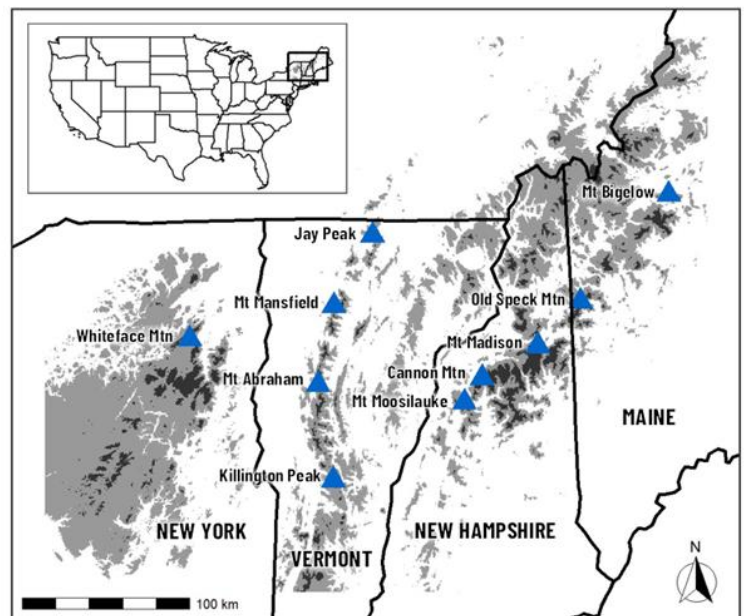


Figure 5. Study area (northeastern United States) and location of ten mountains on which individual research projects are being conducted.

*How do canopy gap disturbances influence **seed rain** of wind-dispersed tree species across elevation?* To quantify potential seed dispersal limitations, we set out 180 seed traps in July on three mountains (Whiteface Mt., NY; Mt. Mansfield, VT; Old Speck Mt., ME). On each mountain, 60 seed traps were deployed on four transects stratified by elevation across the montane temperate-boreal forest ecotone (Figure 9f). Half of these traps were placed in canopy gaps (>20% canopy openness) with the other half placed under closed canopy forest. Where traps were established, overstory tree composition was quantified using the point-center-quarter method (Cottam and Curtis, 1956) and understory seedling composition was quantified within 1m² quadrats. Traps were collected in early October after the bulk of fall seed rain and prior to snowfall. Danny Wehner is leading this project as one chapter of his thesis and is coordinating with an undergraduate, Cora Powell, on processing seed trap contents for analysis (see “Plans for 2026”).

*How do canopy gap disturbances influence **forest floor microclimate** for seedling establishment?* 100 TOMST TMS-4 microclimate dataloggers (Figure 9b) were deployed on ten mountains across the northeast (in addition to the above three, Jay Peak, Mt. Abraham, and Killington Peak, VT; Mt. Moosilauke, Cannon Mt., and Mt. Madison, NH; and Bigelow Peak, ME). On each mountain, 10 dataloggers were placed on five transects stratified across elevation, half in open canopy gaps and half under closed canopy forest, to discern the role of gap-phase dynamics in microclimate mediation. Each datalogger records temperature in the soil, at the soil surface, and ~10cm above the soil surface every 15 minutes. Batteries last ~10 years, and the hope is to leave dataloggers deployed for their usable lifetime.

*To what extent do **soil surface substrates** (e.g., moss, litter) and **rodent granivory** influence seedling establishment?* A field seed addition experiment was initiated on five mountains in August (Whiteface Mt., Mt. Mansfield, Mt. Madison, Mt. Moosilauke, and Old Speck Mt.). Seeds of American beech, sugar maple, and balsam fir (purchased from a regional supplier) were sown in a fully factorial design of manipulated soil surface substrate (moss vs. leaf litter) and granivore access (caged vs. uncaged; Figure 9a). Additions occurred on four transects per mountain (overlapping with those used for the microclimate study above), along which six plots were established ($n = 30$ replicates per treatment per elevational transect). At each plot, seeds were sown within subplots delimited by 10-cm plastic pot tops gently inserted into the soil and held in place by metal landscape staples. A fourth subplot was left empty to quantify background rates of species-specific seedling establishment.

To complement this field experiment, Tee Atwater is leading a greenhouse experiment investigating the effects of soil surface substrates on seedling establishment and growth (Figure 9d). Tee collected boreal forest moss, conifer tree litter, and deciduous tree litter from the field in June, in which they sowed balsam fir and American beech seeds in the ESF greenhouses. They tracked seedling establishment rates over ~two months, and a subset of established balsam fir seedlings were harvested at the end of the experiment and their dry biomass weighed (the same was not done for beech because of low establishment across all substrates). Analyses are ongoing, but our preliminary results indicate that balsam fir establishment was surprisingly highest on temperate litter and lowest on boreal litter (Figure 10a). Balsam fir seedlings also invested in relatively more root than shoot biomass when growing on moss substrates, possibly to puncture the thick mat and reach the soil below (Figure 10b).

How do understory herbaceous plants that associate with arbuscular mycorrhizal fungi (AMF) influence the establishment of sugar maple in the montane boreal forest? As a tree species associated with AMF, sugar maple may face unique establishment limitations during upslope migrations owing to the dominance of ectomycorrhizal tree species in montane boreal forests. Led by master's student Danny Wehner, we began a field and greenhouse study to discern whether two boreal forest understory plant species, *Oxalis montana* (mountain woodsorrel) and *Maianthemum canadensis* (Canada mayflower), provide suitable safe sites for the establishment of sugar maple seedlings. In July, we collected roots of woodsorrel and mayflower across five transects on three mountains (Whiteface Mt., Mt. Mansfield, and Old Speck Mt.; Figure 9c). Root samples (n = 150) have since been cleaned and will be stained to quantify AMF colonization using standard methods (McGonigle et al., 1990). In tandem with root collection, boreal forest soil was collected in October from patches of each understory plant and the surrounding vegetation free "matrix" for use in a greenhouse experiment. Half of each soil sample was sterilized via autoclave, and sugar maple seeds were sown in a fully factorial design of soil source (woodsorrel, mayflower, or matrix) and fungal inoculum (field vs. sterilized). Maples have established (Figure 9e) and will be harvested at the end of the experiment to quantify AMF root colonization differences across treatments. Danny shared progress on this and his seed dispersal project in the recent issue of *Mitchelliana*, the New York Flora Association's quarterly newsletter (Wehner, 2026).

Problems or Changes

As mentioned in previous reports, the manuscript now published in *Journal of Biogeography* was not part of the original proposal. This manuscript utilized an existing dataset to begin addressing our project's research objectives. No problems have been encountered and no major changes that may influence our plans for 2026 or expected outcomes.

Plans for 2026

Progress will continue on all the above projects in addition to several new ones. We have begun planning our summer field season, during which time we will revisit all mountains and (a) download microclimate data from TOMST dataloggers, (b) survey seed additions for establishment rates, and (c) repeat seed rain collections. In the meantime, Tee Atwater will continue data analyses and writing of their honor's thesis, which we hope to present at the annual SUNY Undergraduate Research Conference in April. Danny Wehner will also progress on his master's projects, including seed sorting (with assistance from a new undergraduate mentee, Cora Powell), understory plant root staining, and growing sugar maple seedlings in the greenhouse.

Additional projects have recently begun or will begin in spring. A new master's student, Jenna Meyer, joined the Dovciak lab in fall and will conduct part of her thesis research in relation to this grant by considering seed dispersal in time relative to that in space by focusing on soil seedbank on the study mountains. She is currently developing details of her proposal to be presented to her committee in Spring 2026 prior to the field season. The lab is also welcoming two new undergraduate researchers into the group, Cora Powell and Paige Flynn. Cora will assist Danny with his thesis research and develop an independent research project over the next calendar year, potentially joining us in the field during summer. Paige will conduct a greenhouse

experiment to build on Tee Atwater's findings, sowing balsam fir seeds on six moss taxa of different growth forms (*Dicranum fulvum*, *D. scoparium*, *Hylocomium splendens*, *Hypnum imponens*, *Thuidium delicatulum*, and *Polytrichum* sp.) and testing for variable seedling establishment and growth. Finally, a collaborative project with six researchers from institutions across the U.S. and Canada recently began (see "Collaborations") aimed at (a) synthesizing understanding of the mechanisms governing climate-driven shifts of the temperate-boreal and forest-alpine ecotones and (b) reviewing whether ongoing migration rates differ between the two. This project is in the initial stages of conceptualization and data collection.

Collaboration or Alignment with USFS, Partners, or the Public

We have established new and continued existing collaborations at several institutions in the first year of our 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. Additionally, our collaborative synthesis project (see "Plans for 2026") is being completed with Tourville and Wason from above, as well as Mark Vellend at the Université de Sherbrooke (Canada), Carissa D. Brown at Memorial University of Newfoundland (Canada), Anna L. Crofts at University of Regina (Canada), and Ming Ni at University of Wisconsin-Madison. We also connected with a new Assistant Professor at Paul Smith's College in New York, Don C. Radcliffe, who joined our research team for a field visit on Whiteface Mt. in August, and began conversations with the Northeast Wilderness Trust to coordinate a site visit in 2026.

Products

- Kiel, N. G., J. C. Tourville, J. W. Wason, & M. Dovciak. 2026. Conspecific adult dominance interacts with microsite factors to influence forest regeneration patterns across elevation. *Journal of Biogeography* 53 (1), e70153. <https://doi.org/10.1111/jbi.70153>.
- Kiel, N. G., J. C. Tourville, J. W. Wason, and M. Dovciak. 2025. Tree seedling abundance mediated by local neighborhood effects and microsite conditions ver 1. Environmental Data Initiative. <https://doi.org/10.6073/pasta/a380a7a53f1954d6b4735b2103531db6> (Accessed 2025-12-24).
- Kiel, N. G., J. C. Tourville, J. W. Wason, and M. Dovciak. 2025. Overstory tree neighborhood effects interact with microsite factors to impede or facilitate upslope range shifts. Poster presentation. Annual meeting of the Ecological Society of America, Baltimore, Maryland, August 10-15.
- Kiel, N. G. 2025. Slow vs. abrupt pathways of climate-driven forest change. Invited presentation. Cary Institute for Ecosystem Studies, Millbrook, New York.
- Kiel, N. G. 2025. Slow vs. abrupt pathways of climate-driven forest change. Invited presentation. Department of Biology, SUNY Geneseo, Geneseo, New York.
- Kiel, N. G. 2025. Slow vs. abrupt pathways of climate-driven forest change. Invited presentation. Biology Department, Utica University, Utica, New York.
- Kiel, N. G. 2025. Slow vs. abrupt pathways of climate-driven forest change. Invited presentation. Department of Biology, Syracuse University, Syracuse, New York.
- Kiel, N. G. 2025. Slow vs. abrupt pathways of climate-driven forest change. Invited presentation. Section of Natural Resources and the Environment, Cornell University, New York.
- Wehner, D. W. 2026. An uphill battle: seed dispersal and mycorrhizal constraints on the climate-driven upslope migration of tree species in the northeastern U.S. *Mitchelliana* 37(1):11-13.

References

- Cottam, G. and J. T. Curtis. 1956. The use of distance measures in phytosociological sampling. *Ecology* 37(3):451-460.
- McGonigle, T. P., M. H. Miller, D. G. Evans, G. L. Fairchild, and J. A. Swan. 1990. A new method which gives an objective measure of colonization of roots by vesicular-arbuscular mycorrhizal fungi. *New Phytologist* 115(3):495-501.



Figure 6. Our set of projects to investigate the relative roles of establishment and dispersal limitations to upslope tree species range shifts on mountains in the northeastern United States. (a) Seed addition experiment, with seeds sown in plastic pot tops in a fully factorial design of substrate (litter vs. moss) and granivore access (caged vs. open). (b) TOMST TMS-4 microclimate sensor in a temperate deciduous forest canopy gap. (c) Master's student Danny Wehner harvesting *Oxalis montana*, a common understory plant that associated with arbuscular mycorrhizal fungi. (d) Undergraduate student Tee Atwater measuring the heights of balsam fir seedlings in a greenhouse study (photo: Alexandra Henderson). (e) Sugar maple seedlings growing in soil collected near understory plants that are associated with arbuscular mycorrhizal fungi. (f) A cluster of seed traps (sown net bags held above the ground by wire caging) in a montane boreal forest canopy gap.

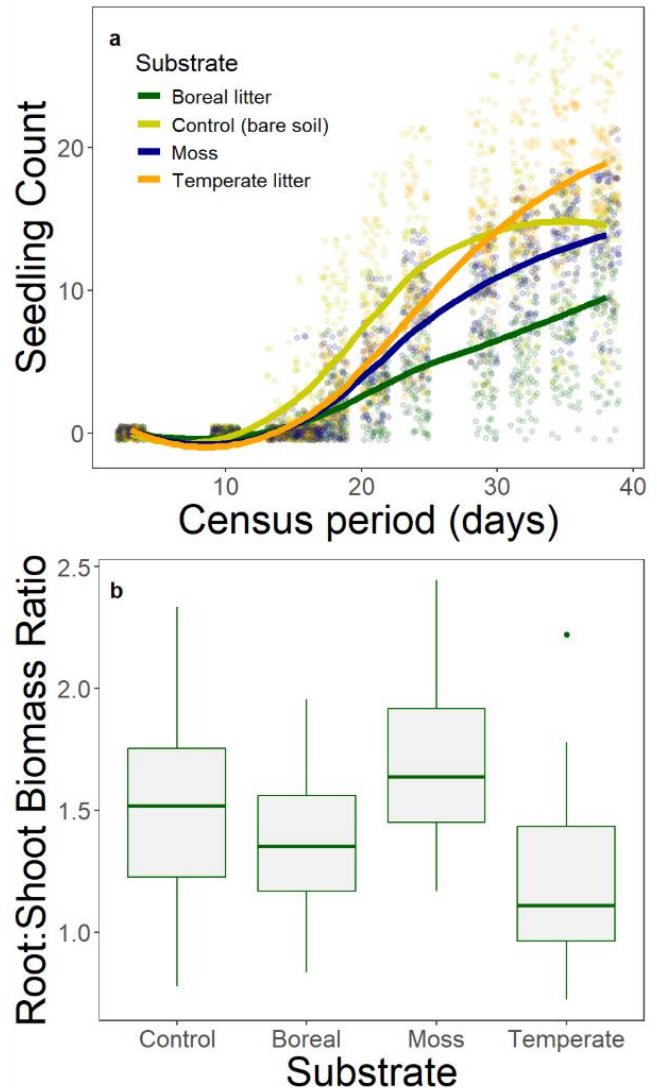


Figure 7. Preliminary results from seed sowing greenhouse experiment; only data for balsam fir are shown because of low establishment rates for American beech. (a) Seedling counts in each pot (individual points) during the first 40 days of the experiment, showing differences by substrate category. (b) Seedling root-shoot dry biomass ratios across substrates.

Tools for Rehabilitative Silviculture to Enrich Habitat and Restore Productivity in Degraded Hardwood Stands

Principal Investigator: John Foppert (Paul Smith's College, jfoppert@paulsmiths.edu)

Summary of Progress in 2026

This project has generally progressed as intended through 2025. An in-person, all-team project meeting was held at Paul Smith's College (PSC) in June. The project team met over three days and discussed the overall research and communication plans for the project, visited the rehabilitative silviculture demonstration site on the Paul Smith's College Forest, visited the Kunjamuk Young Forest Demonstration Project on the Lyme Adirondack Forest Company lands, and a related rehabilitative treatment on a private woodlot in Altona, New York.



Figure 8. Implementation of a regeneration harvest at the Paul Smith's College rehabilitation silviculture demonstration area.

Wildlife habitat use monitoring continued at the PSC site, led by co-PI Lizz Schuyler. Eight monitors were deployed from May through June to monitor for ruffed grouse drumming. Songbird point counts were conducted in June, with assistance from project partners at NY Audubon. Time-constrained herpetofauna searches were conducted in July and deer density pellet surveys were conducted in September with involvement from PSC wildlife students.

Previously collected habitat use data from the Kunjamuk site was shared with project partners and initial data analysis began. The 2026 treatment area in the PSC demonstration site was prepared for harvest. Over 700 variable radius plots were marked by PSC students in the fall Silviculture course, under the supervision of PI John Foppert. Additionally, over 700 were sampled by students with support from Research Technician Tyler Richardson. Co-researcher Alex George began analysis of operational data from the 2025 treatment.

PI Foppert and co-researcher Neal Maker continued work on crop-tree selection modeling methods and began to prepare two manuscripts related to the refinement of the underlying simulation-optimization approach and describing the specific analysis and results of crop tree selection criteria. Frameworks for treatment optimization and regional analyses were developed and work plans for those components of the project were prepared.

PI Foppert presented on the project at the annual meeting of the Forest Ecosystem Monitoring Cooperative in Burlington, VT in November.

Problems or Changes

Minor problems were encountered with the analysis of operational data from the 2025 treatment for the development of harvest cost models. The project aims to develop a high-resolution (30-m-pixel) harvest cost model based on pre- and post-harvest forest inventory data, geospatial attributes (slope, skidding distance and roughness, etc.), observed machine use patterns, and recorded GPS tracks for each machine on the job. Upon analysis, it became apparent that the default track recording interval was too long for the small pixel size we aim to develop the harvest cost model for. New GPS units were acquired for 2026 and reprogrammed for higher frequency data collection.



Figure 9. PI Foppert leading a tour of forest managers through the 2025 treatment at the PSC demonstration site.

Plans for 2026

In 2026, the project will continue to collect habitat use data and will collect data for harvest cost modeling from the 2026 treatment at the PSC demonstration site. Analysis will be completed on data from the Kunjamuk site, and a manuscript will be prepared, intended for submission to *Wildlife Society Bulletin* or *The Journal of Wildlife Management*. Upon completion of data collection at the PSC site, a paper summarizing the findings on habitat use at that site will be prepared, intended for submission to *Northeastern Naturalist* or a similar journal.

In January, a manuscript on the underlying simulation-optimization approach related to the crop tree selection analysis will be completed and submitted to *Canadian Journal of Forest Research*.

In May, project members will present results of the crop tree selection modeling at the annual meeting of the International Society of Forest Resource Economists. A manuscript in preparation will be completed and submitted to *Forestry Economics Review*.

In June, most members of the project team will meet at the North American Forest Ecology Workshop. The team will present a special session at the workshop titled “*Rehabilitative silviculture for degraded northern hardwood stands*” and use the event as the project’s in-person meeting for the year.



Figure 10. Diseased beech in PSC demonstration site prior to 2026 treatment.

Research work on treatment optimization and regional analyses will be carried out throughout the year.

Collaboration or Alignment with USFS, Partners, or the Public

USFS Researcher Nate Anderson has advised and supported this project on research design and data collection. Dr. Anderson travelled to New York for the all-team meeting in June and visited field sites in Altona, Paul Smith's, and Speculator, New York, and provided valuable input into the development of data analysis and communication strategies.

Assessing the Future Northern Forest Through the Lens of Seedling Survival and Sapling Recruitment

Principal investigator: Lucas B. Harris (University of Vermont, lucas.harris@uvm.edu)

Summary of Progress in 2025

The first part of this project was completed in March, which was an investigation of the effects of white-tailed deer browse and other factors on seedling survival across the Northern Forest region (Harris et al. 2025). This paper was published in June in a special issue of *Forest Ecology and Management*, “advancing forest inventory science for enhanced insights into tomorrow’s forests”. Through the first half of the year, a second manuscript was developed and focused on trends in sapling recruitment and seedling abundance and its implications for forest resilience, climate vulnerability and restoration. The manuscript was submitted to *Ecological Applications* in July, where it is currently in revision. In the second half of 2025, we worked on an analysis focused on scaling up insights from Regeneration Indicator seedling data as well as an analysis focused on tree regeneration response to natural disturbance and harvesting. Based on our analysis of disturbance and harvesting, we wrote and submitted a Research Note to the *Canadian Journal of Forest Research* in November documenting a rise in natural disturbance over the past twenty years across the Northeast (Figure 14) along with a decrease in the severity of forest harvests due to an ongoing shift toward lower-severity partial harvesting (Figure 15).

Problems or Changes

The project has continued with a start of July 2024 rather than March 2024.

Plans for 2026

As the project concludes, focus will be on completing ongoing analyses on tree regeneration response to disturbance and harvesting and on scaling up insights from the Regeneration Indicator dataset to forest inventory plots across the region. As manuscripts from this project are published, work will be done with the Forest Ecosystem Monitoring Cooperative (FEMC) to publicly share data, maps, and

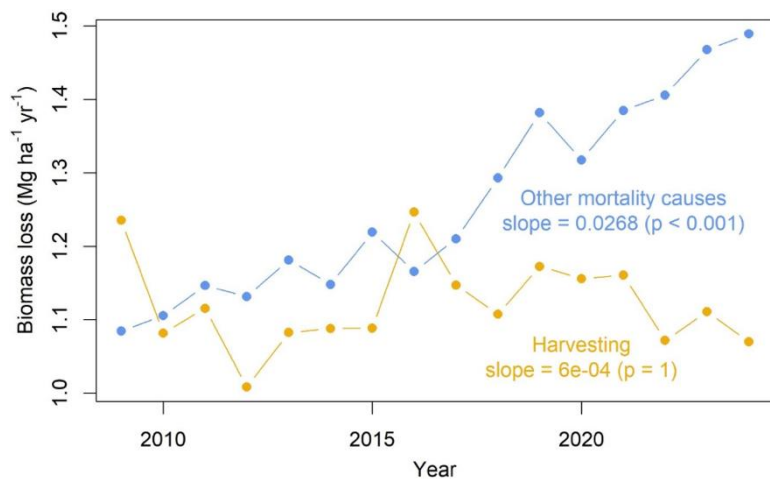


Figure 11. Mean annual live aboveground adult tree biomass loss due to harvesting (yellow) and all other causes of mortality (blue) from forest inventory subplot measurements across northeastern USA forests. Text indicates linear trend estimates from Sen’s slope tests with corrected *p*-values.

code in pursuit of the goal of making improved regional assessments of tree regeneration available in an easy-to-access and updateable format. Results from the project will be shared at the New England Society of American Foresters meeting.

Collaboration or Alignment with USFS, Partners, or the Public

Results from this project were presented at the New England Society of American Foresters meeting in March, the Ecological Society of America meeting in Baltimore in August, and the FEMC conference in November. Work with FEMC has made data and maps publicly available from the first published manuscript on regeneration and deer browse. (<https://femc-uvm.hub.arcgis.com/>).

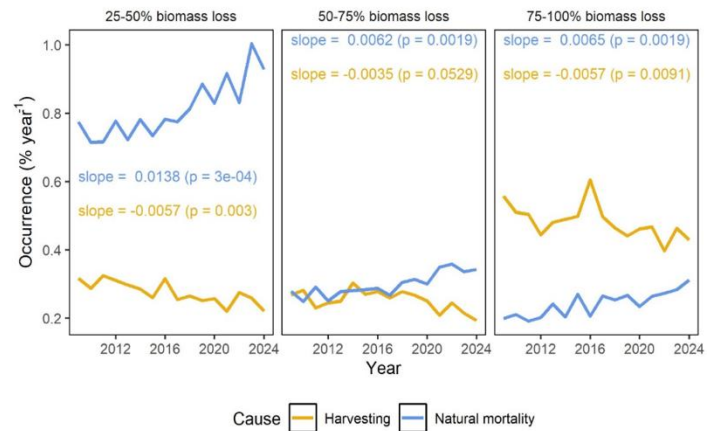


Figure 12. Occurrence of harvesting and natural disturbance (percentage of forest inventory subplot measurements per year) by levels of severity (percentage of live aboveground tree biomass loss, panels). Text indicates linear estimates from Sen's slope tests with corrected p-values.

Products

- Harris, L. B., Pastore, M. A., & D'Amato, A. W. (2025). Effects of browsing by white-tailed deer on tree regeneration vary by ontogeny and palatability in forests of the northeastern USA. *Forest Ecology and Management*, 593, 122906. <https://doi.org/10.1016/j.foreco.2025.122906>
- Harris, L. B., Pastore, M. A., & D'Amato, A. W. (in revision). Tree regeneration trends in forests of the northeastern USA and their implications for resilience and restoration. *Ecological Applications*.
- Harris, L. B., Pastore, M. A., & D'Amato, A. W. (in review). Shifting balance between natural mortality and harvesting in forests of the northeastern USA. *Canadian Journal of Forest Research*.

Northern Historical Atlas Project

Principal Investigator: Daniel Hayes (University of Maine, daniel.j.hayes@maine.edu)

Summary of Progress in 2025

This is a two-year project with a start date of May 15, 2024. [Digitization and](#) analysis of James W. Sewall Company archive of historical aerial photography as a resource for the NSRC region’s researchers, land managers, educators, and broader public continues. As of January 2025, initial scanning and orthophoto mosaic workflow development covered 9.7 million acres of Maine and Northern New Hampshire with high-resolution historical imagery. Over the past year, regional orthomosaic coverage has expanded to 27.5-million acres from 1943 to 1997 by prioritizing orthomosaic development from other existing federal and state digital archives. While the in-house photogrammetry scanner sat idle for part of the year before repair in July, an additional 12 rolls of film (or about ~3,000 negatives) from UMaine’s Sewall Collection were scanned this past year.

Image classification modeling for mapping historical land cover and forest types using panchromatic imagery continue to be refined, with a focus on scaling up to statewide forest cover classification while maintaining acceptable accuracy. Over the past year, additional archives have been explored to find historical forest inventory data that can be used for model training and validation, including forest type maps from the University of Southern Maine’s Osher Map library, historical research plot data Acadia National Park, Seven Islands Land Company inventory data from the Cooperative Forestry Research Unit (CFRU), and Great Northern Paper plot data also from the CFRU. Work has begun with consulting cartographer and web developer Nicholas Underwood to build the North Woods Historical Atlas web platform that will host all historical imagery and forest cover maps in an easy-to-use interactive map with data download functionality. A public release of the web atlas is planned for May 2026.

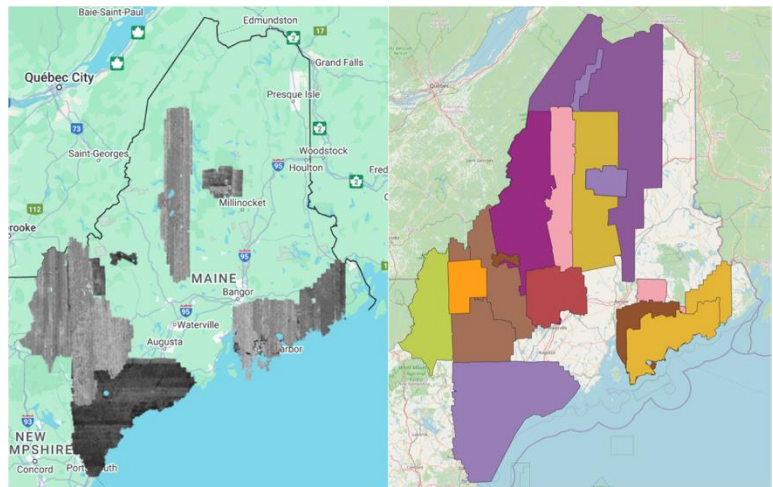


Figure 13. Map of progress developing statewide historical orthomosaic coverage 2024 vs. 2025.

Problems or Changes

The in-house photogrammetry scanner housed in Fogler Library Special Collections (Vexcel Ultrascan 5000) suffered a mechanical issue last spring that required servicing by a field technician who could not come until July. However, the repair was successful, and scanning workflow continues to improve. A scanning tutorial document and in-person workshop to support library staff independently continuing scanning work will remain a goal for the summer of 2026.

Plans for 2026

Primary plans for 2026 include: (1) produce complete orthomosaic coverage of Oxford, Franklin, Somerset, Aroostook, Piscataquis, Penobscot, Washington, and Hancock counties between 1965–1970, (2) produce regional forest cover maps based on classification modeling and historical inventory data, (3) analyze forest change dynamics with focus on spatial patterns of spruce budworm outbreak, salvage harvests, and how regeneration dynamics have shaped present-day forest conditions, (4) develop and release public-facing North Woods Atlas Historical Web Map, and (5) complete scanning tutorial and host digitization training at UMaine summer of 2026.

Collaboration or Alignment with USFS, Partners, or the Public

Work continues 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. Collaboration continues with the University of Southern Maine’s Osher Map Library which manages portions of the Sewall Collection. Work with researchers and resource managers at Acadia National Park and Schoodic Institute continues to expand the remote sensing record of the Acadia region by building decadal orthophoto mosaics of the region dating back to 1944. The collaboration with the Maine State Geological Survey has expanded, using more of the Maine State collection of aerial photographs to produce orthomosaics which once processed are made available to the State.

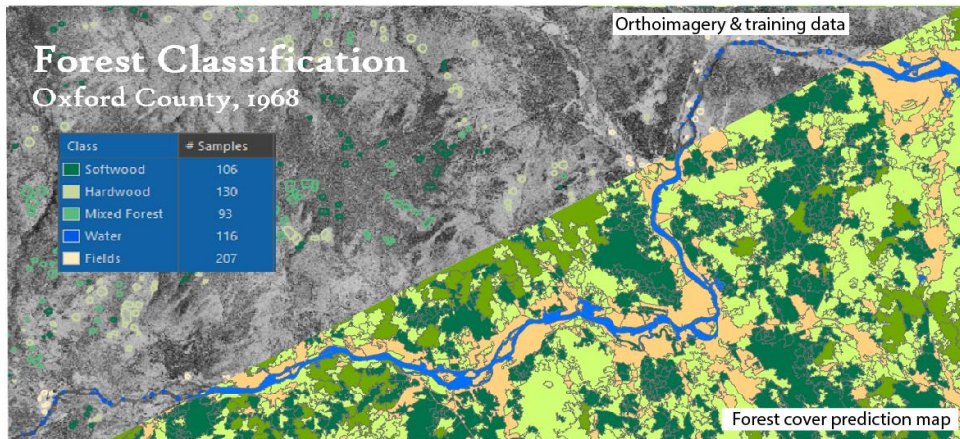


Figure 14. Model training and Forest Classification prediction map derived from historical orthoimagery, Oxford County, 1968.

Products

- Maine Public - [Maine Calling Feature.](#)
- Poster Submission at 2025 Forest Ecosystem Monitoring Conference

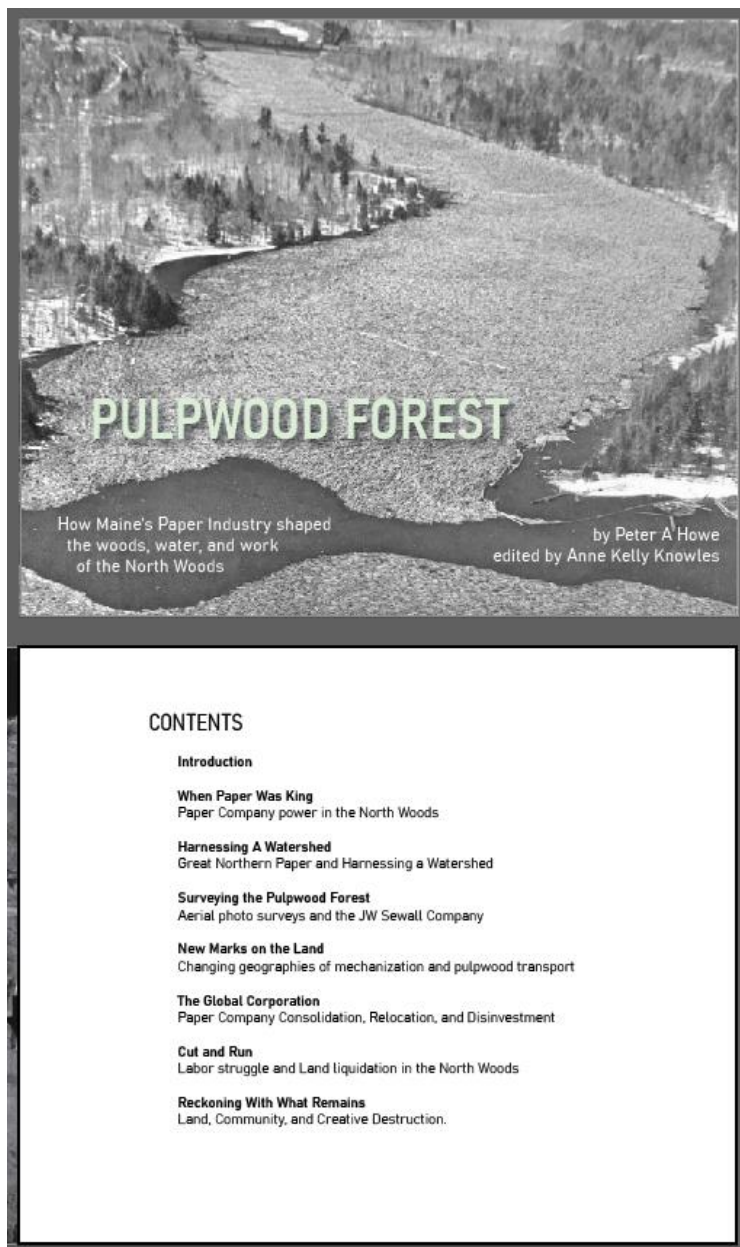


Figure 15. Cover page and Table of Contents of draft atlas *Pulpwood Forest: Historical Geographies of the pulp and paper industry in the North Maine Woods*; drafted and edited with Dr. Anne Kelly Knowles (ongoing production)

Assessing eDNA as a Monitoring Tool for Forest Arthropod Biodiversity and Pests

Preliminary Investigator: Jason Johnston (University of Maine at Presque Isle, Jason.johnston@maine.edu)

Summary of Progress in 2025

Sampling geography was expanded during 2025 to include regions in northeastern and northwestern Maine where spruce budworm abundance was highest. This included sampling within areas following insecticidal treatment, as well as within riparian buffers lacking treatment. 131 additional samples were collected in 2025. All samples were filtered, DNA extracted, and amplified by PCR, resulting in 320 PCR products. PCR amplification success was a high value of 98.75%; only two field samples did not yield PCR product. At this point, sequence data has been obtained on 11 samples, preliminary data analyses have been conducted on this data subset. The bioinformatics effort made significant progress in developing code pipelines using a 4-GPU server by establishing a process to replicate publicly available reference databases (BOLD), and use various DNA bioinformatics procedures (BLAST, Qiime2, Python, MAFFT, ReScript) and containerized to compare experimental data to large reference datasets. Field, lab, and DNA data were collated into a SQL database, and a web interface was developed to access data analysis (still to be tested internally). Five undergraduates were mentored during extensive summer effort. This started with a week of training in lab, field, data management, and computer science methods, and culminated in student presentations in August. Posters were presented at UMPI's annual research symposium (University Day) in April, 2025 by undergraduates Bobby Ramsey and Chandler White (with faculty and undergraduate co-authors), as well as at the Maine Biological and Medical Sciences Symposium in Bar Harbor, ME in April, 2025 by Bobby Ramsey (with co-authors).

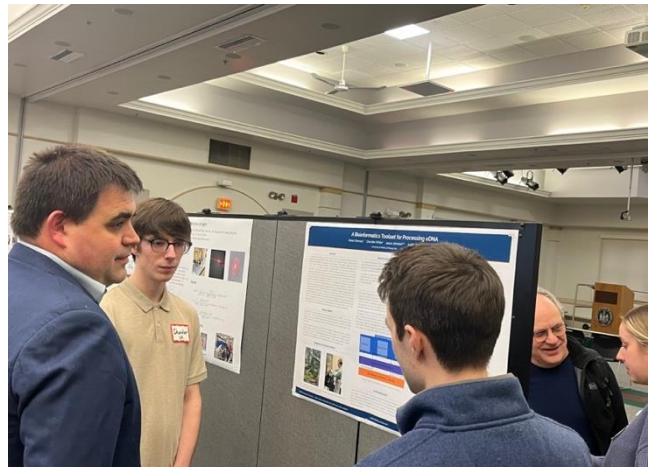


Figure 16 Undergraduates Chandler White, left, and Bobby Ramsey, right discussing their poster, "A Bioinformatics Toolset for Processing eDNA" at the UMPI University Day, April, 2025

Plans for 2026

In the remaining 4 months of this two-year project, laboratory work, data analyses, and bioinformatics pipeline development will conclude and outreach and publication products will be developed. The remaining samples/PCR product (n~150) will be sent during winter 2026 after some additional analyses, lab work, and budget prioritization. The bioinformatics pipeline needs to be completed for data analysis. After that, approaches to package and share its elements will be pursued and then communicated. Manuscript development will not be able to begin in earnest until near the end of this timeline, and during summer, 2026. Other methods of dissemination and communication will also be explored at that time.

Collaboration or Alignment with USFS, Partners, or the Public

Two days were spent in northwestern Maine with Dr. Neil Thompson from the University of Maine at Fort Kent to access various sampling locations with high spruce budworm populations. Neil is directly involved with the statewide budworm monitoring effort, and collaboration and discussion with him may lead to other areas to pursue based on overlapping interest. There is also alignment with goals of an ongoing NSF EPSCoR-funded project called Maine-Forest, of which Johnston is the PI for UMPI and Royer is part of the team under the theme ‘digital AI’. Thus, the research findings of this NSRC project will inform and likely be extended under ongoing NSF work.

Products

- Ramsay, B., White, C., and J. Johnston. (2025). *A Bioinformatics Toolset for Processing eDNA* [Poster presentation]. UMPI University Day, April, 2025



Figure 18. Undergraduate researcher, Garrett Dora, sampling water for environmental DNA (eDNA) in water in a forest pool using a Smith-Root eDNA sampler.



Figure 17. Undergraduate researcher, Milaya Buchanan pipetting a PCR in UMPI's molecular ecology laboratory.

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

Principal Investigator: Ankita Juneja (SUNY-ESF, ajuneja@esf.edu)

Summary of Progress in 2025

This project focuses on complete utilization of abundant FRB to produce valuable bioproducts.

Task 1. Biomass collection and characterization (Complete):

- Three hardwood residues (Ash, Cherry, and Maple) along with their 1:1:1 mix were used. Complete characterization of all the biomass was performed. The extractives, cellulose, hemicellulose, lignin and ash content of the mixed biomass was 9.31%, 35.44%, 29.91%, and 27.64%, respectively.

Task 2. Biomass pretreatment, hydrolysis, and PHB production

- *Subtask 2.1 Pretreatment and hydrolysis of FRB (complete):* Hot water pretreatment was performed of individual biomass as well as the mix at 195 °C for 13 min with 13.5% solid loading in a high-pressure Parr reactor, followed by 3 passes of disc refining method. Both pretreated and untreated biomass was subjected to enzymatic hydrolysis with 10% solid loading (w/v), enzyme (Cellic® Ctec2 and Htec2) loading of 30 FPU/g biomass, 50 °C for 72 hours. Glucan and xylan content of the mix biomass was 44.91 g/L (83.04% conversion) and 13.46 g/L (19.75% conversion).

Task 3. Hydrothermal carbonization of unconverted biomass and hydrochar characterization (Complete):

- The solid fraction after hydrolysis was subjected to hydrothermal carbonization (HTC) to obtain energy dense hydrochar. HTC at 260 °C gave maximum HHV of 27.88 MJ/kg, and energy densification ratio of 1.76. Elemental analysis and a Van Krevelen evaluation confirmed enhanced carbonization, as evidenced by increasing carbon content and decreasing oxygen content. The optimization showed best fuel properties of hydrochar at 260 °C.

Plans for 2026

- Subtask 2.2: To optimize the production of bioplastic (PHB) considering two critical parameters – dissolved oxygen (DO) and feed rate of sugar (from hydrolysis) into the bioreactor.
- Task 4: To develop TEA and LCA modeling framework to optimize the process for both economic and environmental benefits using multi-criteria approaches.

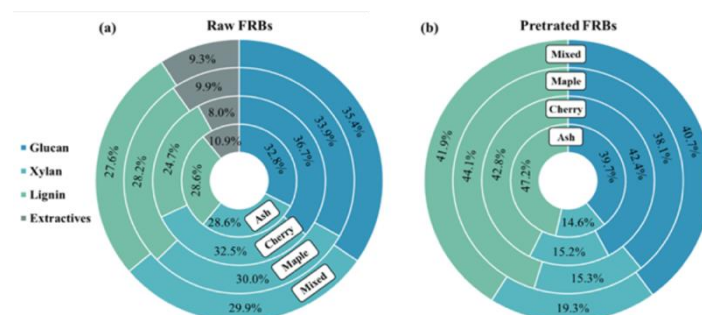


Figure 19. Chemical composition analysis of (a) raw (untreated) and (b) pretreated forest residue biomasses (FRBs).

Products

- Gawali, S*, Kumar, D. and Juneja, A. (2026) Potential of mixed hardwood forest residues from Northeastern United States for the production of different biobased products. *Biomass Futures* (Submitted – Manuscript number BMF-D-26-00017)
- Kumar, M., Cheatham, R., Hossain, M.S., Reza, T., Volk, T.A., Juneja, A., and Kumar D. (2025) Sustainable Valorization of Forest Waste Hydrolysis Residues to Solid Biofuel: Insights into Conversion Mechanisms and Fuel Properties. *Energies*, 18(23), 6156. <https://www.mdpi.com/1996-1073/18/23/6156>

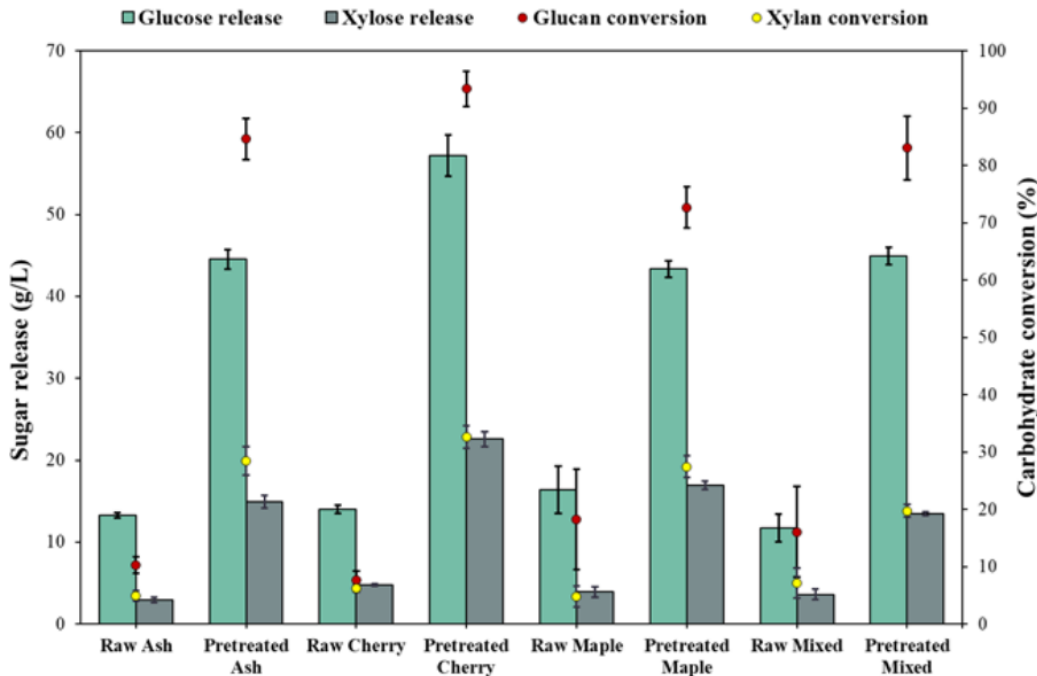


Figure 20. Results of the impact of HTC temperatures on (a) Hydrochar yield, (b) Ultimate analysis results, (c) Higher heating values (HHV) of the samples, and (d) Van Krevelen diagram illustrating the relationship between H/C and O/C atomic ratios.

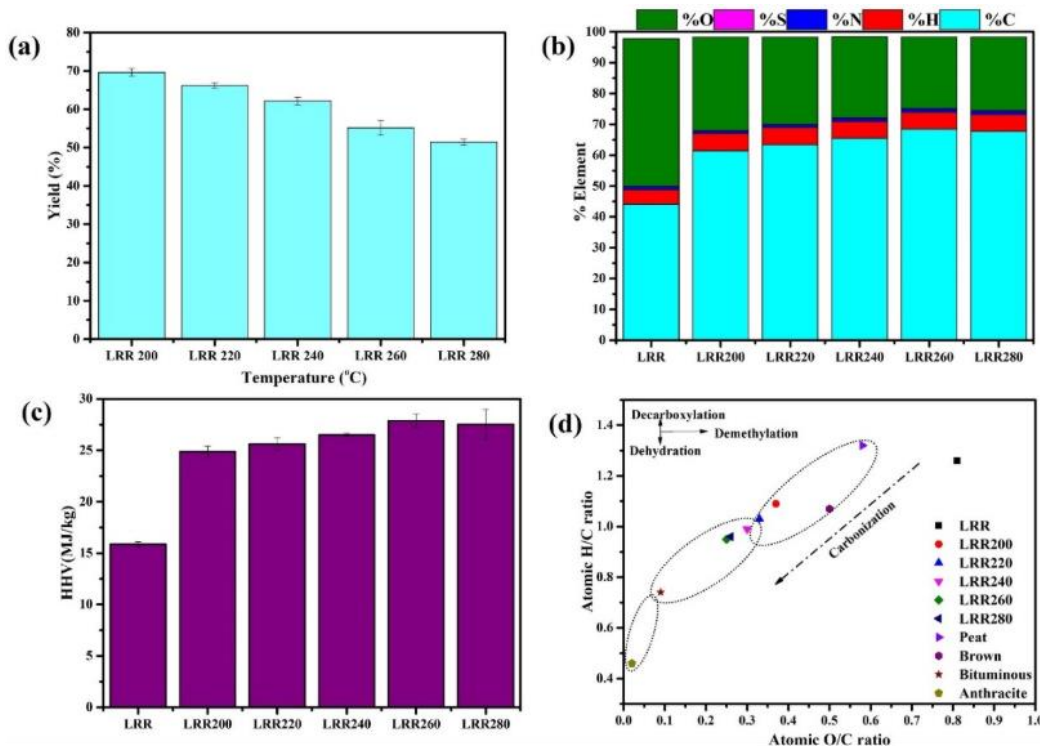


Figure 21. Overall sugar release and conversion rates of glucan and xylan from raw and pretreated FRBs after 72 hrs of enzymatic hydrolysis. Data represents mean of experiments and the error bar shows standard deviation.

Private Forest Landowner Engagement in Forest Management Programs for Carbon Sequestration

Principal Investigator: Danielle Kloster (SUNY-ESF, dpkloste@esf.edu)

Summary of Progress in 2025

In 2025, Elysia Palmieri (PhD student) completed a literature review of forest carbon management and landowner engagement in forest management programs. The landowner survey is complete, with input from PI Kloster, Co-PI Caputo, and others, and IRB approval has been obtained. Mailings will begin shortly. Two undergraduate students have been recruited to help with additional literature review, survey mailing logistics, and data entry and processing. They completed CITI training and are being trained in survey research methods and content analysis. Elysia presented her research plans at the Northern Hardwoods Conference in Syracuse, NY in August 2025 (see proceedings below for an extended abstract) and at the Society of American Foresters annual meeting in Hartford, Connecticut in October 2025.

Problems or Changes

Survey development and deployment were delayed, with deployment moving to 2026. Survey development was paused in Spring 2025 so that Elysia could focus on her doctoral candidacy written and oral exams, which she passed.

Plans for 2026

In Spring 2026, the mailed landowner survey will be deployed, beginning the first week of February and ending around mid-March. Data entry, cleaning, and analysis will continue through the end of Spring 2026 and into Summer 2026. Elysia will plan and obtain IRB approval for the landowner and manager focus group. This will include collaborating with Co-PI Ackerman on forest management visualizations to use in the focus groups. Focus group recruitment will begin in Summer 2026, and focus groups are anticipated to be completed in the fall of 2026.

Collaboration or Alignment with USFS, Partners, or the Public

Co-PI Caputo is a research forester at the Family Forest Research Center (USFS) and collaborated with PI Kloster and PhD student Palmieri on the landowner survey draft. He will continue to be available for consultation during data collection and analysis.

Products

- Cross, A, E Palmieri, D Kloster. (2025). New York State family forest owners' engagement in forest-based climate solutions. *Proceedings of the 2025 Northern Hardwood Conference*.

Understanding the Landscape for Species of Greatest Conservation Need by Uniting Coarse- and Fine-filter Strategies for Conservation

Principal Investigator: Brian Kron (Vermont Center for Ecostudies, bkron@vtcostudies.org)

Summary of Progress in 2025

Species distribution models (SDMs) have been completed, and conservation prioritization tools have been in development based upon SDM outputs and Vermont Conservation Design priorities. Construction has begun of the conservation database, with 48 SDM output models currently available on the repository on Google Earth Engine. The repository is not yet publicly available, until all model outputs are uploaded. Ground-truthing survey locations have been randomly selected within the Northern Forest portion of Vermont. Permission for these locations is being secured, and interviews for a field technician are upcoming. The methodology has been adjusted to include camera trapping as part of the surveys to survey for a greater number of species. The main equipment for the field season (camera traps and automated recorders) has been secured. These steps put the project track towards completing both Objective 1 (utilize SDMs to ground-truth model outputs at 40 randomly selected sites in Vermont's Northern Forest by August 2026) and Objective 2 (assess conservation efficacy and revise Vermont Conservation Design plans by January 1st, 2027) on time.

Problems or Changes

Changes were made to the methodology to include camera traps as part of the survey methods to capture a greater number of modeled species and improve overall model accuracy.

Plans for 2026

Plans for 2026 include the following: finalizing permitting for survey locations, finalizing hire of field technician, finalizing supply purchase, carrying out fieldwork, and completing analyses. Focus groups will be conducted with local conservation organizations to identify which features of the conservation database and prioritization tool would be most beneficial to them and increase overall usefulness. The PI and technician will then deploy automated recorders and camera traps in mid-April, with equipment remaining in the field until late June. Plant surveys will be conducted at each site during a late-June site visit by the PI and technician. Collected data will be analyzed using AI-based species identification algorithms, and the results will be used to statistically evaluate the accuracy of existing species distribution models. If needed, revised models will be generated, and updated model outputs will be added to the conservation database by the PI and Co-PI. Following this, we will launch an outreach and awareness campaign focused on the tools and findings, collaborate with Vermont Fish and Wildlife to update Vermont Conservation Design's prioritization, and finalize a manuscript for submission by late Fall 2026.

Collaboration or Alignment with USFS, Partners, or the Public

Vermont Fish and Wildlife is closely aligned with the project as a key stakeholder that maintains Vermont Conservation Design, prioritizes statewide conservation efforts, and is invested in the

project's outcomes. The organization has provided input on the species selected for modeling and receives quarterly updates on project progress. Feedback is offered as needed to support an effective and collaborative working relationship.

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

Principal Investigator: Angela Mech (University of Maine, angela.mech@maine.edu)

Summary of Progress in 2025

- Selected locations in Maine that encompass all 3 treatment types: 1) HWA + biocontrol (*Laricobius* spp.) released, 2) HWA with no biocontrol releases, and 3) no HWA (Figure 25). 3- sites for each type were found and permissions to conduct experiments were granted.
- Adelgid-infested hemlock and white pine branches were collected from 3 different plots per site in early-mid June 2025. Branches were placed in Lari-Leuco containers ($n = 54$ buckets) (Fig. 26A) to capture predators. All *Leucotaraxis* fly adults were identified to species, while larva and pupae were temporarily morphotyped until identifications can be completed. *Leucotaraxis* adults (91% were *L. argenticolis*) were only collected from PBA-infested white pine branches. *Laricobius* beetle larvae and pupae were also predominantly found from white pine samples (93%). A higher proportion (62%) were found at sites that also had HWA present. Overall, 117 predator specimens were recovered from the buckets, with the majority (68%) being fly larvae (e.g., Syrphidae). Preliminary results show some potential preferences (e.g., lacewing larvae were predominantly feeding on HWA (91%) compared to PBA).
- Soil emergence tents (Fig. 26B) were set up in September 2025 and checked biweekly until no *Laricobius* adult beetles were found. A total of 35 *Laricobius* adults were caught. Of those found associated with HWA, 69% were from sites that had releases of *Laricobius* as biocontrol. Nearly all adults emerged from late September to early November (Fig. 27).
- Infested white pine and hemlock trees (3 each per-site) were identified and 2 branches per tree had their adelgid densities counted; one branch received a sleeve cage (Fig. 26C), to prevent predation, while the other branch did not. Population counts will continue over the next 3 years to look at changes over time.
- Forest stand characteristics were collected for 3 plots per-site for year 1.

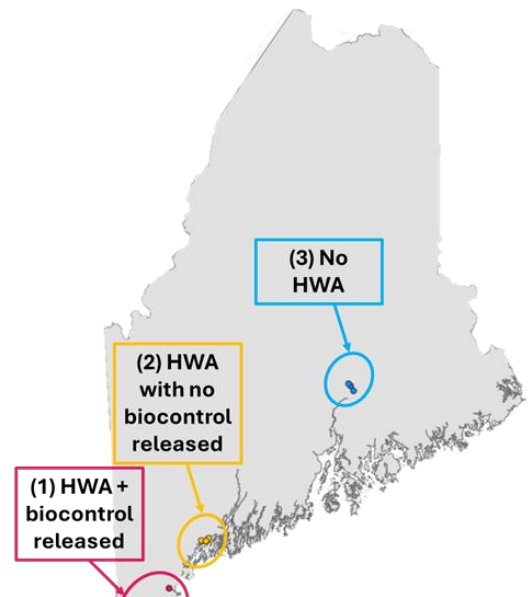


Figure 22. Map of Maine showing the locations of the sites representing the 3 types of adelgid treatments. All sites have adelgid-infested white pines.

Problems or Changes

- Branch collections occurred in June 2025, but due to the lack of emergences from the HWA-infested branches, those collections may have occurred too late (i.e., after predator species had already emerged).

- Soil emergence tents were set up in September 2025. For hemlock, tents were set up directly under infested branches. However, for white pine, most of the infested branches were on seedlings or saplings where a tent would not fit under. Seedlings were instead trimmed at the base and then placed the tent over the area the seedling was, which also ensured that emerged adults went into the collection cups and not back on to the tree. However, due to the extremely low emergence of *Laricobius* from the white pine tents (only 2 individuals), there is concern that the seedling was removed before any of the *Laricobius* larvae had dropped to the soil to pupate. A new design or timeline will be implemented for the next collection season.

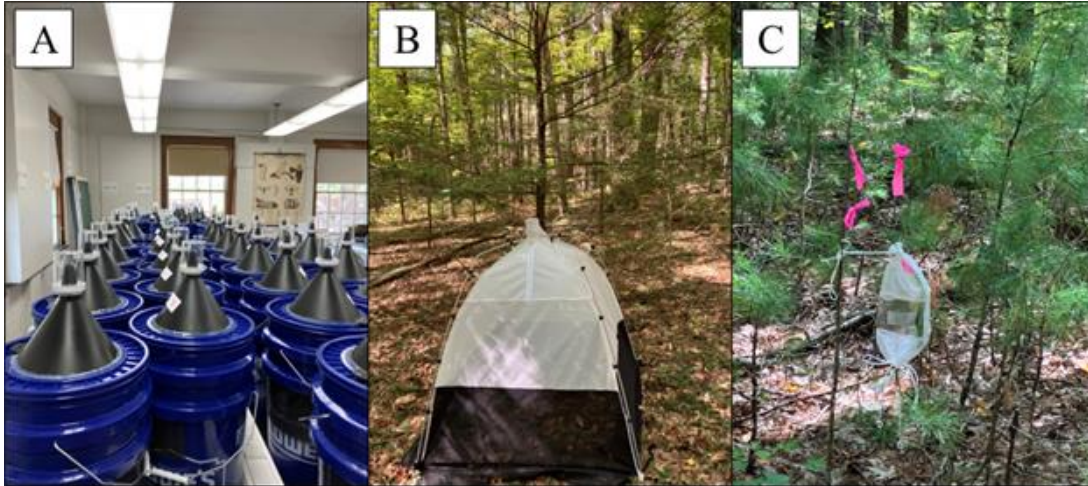


Figure 23. (A) Lari-Leuco containers - adult flying insects get caught in the top cup while larvae and/or pupae will fall to the bottom of the bucket for collections; (B) a soil emergence tent – placed under adelgid-infested branches, any *Laricobius* adults that emerge in the fall will be captured at the top of the tent; (C) sleeve cage – a branch with a predetermined adelgid density are placed in the sleeve cage to prevent predation so adelgid populations can be observed with versus without predators.

Plans for 2026

- Second year of adelgid-infested branch collections to evaluate predator species and preferences. New collection times will be tested based on the pilot/year 1 study results.
- Second year of forest stand characteristics (3 more plots per site) will be collected.
- *Laricobius* adults collected in fall 2025 will be identified to species using molecular/genetic methods.
- Identify predator larval morphotypes found from 2025's branch samples.
- Remeasure HWA & PBA densities on sleeve and non-sleeve branches to estimate the impacts of top-down predation pressure.
- Second year of soil emergence tents will be set up. New setup timeline will be implemented based on the pilot/year 1 study results.

Collaboration or Alignment with USFS, Partners, or the Public

Work continues with Dr. Nathan Havill (USFS) for all adelgid predator identifications, as well as Colleen Teerling and Allison Kanoti (Maine Forest Service) regarding site information and HWA biological control release data. Work will be done with municipalities and organizations associated with city parks and easement properties being used in this study. Lastly,

all tents and sleeve cages include project team contact information on them so any questions from the public can be answered.

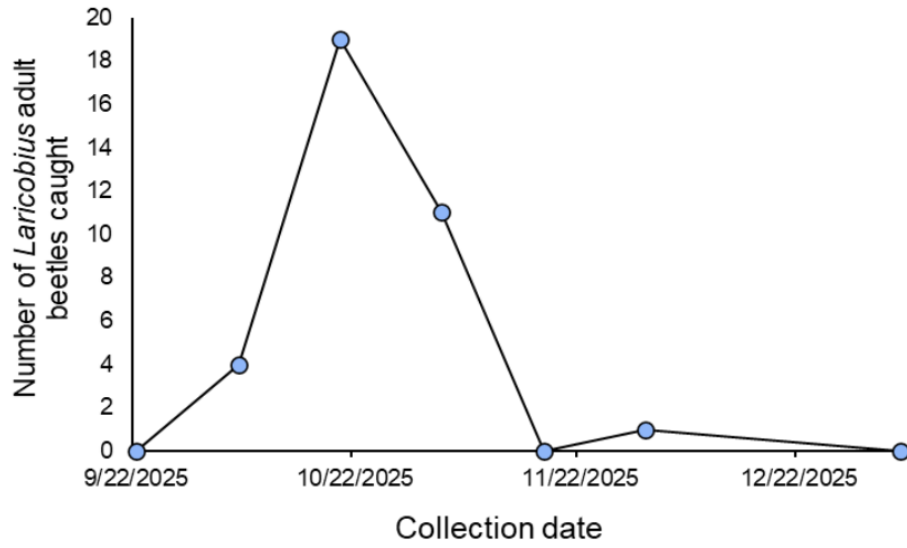


Figure 24. Emergence of *Laricobius* adults over time. Collections from soil emergence tents occurred biweekly from September 2025-January 2026.

Decadal-scale Trends in Northern Forest Carbon Storage in Relation to Nutrient Availability and Rising Carbon Dioxide

Principal Investigator: Scott Ollinger (University of New Hampshire, scott.ollinger@unh.edu)

Summary of Progress in 2025

This past year was very productive, with a substantial field campaign at the Bartlett Experimental Forest (BEF) led by two graduate students, both of whom are supported by the NSRC award.

A major effort in 2025 focused on measuring soil respiration in plots throughout the forest. More than 2000 respiration measurements were collected and are being used to investigate whether changes in soil respiration can explain an observed increase in ecosystem respiration derived from the BEF eddy covariance tower. Preliminary results

were presented at the Annual American Geophysical Union (AGU) meeting by MS student John Dionis. These measurements show that soil respiration has markedly increased since first measured approximately 20 years ago (Figure 28) and is likely a key driver of the observed ecosystem respiration patterns.

In 2025, we also measured wood growth rates across 23 plots (> 2000 trees) spanning a wide range of forest composition and N cycling rates. We also collected soil cores, leaf litter samples, and fresh foliage samples that are being analyzed as indicators of N cycling rates. MS student Arielle Kotulak presented preliminary wood growth and foliar nitrogen patterns at AGU. These data are being used to determine whether relationships among wood growth and indices of N availability have changed over the 25-year period since these patterns were last observed.

Finally, this project has supported five recently submitted or published manuscripts focused on remote sensing or modeling of nitrogen cycling (Sullivan et al. 2026, Ouimette et al. in review; Zhou et al. 2025) and ecosystem carbon fluxes at the Bartlett Experimental Forest (Liu et al. 2026, Bergl in review).

Problems or Changes

The northern forest region experienced a severe drought that developed during the second half of the 2025 growing season. Although a number of our core measurements were collected prior to the onset of drought (e.g., foliar nitrogen, soil cores), soil respiration measurements continued throughout the anomalously dry period. These data were collected throughout the summer and autumn to develop soil respiration–temperature response functions spanning a wide range of soil

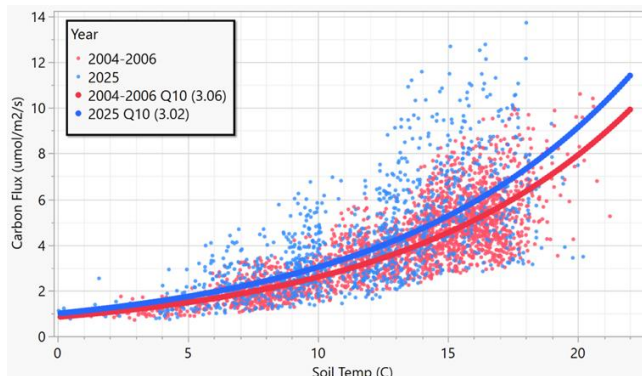


Figure 25. The relationship between soil temperature and soil respiration in 2024-2025 as compared to data from 2004-2005. Data are from 48 inventory plots located around the Bartlett Experimental Forest eddy flux tower. These data help explain an observed increase in ecosystem respiration measured from the flux tower (Bergl et al. in review).

temperatures. We are currently assessing approaches to account for this source of uncertainty, but additional measurements in 2026 (hopefully under more typical conditions) may be needed.

Another variable that may have been influenced by the drought is annual wood growth. Wood growth in northern hardwood and conifer species is generally highest in the early to mid-growing season, suggesting that the 2025 drought may not have substantially affected this year's wood growth, though we might expect a lagged impact for 2026 growth. Since 2004, we have measured annual growth on approximately 1100 trees within "tower plots" distributed around the eddy covariance tower at BEF. This long-term record provides a strong basis for contextualizing any potential drought effects on wood growth.

Plans for 2026

In 2026, we will focus on data analysis and manuscript preparation. Both MS students will lead manuscripts, with one assessing shifts in carbon allocation and soil respiration in plots surrounding the flux tower, and the other examining relationships between nitrogen availability and forest productivity across our plot network.

We are also collaborating with NEON staff scientists to compare soil respiration measurements from our collar-based survey with their continuous diffusion gradient approach, and these measurements will continue throughout 2026. Pending results of the 2025 data analysis, we may also conduct a focused set of additional measurements to better understand the effects of the 2025 drought.

Collaboration or Alignment with USFS, Partners, or the Public

The northern forests are increasingly being managed to optimize woody biomass for timber and wood products, while also leading to forests that are well adapted to future stress factors. For these management goals to be met, managers require information pertaining to current trends in forest growth and C cycling, underlying mechanisms that are affecting them, and how they are likely to change in the future.

Despite extensive research on patterns of wood growth and whole ecosystem productivity 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 environmental change is interacting with other stressors is critical to stakeholders of the region. The potential to combine historical measurements from +25 years ago with new measurements and model predictions provides our research team with a unique opportunity to address these questions and help plan for more resilient forests in the future. Our 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 overwhelming importance to the economic vitality of the region.



Figure 26. UNH graduate student John Dionis measuring soil respiration at the Bartlett Experimental Forest in 2025.

Products

- Bergl, D.D., Carbone, M.S., Hollinger, D., Liu, Y., Lucas, B., Ollinger, S.V., Ouimette, A.P., Templer, P., Richardson, A.D. Increasing Respiration Weakens the Carbon Sink over Two Decades in a Temperate Deciduous Forest. *Global Change Biology Communications*. In Review.
- Ouimette, A.P., Hastings, J.H., D'Amato, T., Battles, J.J., Ducey, M., Foster, J.R., Fuss, C., Goodale, C., Johnson, C., Lang, A., Ollinger, S.V., 2026. Can Coarse Woody Material Account for the Nitrogen Imbalance at Hubbard Brook Experimental Forest, New Hampshire, USA? *Biogeochemistry*. In Press.
- Liu, Y., Stoy, P., Chu, H., Hollinger, D.Y., Ollinger, S.V., Ouimette, A.P., Durden, D.J., Sturtevant, C., Lucas, B. and Richardson, A.D., 2026. A tale of two towers: comparing NEON and AmeriFlux data streams at Bartlett Experimental Forest. *Agricultural and Forest Meteorology*, 378, p.110939.
- Sullivan, F.B., Hastings, J.H., Ollinger, S.V., Ouimette, A., Richardson, A.D. and Palace, M., 2026. Parsing the Relative Contributions of Leaf and Canopy Traits in Airborne Spectrometer Measurements. *Remote Sensing*, 18(2), p.355.
- 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. and Laflower, D., 2025. Integrating nitrogen and carbon cycling into LANDIS-II/PnET-Succession to improve forest landscape modeling: methods and sensitivity analyses. *Ecological Modelling*, 510, p.111285.

Presentations:

- Dionis, J., Kotulak, A., Contosta, A., Ouimette, A., Blommel, C., Hastings, J., Tetreault, E., Vandewater, V., Ollinger, S.V., 2025. Assessing Shifts in Carbon Allocation Over Two Decades in a Mixed Northern Hardwood Forest. Poster presentation at the American Geophysical Union Annual Meeting, New Orleans, LA, December 15–19.
- Kotulak, A., Dionis, J., Frey, S., Ouimette, A., Blommel, C., Hastings, J.H., Tetreault, E., Vandewater, V., Ollinger, S.V., 2025. Long-Term Patterns of Forest Productivity and Nitrogen Availability in a Northeastern Temperate Forest. Poster presentation at the American Geophysical Union Annual Meeting, New Orleans, LA, December 15–19.
- Dionis, J., 2025. Is rising atmospheric CO₂ and nutrient limitation driving changes in carbon allocation in northeastern temperate forests? Talk at the UNH Department of Natural Resources Spring Seminar.
- Kotulak, A., 2025. Long-term changes in forest C allocation, N availability, and mediation by mycorrhizal fungi. Talk at the UNH Department of Natural Resources Spring Seminar.

Assessing Fire-Dependency in Natural Red Pine Forests of the Northeast

Principal Investigator: Simon Pendleton (Plymouth State University,
simon.pendleton@plymouth.edu)

Summary of Progress in 2025

- PI Guiterman added one new site in the Mount Washington Valley area east of North Conway, NH and completed processing and dating of all fire-scarred materials collected in 2024. Analysis of the fire histories is ongoing, with preliminary findings shared among the broader team and in two invited presentations in the Northeast region.
- PIs Pendleton, Doner, and Neely along with PSU students, and members of the Tamworth Conservation Commission retrieved a ~4-m sediment core from Black Spruce Bog Pond in Tamworth, NH in January 2025 (Figure 28). Glaciogenic sediments were observed at the bottom of the sediment core indicating that the entire sediment record back to deglaciation by the Laurentide Ice Sheet was recovered (supported by radiocarbon dating). An adjacent surface sediment core was also retrieved which overlaps the larger core and allows for charcoal and other sediment records to be extended up through the present.
- PSU student Virginia Moore completed charcoal analysis on the ~7m core from Cone Pond in Thornton, NH. Alongside previously completed temperature and hydrologic reconstructions we now have a growing record of fire and environmental change from Cone Pond. Particle size analysis on Cone Pond is about 50% completed.
- PSU Student Maggie DelBove began work in summer 2025 on the charcoal analyses from the Black Spruce Pond Bog core from Tamworth, NH. Loss on ignition and magnetic susceptibility analyses were also performed on the core alongside the charcoal record. Particle-size analysis on the Black Spruce Pond core began in Fall 2025.
- In summer 2025, University of Arizona undergraduate Oliff Dorion worked as an REU student to develop the Middle Mt Bog and Black Spruce Pond organic content and magnetic records. This was presented at the Geologic Society of America meeting in San Antonio, Oct 2025

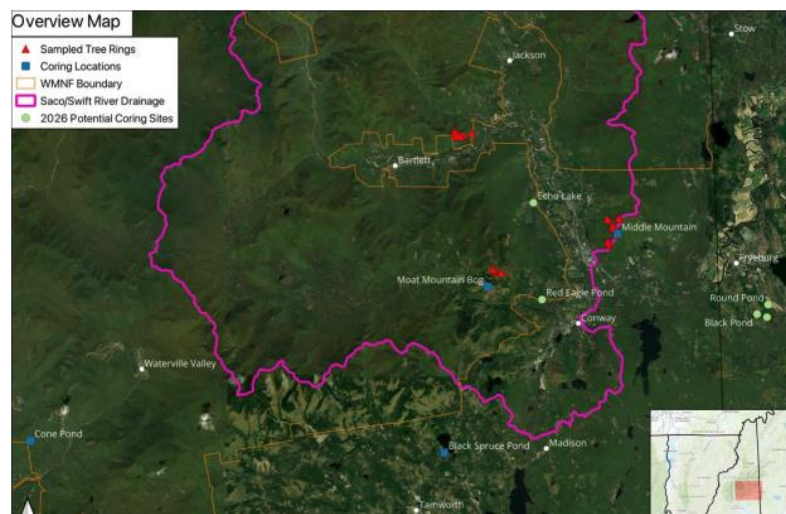


Figure 27. Overview map of the study area showing sampled red pine tree stands (red triangles), already cored lakes/bogs (blue squares) and potential sediment coring locations for 2026 (green circles).

Problems or Changes

- Charcoal analyses are labor-intensive and time-consuming. For example, every centimeter of the Cone Pond core was sampled (758 samples), and each sample was treated and sieved to three particle sizes and then quantified under a microscope, which amounts to 2,274 individual analyses for that one core. The challenge here has been establishing protocols and schedules to ensure consistent progress without overwhelming project teammates.
- In some of the bogs we have been targeting for sediment coring we have found age reversals in the radiocarbon chronologies (i.e., a radiocarbon age deeper in the core younger than a radiocarbon age higher in the core). A possible explanation for this in bog settings could be bioturbated by large animals (e.g., moose) walking through the bog and driving sediments/vegetation/charcoal further down into the core with their hooves. Given this issue we rely on this assumption and additional radiocarbon ages to resolve the chronology. Additionally, we have been targeting deeper bogs or ponds where the coring location is less likely to have been traversed by large animals.
- One of the core sections from Black Spruce Bog Pond was very organic rich which posed challenges in the identification and quantification of charcoal (too much other organic material in the way/clumping together). To better disaggregate the samples during the bleaching process, we applied a vortexing step. However, subsequent analysis suggested that the vortexing was breaking apart charcoal, biasing the charcoal counts. We redid sample preparation with longer bleaching in H₂O₂ and more gentle agitation (swirling beakers by hand) to disaggregate organic matter. This improved sample preparation without biasing charcoal particle size counts and distribution.

Plans for 2026

- At least one new tree-ring site is hoped for to help in fill in the complete Mount Washington Valley area
- The team has plans to core Red Eagle Pond in Albany, NH (Figure 30) in February of 2026. We are in the process of attempting to obtain samples from cores already taken from Echo Lake in Conway, NH; if samples are not available, we hope to core this lake as well. Finally, several ponds in the Saco River basin to east in Fryeburg, ME have promise and we will explore the possibility of coring these lakes to add to the project (keeping in mind our timeline and ability to process cores as well as what compilation of cores/records we want to include in future publications).
- Continue to establish chronologies the collected sediment cores via radiocarbon dating and ²¹⁰Pb dating.
- Charcoal analyses will continue through 2026 on cores already in hand (Black Spruce Bog Pond, Middle Mountain) as well as cores to be collected in 2026.
- As charcoal analyses come in, PI Doner will perform pollen assemblage analyses at specific core intervals to provide insight into ecosystem changes in conjunction with changes in the charcoal records.
- Though not specified in the original proposal, but well within the scope of our project goals, we are exploring the possibility of supporting a student from a local/regional indigenous group in the summer of 2026 to participate in ongoing analyses and construction of fire records.

Collaboration or Alignment with USFS, Partners, or the Public

We continue to collaborate with our indigenous partners through the Indigenous New Hampshire Collaborative Collective. Especially as our charcoal records come together we will be seeking their insight and knowledge to help us interpret said records. We continue to work with the USFS and also hope to begin engaging in more dialogue as our records come together. The USFS can provide us with insight from their experience and goals. PI Pendleton was able to connect with several other regional USFS individuals at the 2025 FEMC conference, which was a great networking opportunity.

Products

- DelBove, M., Doner, L., Pendleton, S., & Doiron, O. (2025). *Reconstructing Holocene wildfire activity in the White Mountain Region using paleolimnology* (Abstract PP23E-1012). [Poster presentation]. AGU 2025 Fall Meeting, San Francisco, CA, December 15–19, 2025.
- Doiron, O., Doner, L., Pendleton, S., & DelBove, M. (2025). *12,000 years of environmental change in New England: A dual-site paleolimnological study* [Poster presentation]. GSA Annual Meeting, San Antonio, TX, October 17–22, 2025.
- Guiterman, C. (2025). *Historical wildland fire in the northeastern US as reconstructed from tree rings*. [Invited Seminar] Albany Pine Bush Preserve Science Lecture Series, Albany, NY.
- Guiterman, C., Marshall, J., & Stambaugh, M. (2025). *Historical fire in the Northeast as viewed from tree rings* [Presentation]. Northeast Association of Fish & Wildlife Agencies Conference, Bartlett, NH.
- Hynes, A., Doner, L. A., & Pendleton, S. (2025). *Fire and the forest: Sedimentary charcoal records of paleo-wildfires in New England*. GSA Joint 60th Annual Northeastern/59th Annual North-Central Section Meeting, Abstract #407208.
- Moore, V., Pendleton, S., Doner, L., Doiron, O., Talon, G., Hastings, E., Hynes, A., & Coleman, M. (2025). *Entire Holocene fire activity in the White Mountains, NH reconstructed through sedimentary charcoal* (Abstract PP23E-1011). Presented at AGU 2025 Fall Meeting, San Francisco, CA, December 15–19, 2025.
- Moore, V., Pendleton, S., Hastings, E., Doner, L., Doiron, O., Talon, G., Hynes, A., & Coleman, M. (2025). *13,000 years of wildfire history in the Cone Pond Watershed*. Presented at the NH-LIFT Summit, Jefferson, NH, August 19–20, 2025.
- Pendleton, S., Doner, L., Guiterman, C., Neely, J., Moore, J., DelBove, M., Doiron, O., Hastings, E., Hynes, A., Gifford, A., Talon, G., & Coleman, M. (2025). *Tree rings and mud: An (ongoing) collaborative reconstruction of historical fire regimes in northern New Hampshire*. Presented at the Forest Ecosystem Monitoring Cooperative Annual Conference, Burlington, VT, November 20, 2025.

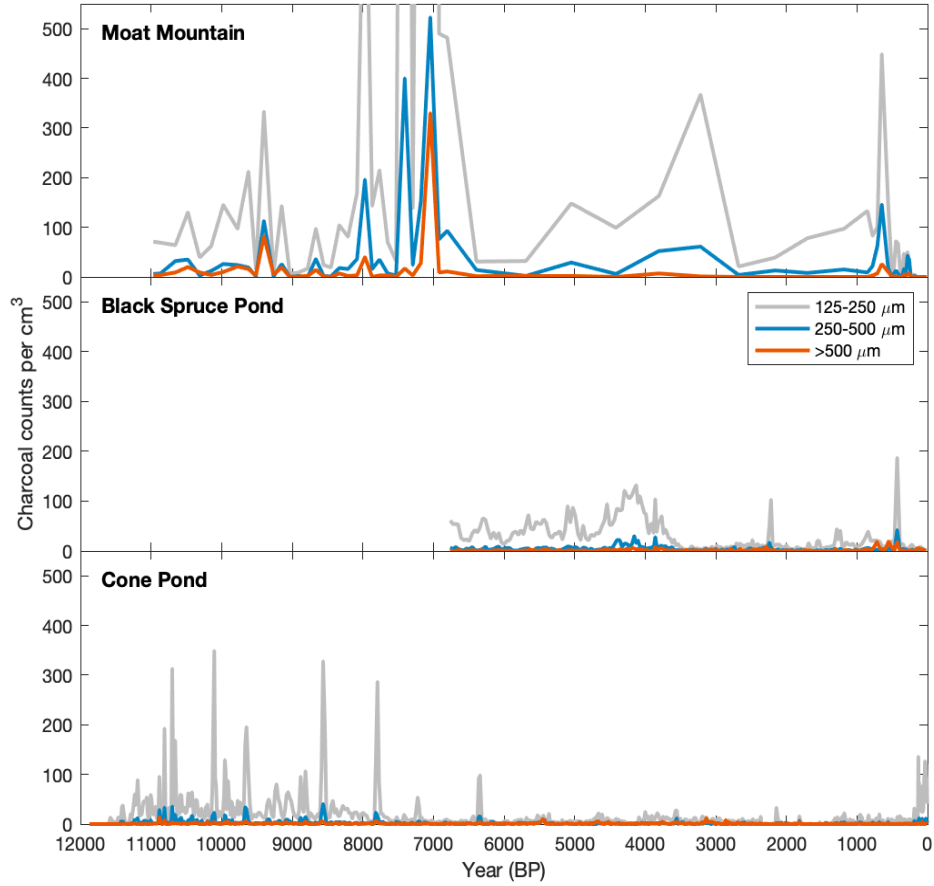


Figure 28. Charcoal particle size data (to date) from coring locations across the project area (See figure 30 for locations).



Figure 29. Tree-ring fire scar sample collection in red pine forests near North Conway, NH.



Figure 30. Project team members, PSU students, members of the Tamworth Conservation Commission, and friends at the end of a successful coring day on Black Spruce Bog Pond in Tamworth, NH.

Digital Species-Site-Suitability Systems for Regenerating Northern Forests

Principal Investigator: Mike Premer (University of Maine, Michael.premer@maine.edu)

Summary of Progress in 2025

During the second project year, a PhD student was hired and began their program of study at the University of Maine. The student successfully completed the first semester of coursework and continued with data standardization of soil chemical and textural variables of 1,791 pedons sourced from the National Cooperative Soil Survey (NCSS).

Digital Soil Mapping Pedons In The Northeast



Figure 31. 1791 pedons across the Northern Forest from NCSS.

Problems or Changes

To date, the only challenge was a delay in hiring a PhD student. Given this detail, a 1-year extension to 2028 was requested.

Plans for 2026

Soil data from the Forest Inventory and Analysis (FIA) database is currently being processed (1,300 samples). When integrated with the NCSS dataset and remote-sensing based estimates of site-specific physio climatic variables generated to date (see progress report year 1), these data will serve as a baseline for Project Objectives². In the spring, focus will be on testing a variety of (non)parametric approaches to estimate forest soil variables across the Northern Forest. Final regional digital soil and site maps are planned for completion in the fall and will be available online. Project highlights and upcoming deliverables from Objective 1 plan to be shared at the National Society of American Foresters Convention in Tacoma, Washington in October of 2026.

Collaboration or Alignment with USFS, Partners, or the Public

With the completion of our prototype for several species across Maine, several geospatial raster products have been deployed for testing by project collaborators, Seven Islands Land Company, JD Irving, and American Forest Management. Feedback from the products will be used to enhance the approach for the entirety of the NF region.

² Integrate forest inventory and plot vegetation records with Light Detection and Ranging data, physio-climatic variables, and georeferenced soil pedon data to produce high resolution (20-m) site and soil raster layers to serve as stand-alone products and a testing framework.

Products

There have been no scientific or general publications directly from this project to date, but a proof of concept and overview of the general workflow and approach for Maine can be found at: <https://www.maineforestlab.com/single-project> and a prototype of the decision support tool available at: https://glc5xc-mike-premer.shinyapps.io/AFM_Demo/.

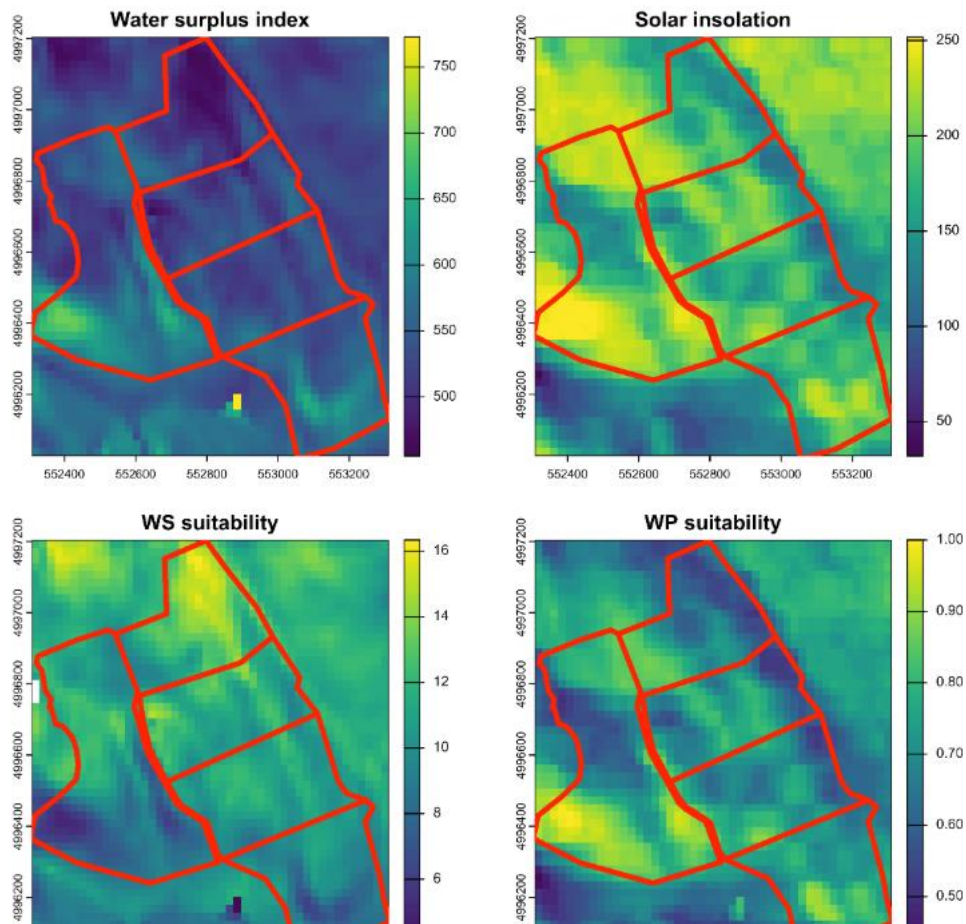


Figure 32. Water surplus index (mm-top left), Solar insolation (top right), site suitability for *Picea glauca* (WS - bottom left) and *Pinus strobus* (WP - bottom right) at 20 m resolution within a given stand polygon

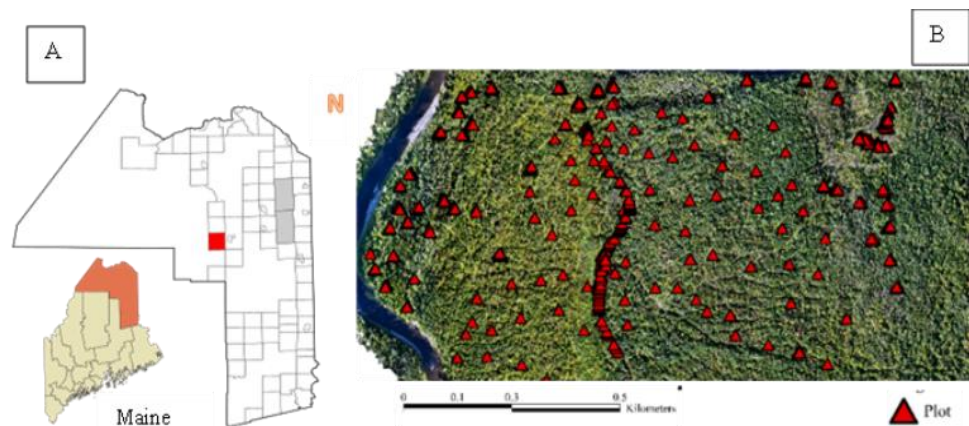
Integrating Advanced Geospatial Analysis and Indigenous Forest Knowledge for Protecting Ash Species

Principal Investigator: Parinaz Rahimzadeh (University of Maine, parinaz.rahimzadeh@maine.edu)

Summary of Progress in 2025

This project started in October 2024. In 2025, the work mainly focused on Objective 1: “creating models for ash tree mapping using very high-resolution remote sensing (RS) imagery”. In spring 2025, several ash-dominated forest sites were identified in the northern part of Maine (Figure 36). Field data collection was conducted in the summer of 2025 and included GPS points for different tree species as well as Unmanned Aerial Vehicle (UAV) imagery (Figure 37). Several methods were developed and tested to identify and classify individual tree species using PlanetScope and UAV-derived imagery, applying both pixel-based and object-based approaches (Figure 36).

Figure 33. (A) location of the study area within the state of Maine, USA. (B) High-resolution UAV-derived RGB orthomosaic of the study area collected in summer 2025 as well as distributions of field data (red triangles).



Pixel-Based Level Analysis: Seasonal, snow and cloud-free PlanetScope imagery was used to extract spectral signatures and derive multiple spectral vegetation indices (SVIs). In addition, canopy height models (CHM), digital elevation models (DEM), and texture features were calculated. Three non-parametric machine-learning techniques: Random Forest (RF), Support Vector Machine (SVM), and Extreme Gradient Boosting (XGBoost) were applied for tree species classification. RF model achieved the highest classification accuracy (0.83), outperforming XGB and SVM models. Black ash was classified with high precision, while mixed broadleaf classes particularly those including red maple showed greater confusion. CHM was identified as the most important predictor, followed by selected spectral indices, texture features and DEM-derived variables for tree classification.

Object-Based Analysis: An object-based approach was applied to delineate individual tree crowns using a Convolutional Neural Network (CNN) model. The model was implemented on high-resolution UAV imagery to detect and segment tree crowns at the individual-tree level. Ongoing evaluation is being conducted to assess model performance and further refine tree crown delineation results across the study area.

Plans for 2026

1. **Finalizing the individual tree species classification project:** refining the object-based classification approach, presenting Objective 1 results at the 2026 IEEE International Geoscience and Remote Sensing Symposium (IGARSS) Conference in August 2026, preparing a manuscript, and submitting it to a peer-reviewed journal by spring–summer 2027. This phase will focus on enhancing model performances, improving feature selection, and confirming the transferability of the classification method across various forest sites.
2. **Mapping ash trees in urban areas:** in addition to forested environments, individual tree crown delineation and classification using both pixel-based and object-based techniques will be applied to the city of Bangor, Maine, as an urban study area. This task will evaluate how urban complexity—heterogeneous land cover, a high diversity of tree species, and limitations on UAV flights—affects tree detection and classification accuracy and will assess the adaptability of the developed methods to non-forest environments.
3. **Ash tree health monitoring and emerald ash borer (EAB) infestation detection:** In spring 2026, several sites will be identified for this component of the project. Field data, including ash tree health assessments and UAV imagery, will be collected from these sites between May and August 2026. This study will combine field observations with remote sensing data to detect EAB infestation and to facilitate proactive monitoring and management strategies.

Collaboration or Alignment with USFS, Partners, or the Public

This project has benefited from collaboration with several researchers and professionals across the Tribal Nations and the U.S. Forest Service (USFS). Collaborators from Mi'kmaq Nation (Shannon Hill and Jon Scott) provided permission to access forest lands for field data collection during summer 2025. They also provided feedback on the study results and map products. Dr. Nathan Siegert from USFS has been helping us with identifying sites for EAB monitoring for the summer 2026 field work. He is also guiding field data collection and helping with methodology development for EAB monitoring.



Figure 34. Collecting data in the field by the research team in summer 2025.

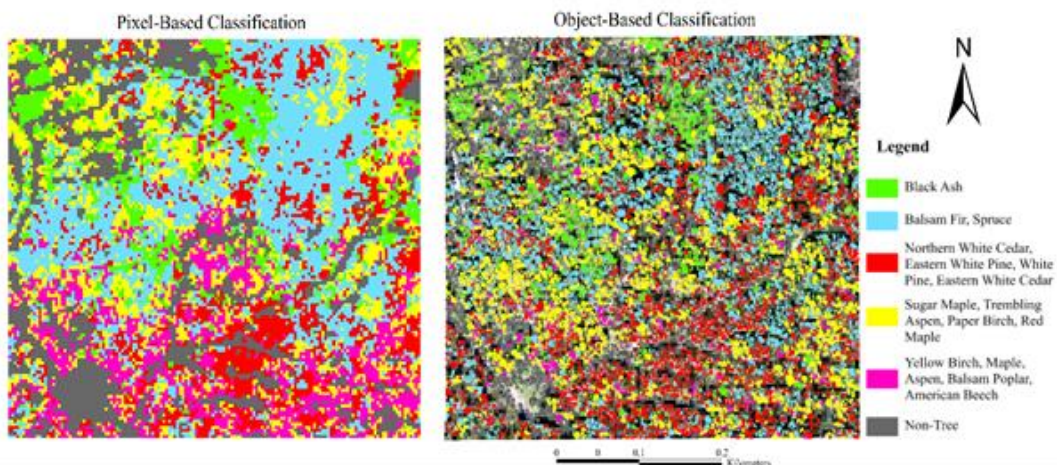


Figure 35. Pixel-based and object-based tree species classification maps. Major tree species groups are Black Ash, Balsam Fir-Spruce, Northern White Cedar-Eastern White Pine and Mixed Broadleaf species (such as Aspen, Paper Birch, and Red Maple).

Satellite Monitoring of Eastern White Pine (EWP)

Health through Assessing the Forest Structure

Principal Investigator: Parinaz Rahimzadeh (University of Maine, parinaz.rahimzadeh@maine.edu)

Summary of Progress in 2025

Validating and improving field level Leaf Area Index (LAI) estimation

Field data (152-plots) was processed from 2023 and 2024. 2023 data was from a previous NSRC project, while 2024 from dominant EWP sites in Maine, New Hampshire, and Vermont. LAI data were collected using Plant Canopy Analyzer (LI-COR, Inc., Lincoln, NE) and Digital Hemispherical Photographs (DHP). A model was developed to estimate LAI using DHP, which provides reliable estimates in various illumination conditions for fine structure EWP needles. This approach uses a deep learning model (U-Net) and the results were validated against traditional field methods (i.e., Plant Canopy Analyzer data). The model provides an average accuracy of ~94% in all types of sky and illumination conditions (Figure 39). The model improved DHP-based LAI estimates ($R^2=0.73$, $RMSE=0.48$) compared to a traditional software (CANOPY) ($R^2=0.62$, $RMSE=0.65$) (Figure 40).

Remote Sensing (RS) modelling of LAI and Live Crown Ratio (LCR)

The remote sensing data were collected and processed for the three states: Maine, New Hampshire, and Vermont. This includes Sentinel-2 (10-m) and PlanetScope (3-m) optical data, Sentinel-1 SAR data, and USGS 3DEP LiDAR data. The 3DEP data (for the recent years, since 2017) were available for 74 plots out of 152 plots. Spectral Vegetation Indices (SVIs) related to vegetation's physiology/stress, structure and biochemistry were used as predictor variables, which were used to model LAI and LCR using five machine learning algorithms: Random Forest (RF), Support Vector Machine (SVM), XGBoost (XGB), Gradient Boost (GBM), CATBoost (CAT). The combination of Sentinel-1 and Sentinel-2 produced the best regression result for LAI with R^2 between 0.59 to 0.82 based on different model configurations. The LCR was classified into three classes as low (≤ 30), moderate (31-40), and high (≥ 40) for modelling. The best LCR classification models (GBM, RF) achieved an overall accuracy of 0.57 and Kappa=0.35 using Sentinel-1 and Sentinel-2 data.

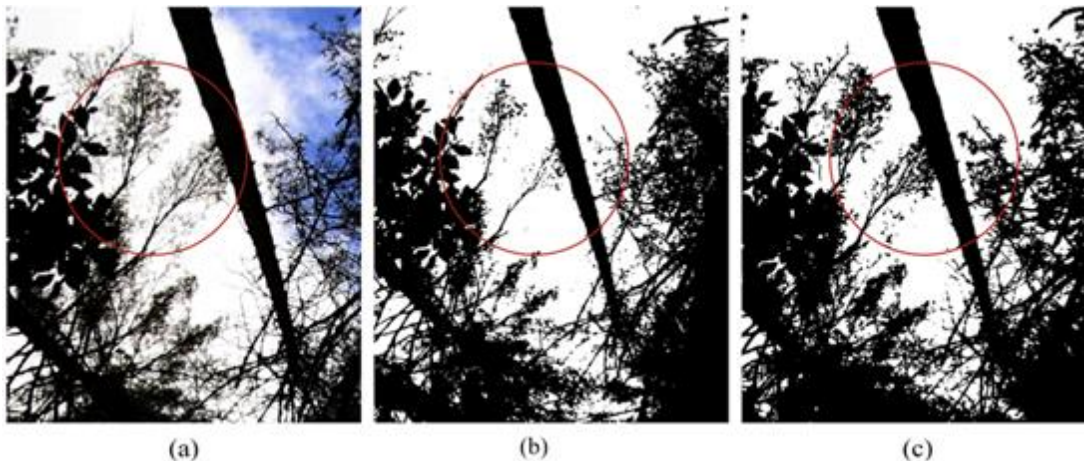


Figure 36. (a) original DHP image, and segmentation results by (b) K-Means and (c) U-Net K-Means

Plans for 2026

Health index modeling

In 2026, EWP health will be modeled using two different approaches: 1) Estimating the EWP stand health based on field data, without producing the intermediate layers; 2) estimating EWP health using LAI, LCR, tree height, and stand density data following Das et. al, (2024). PlanetScope imagery along with Sentinel-1 and 2 data will be used to improve model accuracy. The best model predicted health index layer data will be published on the developed web platform. This web-application (based on Google Earth Engine: GEE) is under development and when the map products are final they will be uploaded on the portal (Figure 41). This allows continuous LAI, LCR, and health monitoring at 10 m spatial resolution. This is useful for timely planning of EWP management, silviculture practices, and suitable interventions to mitigate the impacts of climatic, pest and disease attack, and other stressors on EWP.

Field data processing for further validating health map product

Mr. Aaron Bergdahl (MFS, Augusta, Maine) and Dr. Cameron McIntire (USFS, New Hampshire) are collecting increment cores on the sampled plots. These cores will be processed for annual tree-ring analysis and quantitative tree growth assessment. These data will be used to validate the stand health map.

Workshop/ webinar for forest landowners

A workshop and online webinar (hybrid) will be planned for the associated partners and forest landowners of Maine, New Hampshire, and Vermont. The purpose of the event is to disseminate/share the data with the forest landowners, who can use the project outputs (i.e., health index map for EWP management).

Collaboration or Alignment with USFS, Partners, or the Public

Collaboration with USFS and Maine Forest Service has continued in the past two years and products from this project are designed to be directly used for EWP health monitoring by USFS and Maine Forest Service (MFS). Forest pathologists Cameron McIntire (USFS, New Hampshire) and Aaron Bergdahl (MFS, Augusta, Maine) are collaborators in the project. Aaron Bergdahl helped with identifying appropriate sampling locations acting as a mediator between the forest landowners and the research team in both summer 2023 and 2024. He assisted with data collection, reviewing the techniques/approaches, and providing feedback on the study results. Similarly, Cameron McIntire has been very supportive by guiding data collection, finding study sites, processing data and providing feedback on our results. The University of Maine's Forest Manager, Keith Kanoti, helped us with providing permission for the University of Maine's forest sites. Drs. Jessica Wikle (Research Forests Manager, University of Vermont) and Josh Halman (Forest Health Specialist, Vermont Department of Forests) helped with identification and permission of Vermont sampling locations. Project collaborators periodically join the research discussions and review the data processing methodology. Dr. William Livingston, at School of Forest Resources, University of Maine, has been supporting this project through regular discussions and providing feedback.

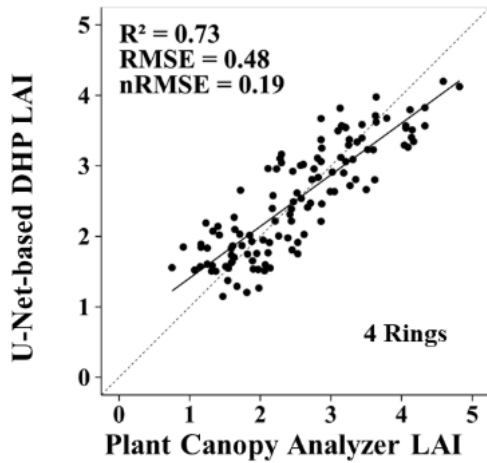


Figure 38. Regression Analysis between U-Net (4-Rings) segmentation derived LAI with Plant Canopy Analyzer

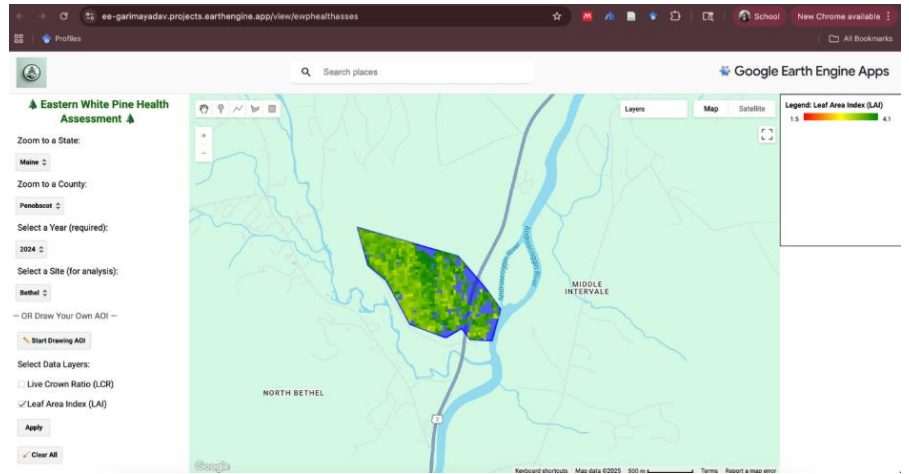


Figure 37. Web application under development using GEE: select state, county, and site (available list) or draw area of interest (AOI) to view predicted LAI and LCR. The health map will be added soon.

Products

- Yadav G., Rahimzadeh-Bajgiran P., and Das P. (2025). Remotely Sensed Canopy Structural Parameters as Indicators for Eastern White Pine Health, AGU 2025, December 15–19, New Orleans, LA, USA. <https://agu.confex.com/agu/agu25/meetingapp.cgi/Paper/1937888>
- Yadav G., Rahimzadeh-Bajgiran P., & Das P. (2025). Automating Eastern White Pine Health Assessment Through Modeling Canopy Structural Parameters, Northeastern Forest Pest Council 87th Annual Meeting, March 11–13, 2025, Middlebury, VT, USA <https://www.northeasternforestpestcouncil.org/previous-meetings> (this presentation received 2025 Gerald N. Lanier MS Student award)
- Yadav, G., Rahimzadeh-Bajgiran, P., Das, P., Weiskittel, A. (2025). Automating leaf area index (LAI) estimation in the field and at landscape scale using image processing techniques and remote sensing (submitted to a peer-reviewed journal and it is currently under review)

A Predictive Scaling Framework of Forest Structure and Functional Diversity in a Non-Equilibrium World

Principal Investigator: Sydne Record (University of Maine, sydne.record@maine.edu)

Summary of progress

Objective 1 was completed (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).

Results for Objective 1 are published in *Global Ecology and Biogeography* in a paper entitled, “The impact of disturbance on tree size distributions in the United States.” It was found that disturbances result in predictable changes to forest size-abundance slopes. Maximum tree height and stand age were also reliable predictors of tree size-abundance distributions, but a structural equation model demonstrated that the impact of disturbance on size-abundance slopes was not mediated through its indirect effects on stand age or maximum tree height, suggesting a direct pathway of influence (Figure 42).

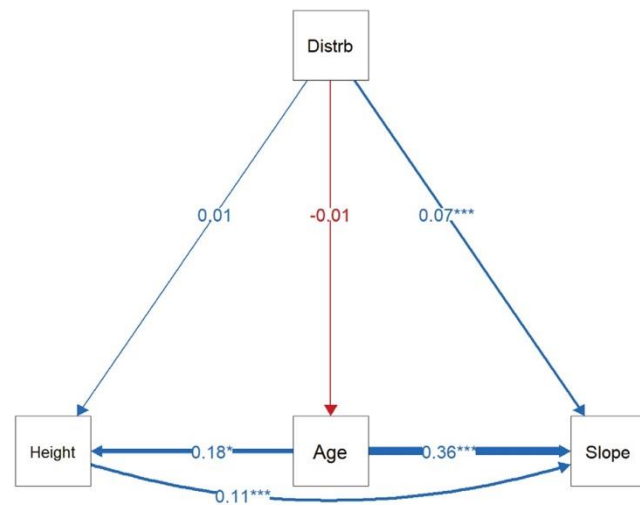


Figure 39. Diagram of the Structural Equation Model

Significance values are displayed as * $p < 0.05$; *** $p < 0.001$. Disturbance is abbreviated as ‘Distrb.’ Red indicates negative relationships, whereas blue indicates positive relationships. Arrow thickness indicates the strength of the relationship, represented numerically by the numbered label.

Progress was made on Objective 2 (using remote sensing canopy data inputs with the objective one models to make predictions across space). A second paper was published in *Global Ecology and Biogeography* entitled, “Leveraging remote sensing and theory to predict tree size abundance distributions across space,” wherein an approach is presented that integrates size-abundance scaling theory with remotely sensed data to improve predictions of forest structure. An R package was created to implement this workflow. Additionally, PhD student East presented an analysis to see if coarser resolution using National Agricultural Imagery Program (NAIP) data for the workflow at the American Geophysical Union Annual Meeting could be used. For Objective 3 (using Objective 2 outputs to calculate connectivity metrics between conserved and working lands), East has scheduled meetings with project stakeholders early in 2026.

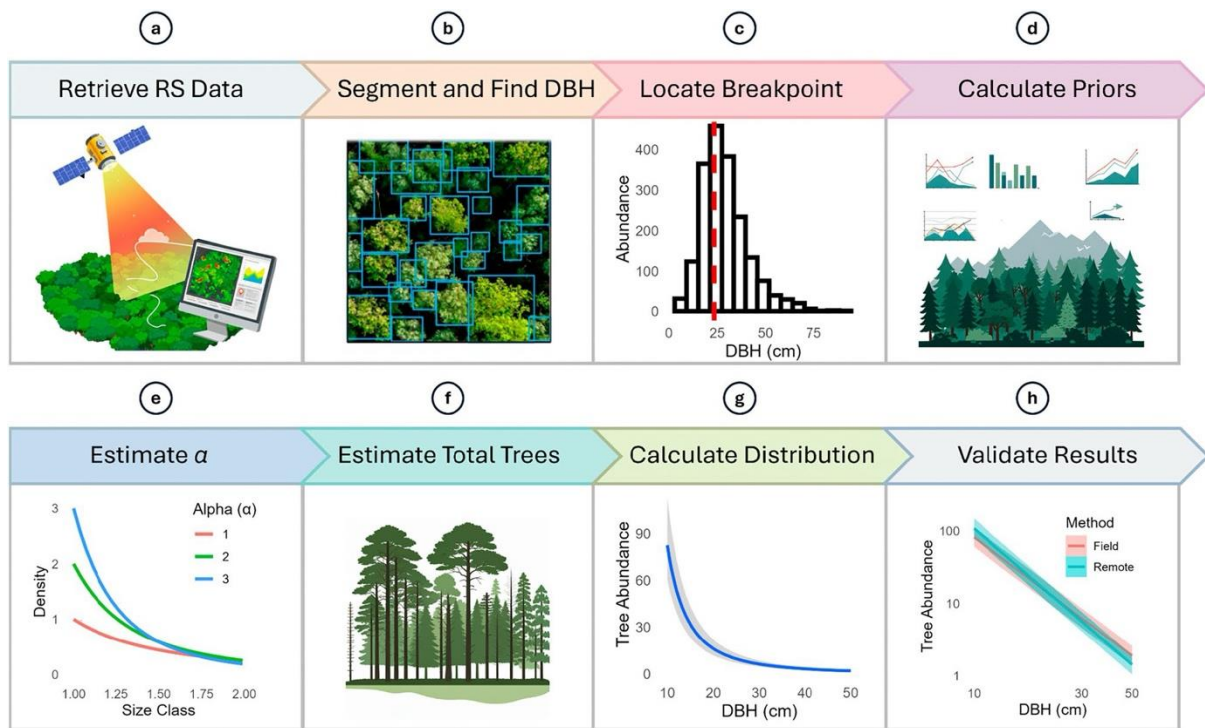


Figure 40. Visual representation of our method for estimating the size-abundance curve for a given forest based on remotely sensed (RS) data from the canopy. (a) RS data, including canopy height and red-green-blue (RGB) imagery, must be retrieved, either from an online database or gathered by drone. (b) A canopy segmentation algorithm is applied to create polygons of individual trees, and then the DBH of each tree is recovered via allometric equations utilizing both canopy height and diameter as parameters. (c) The breakpoint $x_{\text{breakpoint}}$ for the RS data, representing the DBH above which the size-abundance curve from RS data follows a known size-abundance distribution, is estimated (trees below this threshold are assumed to be occluded, and only data with $\text{DBH} \geq x_{\text{breakpoint}}$ is used in subsequent steps). (d) Informed priors for the α parameter of a Pareto distribution are derived from environmental data for each plot (e.g., maximum tree height, elevation), using a random forest model trained on forest inventory data. (e) The posterior distribution for α is then estimated with a Bayesian model. (f) Uncertainty in the posterior distribution for α is propagated into the next step, where a separate Bayesian model is used to estimate a posterior distribution for the total number of trees (N_{tot}) in the plot. (g) A final size-abundance distribution with uncertainty is created by fitting the Pareto distribution with samples from the estimated α posterior distribution and multiplied by samples from the estimated N_{tot} posterior distribution. Because the interpolated distribution is only estimated up to the threshold of 50 cm DBH, it can be extended by directly appending empirically observed trees from remote crown segmentation for $\text{DBH} > 50$ cm. This approach avoids double-counting, as the interpolation uses only trees ≤ 50 cm, while the segmentation data are reliable only for larger trees. (h) The final size-abundance distribution(s) can then be validated with in situ data (which will cover a smaller subset of a given area of interest). The end result allows for a large-scale raster dataset predicting forest size abundance distributions. Clipart in steps (a), (d), and (f) were created with the assistance of Google's Imagen, an AI language model.

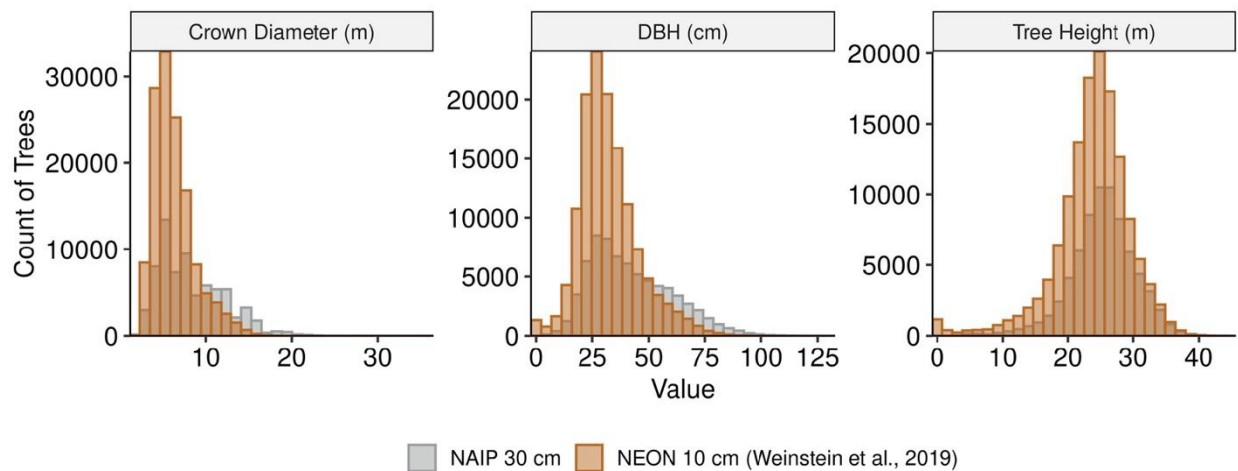


Figure 41. Histograms of published reference tree crowns from Weinstein et al. (2019) segmented from 10 cm NEON RGB images (orange) compared to crowns segmented from National Agricultural Imagery Program (NAIP) 30 cm images tuned from the DeepForest crown segmentation model (grey).

Problems or Changes

The original plan involved fitting the objective-one models with covariates from gridded products representing climate, topography, and disturbance. This approach had to be revised due to the recent pause on new agreements permitting the use of actual geographic coordinates for USFS FIA plot locations (Goeking et al. 2024). Fortunately, all models have been successfully fit using in-situ FIA database variables—specifically stand age and canopy height—eliminating the need to integrate additional gridded data products for objective one. For spatial predictions under objective two, canopy height and stand age estimates from remote sensing sources can be used, allowing alignment between prediction inputs and the variables used to fit the objective-one models. The project also initially included travel for team members to collaborate in person with Co-PI Knott, as well as visits to Maine by Co-PI Knott. These plans were disrupted by Knott’s travel restrictions and additional interruptions associated with the fall federal government shutdown. Permission was obtained from Aaron Weiskittel to redirect the unused travel funds to support PhD student East’s stipend. Although the project originally budgeted for an MS student, the higher PhD stipend is appropriate given East’s strong background in remote sensing, which made East an excellent fit for the project. Additionally, the budget buffer created by unused travel funds has helped accommodate increased graduate student stipend and insurance costs resulting from the recent unionization of graduate students at UMaine.

Plans for 2026

In 2026, the plan is to focus on Objectives 2 (using remote sensing canopy data inputs with the objective one models to make predictions across space) and 3 (using objective two outputs to calculate connectivity metrics between conserved and working lands). Plans are to segment tree

crowns for the northern forest using NAIP images, given the confirmation that Maxar commercial images are spotty in the study region. NAIP data will be segmented and compared to ground-truthed, in-situ field data collected by the Maine Adaptive Silviculture Network (MASN). Additional tree crown measurements for ground-truthing were possible this year by supporting UMaine undergraduates through another grant on MASN sites. To work towards objective three, meetings will be scheduled with partners identified in the proposal and new partners (see below) to ensure that the connectivity metrics we calculate between conserved and working lands in the Northern forest are relevant to management to ensure the translation of our science.

Collaboration or Alignment with USFS, Partners, or the Public

The project works closely with USFS through a collaboration with Co-PI Knott. Knott provides invaluable context for the FIA data used to fit the models for Objective 1. Co-PI Knott has also provided invaluable remote sensing expertise for Objective 2. The team has regular meetings to ensure collaborative work. Meetings are being scheduled with the following partners to ensure that the outputs of Objective 3 will be helpful for the management of Northern forests: Maine Department of Agriculture, Conservation, and Forestry (Megan Leach), Appalachian Mountain Club (Sarah Nelson, Carolyn Ziegra), Tricia Bhatia (The Nature Conservancy – formerly at the Northeast Wilderness Trust), and the Maine Cooperative Forestry Research Unit (Regina Smith). Note that new partners have been added (Appalachian Mountain Club and Maine Cooperative Forestry Unit) since the writing of the project proposal given interest by these groups in this work.

Products

- East, A.M., A.M. Eichenwald, and S. Record. Multimodal crown segmentation across spatial resolutions. American Geophysical Union Annual Meeting, New Orleans, LA, USA, December 2025 – poster presentation.
- Eichenwald, A.M., J.M. Grady, J.A. Knott, Q.D. Read, J.M. Rodriguez, and S. Record. 2025a. The impact of disturbance on tree size distributions in the United States. *Global Ecology and Biogeography*, 34: e70102. <http://doi.org/10.1111/geb.70102>
- Eichenwald, A.M., J.M. Grady, J.A. Knott, Q.D. Read, J.M. Rodriguez, B. Weinstein, D.A. Orwig, and S. Record. 2025b. Leveraging remote sensing and theory to predict tree size abundance distributions across space. *Global Ecology and Biogeography*, 34: e70085. <http://doi.org/10.1111/geb.70085>
- Eichenwald, A.M., J.M. Grady, A.M. East, N. D. Charney, and S. Record. In major revision. ScalingFromSky package: An R package to infer forest structure from remote sensing data. *Methods in Ecology and Evolution*. <https://anonymous.4open.science/r/ScalingFromSkypackage-7CB2/README.md>

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: Bahram Salehi (SUNY-ESF, bsalehi@esf.edu)

Summary of Progress in 2025

This project has two primary technical objectives:

1. developing machine learning models to generate canopy height models (CHMs) for Northeastern United States (NEUS) forests, and
2. developing models to estimate aboveground biomass (AGB) across NEUS forests.

Over the past 12 months, the project has made significant progress toward fulfilling the first objective. This progress was achieved through close collaboration with the U.S. Forest Service Forest Inventory and Analysis (FIA) program, particularly in method development and validation using independent FIA plots.

Plans for 2026

The plan for 2026 is to focus on the second objective of this project: developing machine learning-based aboveground biomass (AGB) models and generating annual AGB maps, along with corresponding change maps, for forests across the NEUS. Achieving this objective requires access to precise geographic coordinates of FIA plots for model training and validation. We are currently working with the U.S. Forest Service Northern Research Station FIA program to obtain access to FIA plot coordinates in the NEUS through a Request for Spatial Data, Analysis, and a Material Transfer Agreement (MTA). In addition, we will collaborate with project partners across the NEUS to access locally collected AGB datasets, which will be incorporated into model training and validation workflows. We will also engage key stakeholders, including the U.S. Forest Service, by sharing the resulting canopy height model (CHM) and AGB maps for feedback and potential testing within their areas of responsibility. We anticipate producing an additional two to three conference presentations and one to two peer-reviewed journal publications as outcomes of this work. Ultimately, this effort will result in the development of high-resolution AGB maps for the study area.

Collaboration or Alignment with USFS, Partners, or the Public

Collaboration continues with the U.S. Forest Service Northern Research Station FIA program to validate and test our CHM products using FIA plots. Because FIA plot coordinates are

confidential and not directly available to our team, the FIA program has conducted the validation analyses on our behalf without disclosing sensitive location information. Dr. Barry Taylor Wilson of the U.S. Forest Service Northern Research Station FIA program is a co-author on the submitted manuscript referenced above, reflecting this close collaboration.

Work continues with the FIA team to secure access to FIA plot coordinates for aboveground biomass (AGB) model development, including both training and validation, through appropriate data-sharing agreements. In addition, collaborating has been ongoing with the School of Forest Resources at the University of Maine to access local forest plot data and facilitate data sharing for model development and validation purposes.

Products

- Poster presentation at the National Association of American Foresters conference in Hartford, Connecticut, in October 2025.
- Abstracts submitted and accepted to the International Society of Photogrammetry and Remote Sensing (Toronto, July 2026) and the ForestSat Conference (Florida, April 2026).
- A manuscript titled “Annual Canopy Height Estimation of the Northeastern United States Through the Fusion of GEDI, SAR, Optical, and Topographic Data Using Random Forest Regression Models,” submitted to ISPRS Journal of Photogrammetry and Remote Sensing in January 2026.
- Conference paper titled “Multisensor machine learning for annual (2019–2024) forest canopy height mapping and change detection using GEDI in the northeastern united states” submitted to the IEEE-IGARSS conference
- Successful defense of the PhD candidacy examination by the project’s doctoral student, who advanced to PhD candidacy in August 2025.
- [LinkedIn Post](#)

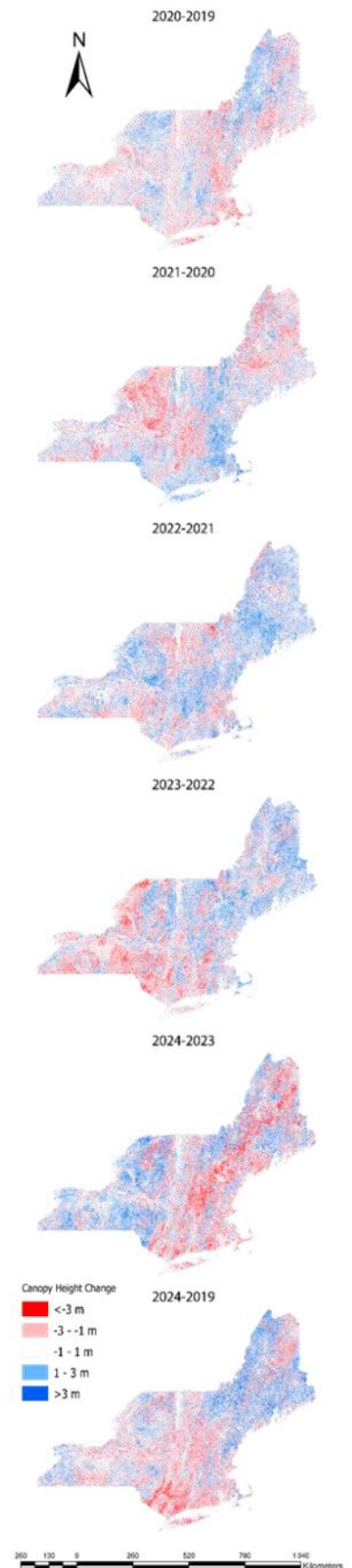


Figure 42. Annual CHM change maps for Northeastern US Forests for the period of 2019-2024.

SEED: Social, Economic, and Ecological Dimensions of Climate Adaptive Silviculture

Principal Investigator: Erin Simons-Legaard (University of Maine, erin.simons@maine.edu)

Summary of Progress in 2025

In 2025, an experimental unit layout was completed for a new large-scale adaptive silviculture project at the Penobscot Experimental Forest (PEF). Permanent sample plots and unit boundaries were established. Inventory was started and is set to be completed ahead of harvesting in 2026. Work also progressed on assessing the adaptation potential of conventional silvicultural systems, using long-term and newly collected data from the existing Compartment Management Study on the PEF. Preliminary results of that assessment were used to refine treatments for the new experiment and have been presented at conferences and workshops. Finally, a survey instrument was developed to determine commercial forestland managers' values, perceptions, barriers, and acceptability of climate adaption broadly as well as several specific silvicultural treatments.

Problems or Changes

Inventory was extended into 2026 and treatment application (harvesting) delayed until the winter of 2026–2027 due to the federal workforce restructuring and furlough in 2025. The wildlife researcher collaborating with us on the project left his U.S. Forest Service position and is no longer engaged in the work; the social scientist also left her Forest Service position but continues to work closely with us.

Plans for 2026

The survey will be deployed early in 2026 with assistance of the Cooperative Forestry Research Unit. A virtual meeting will be convened with the practitioner advisory committee to provide them with an update on progress to date and solicit their feedback on planned silvicultural treatments. Analysis of the adaption potential of existing treatments will be completed, as well as assessment of commercial forestland managers' values, perceptions, barriers, and acceptability of climate adaption. Following this, the graduate student on the project will defend his thesis and submit two papers for publication. Pre-treatment inventory for the new experiment will be completed in the summer, with timber marking and harvest layout in the fall. Experimental units in the new adaptive silviculture experiment will be harvested in winter 2026–2027.

Collaboration or Alignment with USFS, Partners, or the Public

Collaboration with the U.S. Forest Service, Northern Research Station is integral to the project and ongoing. The Forest Service is providing the research area for the long-term experiment and has taken the lead on silvicultural prescription writing and inventory. They also are conducting the Compartment Management Study that is being used to assess climate adaptation outcomes of existing treatments. The graduate student's committee includes two current and one former Forest Service employees, all of whom are coauthors on presentations of the work. In addition, ongoing engagement continues with commercial forestland managers through virtual meetings and are collaborating with the Cooperative Forestry Research Unit to disseminate the survey to their membership.



Figure 43. Illustrations of silvicultural treatments accompanied prescriptions in the survey of commercial forestland manager's values, perceptions, barriers, and acceptability of climate adaption. These drawings show a stand a) before and b) after continuous cover irregular shelterwood, a resilience treatment. Credit: Maeve Noone-Price.



Figure 44. Our work includes a new adaptive silviculture experiment in conifer-dominated lowlands in the U.S. Forest Service research area on the Penobscot Experimental Forest. Inventory is underway and harvesting is planned for the winter of 2026-2027. Credit: U.S. Forest Service.



Figure 45. Adaptive silviculture includes resilience treatments intended to help forests adapt to effects of climate change such as increasing frequency and intensity of wind storms that cause blowdown like that shown here on the Penobscot Experimental Forest. Credit: U.S. Forest Service.

Products

- McCloskey, D.; Kenefic, L.; Simons-Legaard, E.; Rogers, N.; Sachdeva, S.; Roach, S. (2025). *Climate Adaptivity Outcomes of Conventional Silviculture in Northern Conifer Forests* [Poster presentation]. New England Society of American Foresters Winter Meeting, Devens, MA, March 2025. Published abstract (page 22 of News Quarterly): https://nesaf.org/wp-content/uploads/2025/04/NQ_apr_2025.pdf
- McCloskey, D.; Kenefic, L.; Simons-Legaard, E.; Rogers, N.; Sachdeva, S.; Roach, S. (2025). *Managing Mixedwood Forests for the Future: Outcomes from Long-Term Silviculture* [Poster presentation]. Northern Hardwoods Conference, Syracuse, NY, August 2025. Published abstract (page 22-23 of Proceedings): <https://docs.google.com/document/d/16foFjBk6h1qUAj0v-nKIcObWPOSR8IxZ/edit>
- McCloskey, D.; Kenefic, L.; Simons-Legaard, E.; Rogers, N.; Sachdeva, S.; Roach, S. (2025). *Conventional Silviculture and Climate Adaptivity: Outcomes from 70 Years of Data in Northern Conifer Forests* [Poster presentation]. Society of American Foresters National Convention, Hartford, CT, October 2025.

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, shoban@mortonarb.org)

Summary of Progress in 2025

A key project goal was to partner with Circle of Courage (COC) to provide education and mentoring for youth in both Indigenous and Western approaches to forest health assessment. In 2025, participating youth engaged in forest walks to learn how to identify butternut trees, assess butternut health, and explore broader forest ecology, including the names and uses of various plants. They collected and prepared seeds for winter storage, discovered new butternut tree locations in both summer and winter, and used butternut husk extract to dye cultural items such as drums and rattles. Youth also documented their observations through drawings and letters and assisted with installing deer-exclusion cages to protect butternut seedlings.

Another goal was to work with Tribal leaders and members to identify seed producing trees for sampling to plant butternut seedlings in communities. Trees have been identified in several locations including locations identified by tribal members. Over 300 seeds were collected. Seedlings will be distributed in 2026 and will also be planted at the Shelburne Museum in Shelburne, VT.

Another project goal was to dialogue with indigenous partners about butternut health, management, care, and solutions to restoring butternut. The team met monthly with the projects indigenous partner virtually and several times in person to progress this dialogue.

A final goal of the project was to collect samples for DNA analysis from healthy and diseased trees to better understand how many healthy trees truly are butternut vs hybrid trees. The DNA tests will also be used to test the butternut status of adult trees producing seed and seedlings to be distributed and results on more than 200 trees were already obtained.

Problems or Changes

No problems have arisen and no changes have been made to original plans. A budget change was requested and approved.



Figure 46. Circle of Courage participants help to collect butternut tree seeds, and check the condition of butternut seedlings and the deer caging that is protecting the seedlings.



Figure 47. Project participants inspect a butternut tree for signs of the butternut canker disease.

Plans for 2026

Plans to engage COC youth in forest ecology and butternut tree health lessons across all seasons will continue in 2026. Lessons will include discussions about butternut, ecological concepts, stories, and forestry practices, and youth will continue documenting their experiences and learning in field notebooks. Bergdahl, Kratt, and Gagne will participate in program activities, supported by contractor Roth and the tribal coordinator.

Butternut seedlings from Isle La Motte (VT)—confirmed to be true butternuts—will be distributed for planting at sites selected by tribal partners and likely at Shelburne Farms and the Shelburne Museum. Data analysis of hybridization will continue. Kratt will continue

surveying and deer-fencing butternut seedlings. Another butternut population within a wildlife management area is also being monitored; more than 30 trees were deer-caged, along with an equivalent number left uncaged, and survival in both sets of seedlings will be assessed. Additional sites will be surveyed for butternut occurrence, and selected trees and seedlings will be reassessed.

NSRC-funded interns will participate in many of these activities. Data collected on tree health and butternut habitat management will continue to be discussed with Indigenous partners. COC participants will also continue to plant their own seedlings in pots, monitoring the growth and health of their trees throughout 2026.

Collaboration or Alignment with USFS, Partners, or the Public

Dale Bergdahl is in communication with staff at the University of Vermont, Vermont Department of Forests, Parks, and Recreation, and USFS regarding care and maintenance of the butternut orchard. He is in communication with The Nature Conservancy and the US Fish and Wildlife Service regarding butternut populations and possible locations for reintroductions. A USFS colleague is preparing a butternut common garden to be planted likely in 2026.

Field survey sites in 2026 may include the Green Mountain National Forest among other locations and coordination with USFS personnel will continue. Activities are being communicated to partners including the USFS geneticists for the northern and southeast region, and several state DNR, to put the health of butternuts in Vermont into national context.



Figure 48. Circle of Courage participants use the husk of the butternut seed to provide a dye for a drum that they are creating.

In addition, project activities have been enhanced by an early career scientist at The Morton Arboretum who is funded by another grant.

Bergdahl presented the project at the New York Nut Growers Association meeting. Public engagement has occurred through engaging volunteers at Charlotte Park, with an evening presentation and discussion with volunteers planned for next month. Stewards have identified butternut trees, removed brush, and installed deer cages. Seedlings will be provided to the Shelburne Museum, which will be showcased to the public. Landowner Kratt has also discussed the project and the identification and care of butternut trees with other local landowners. The butternut tree will also be featured in an upcoming episode of the children's TV show Wild Kratts.

Restoring Tribal Relations and Forest Knowledge

Principal Investigator: Jessica Raspitha (Saint Regis Mohawk Tribe, Jessica.raspitha@srmt-nsn.gov)

Summary of Progress in 2025

The *Restoring Tribal Relations and Forest Knowledge* project was intended to provide meaningful opportunities to indigenous youth from the northeast that were interested in pursuing a career in natural resource management, while highlighting the role of Indigenous Traditional Ecological Knowledge in forest management, while also fostering inter-Tribal cultural knowledge exchanges that restore historical inter-tribal connections related to forest systems. During the course of the mentorship program, each student was tasked with identifying a forestry-related research topic of their choice to focus on during the cultural exchanges to gain a better understanding of how different tribal cultural viewed their topic (whether similar or differently) and how these perspectives are incorporated in to the current resource management actions by each Tribe.

The first year of this project (2025) was an overall success that incorporated a mentorship program for young adults related to natural resource management and the integration of Indigenous Traditional Ecological Knowledge, cultural exchange camps (2), and a capstone event. The project sponsored a total of eight (8) mentorships including four Haudenosaunee students and four Wabanaki Students, with one cultural exchange camp hosted in Akwesasne in New York, and a second hosted by the Wabanaki Youth in Science (WaYS) program in Maine. The capstone event took place in August in Manchester, NH (a mid-point for all travelers), for the student mentees to present their research projects to the collective group of mentors and to each other. The students and mentors both found a lot of value in the project and look forward to continuing the effort in 2026.

Problems or Changes

There were no major problems encountered during the first year of this project. Challenges included initial delays related to the sub-award and contracting processes in place that allowed us to facilitate payment to project partners for their time and involvement, but these issues were resolved in early 2025 and the implementation of the project, including the mentorship programs, cultural exchange camps, and capstone event went well. Another challenge was the retirement of the project's original principal investigator, Les Benedict, in December 2025, however, the PI has since been updated.

Plans for 2026

To continue this effort, a similar youth mentorship program will be implemented that once again seeks to pair aspiring natural resource managers with current environmental professionals. We will follow a similar set up, with 4 Haudenosaunee students and 4 Wabanaki students, with cultural exchange camps hosted by each, and concluding with a capstone event to share the final research projects.



Figure 49. During the Akwesasne Cultural Camp in July 2025, participants visited one of the black ash stands managed by the Saint Regis Mohawk Tribe to discuss how EAB damage is being mitigated through biological control releases, silvicultural prescriptions, and pesticide applications. These stands are specifically chosen to preserve basket-grade ash trees. Field lead, Angello Johnson, demonstrates the selection process for high-quality basket-trees. (Photo by Jessica Raspitha, SRMT)

Collaboration or Alignment with USFS, Partners, or the Public

The success of this project relied heavily on the successful collaboration with our project partners, the WaYS program, the Haudenosaunee Task Force on the Environment (HETF), the University of Maine's School of Forest Resources, the Nibezun Program, the Akwesasne Cultural Center, and the University of Vermont's Forestry Program. The WaYS program was integral in providing mentorship opportunities to indigenous youth (from the Penobscot Nation and the Passamaquoddy Tribe), while HETF provided mentorships to two Haudenosaunee youth from the Onondaga Nation, complementing the two youths from the Akwesasne Mohawk Nation hosted by the SRMT Environment Division.

The cultural exchange camps were supported by the cultural knowledge and expertise provided by project partners at the Nibezun program and the Akwesasne Cultural Center, while additional support related to forest management were provided by our academic partners.

Products

Akwesasne Cultural Exchange Camp [summary article](#) prepared by the SRMT Center for Media and Communications for inclusion in the Kanenna'ké:ne/ Fall 2025 Community Newsletter. (PDF Page 8, Print pages 14–15)

2025 Summer Program Student Final Projects:

- A story map on Non-Indigenous Relatives' Impact on Wabanaki Traditions by Apemesim Galipeau, Penobscot Nation.
- A field guide titled, Wabanaki Cultural Crafts and Forest Knowledge Guide, by Sierra Lank, Passamaquoddy Tribe at Motahkomikuk.
- A poster presentation on Shifting Changes in Moose in Maine, prepared and presented by Frank Milano IV, Passamaquoddy Tribe at Motahkomikuk.
- A poster presentation on Wolahkakoniw: It is plentiful, it is a good crop, focusing on food sovereignty, prepared and presented by Taliah Doughty, Passamaquoddy Tribe at Sipayik.
- A slide show presentation on Returning Native Species to the Thousand Acres Reclaimed by the Onondaga Nation, prepared and presented jointly by Riley Thornton and Kenji Frazier, both from Onondaga.
- A presentation and hands-on demonstration focused on Insect Biodiversity, lead by Cora Thompson, Akwesasne Mohawk.
- A video presentation on the Wildfire Risk in Akwesasne, prepared and presented by Ty David, Akwesasne Mohawk.



Figure 50. During the Akwesasne Cultural Camp, a log-pounding demonstration is done to provide a hands-on understanding of how a black ash tree is refined into the splints needed for traditional basketry. (Photo by Jessica Raspitha, SRMT)



Figure 51. During the Wabanaki Cultural Exchange Camp, August 2025, participants were provided with another log-pounding and splint refining demonstration to highlight the similarities and differences that exist between the two traditional practices. While Haudenosaunee and Wabanaki produce similar results, there are distinct differences throughout the process and in the final results. (Photo by Jennifer Galipeau, WaYS Program)

Effects of Road Crossing Construction on The Aquatic Community of a Beaver-Influenced Landscape

Principal Investigator: Ben Simpson (Penobscot Nation, ben.simpson@penobscotnation.org)

Summary of Progress in 2025

A graduate student, Kyle Hubbard, started at the University of Maine in January 2025 and has been working closely with the Penobscot Nation (PN) and his advisors in the Maine Cooperative Fish and Wildlife Research Unit. To date, 6 months of water temperature and water depth data have been collected from 11 HOBO loggers spread across both wetland complexes, a nearby reference wetland complex where there will be no construction, and the outflow stream (Birch Stream). Six months' worth of camera trap pictures and videos have been collected from 10 sites dispersed across the same locations. These images are composed of 13 mammalian species (and counting) as well as many birds and waterfowl. Preliminary fish community data from backpack electrofishing effort completed in the downstream and outflow sections of all sites has also been collected.



Figure 52. Bridge sites targeted for reconstruction, corresponding to the southern site (left) and the northern site (right). Photos: Kyle Hubbard

Plans Moving Forward

Overall, this project will collect and analyze data on fish communities through electrofishing, netting, and environmental DNA; physical habitat through water parameter measurement and macroinvertebrate sampling; and terrestrial fauna movements through beaver tagging and camera trapping.

Currently, pond depths and water temperatures are being catalogued to create a baseline map to compare changes to. Temperature and depth are passively monitored with HOBO water level loggers in strategic positions. Downstream areas will be similarly sampled. Alongside these passive data collections, a thermal imaging drone will conduct flyovers in the fall before and after construction to describe surface water temperatures and pond depth on a broader scale.

Terrestrial animals are being passively sampled with camera traps to assess overall faunal usage of the pond. Cameras have been placed to capture usage of beaver structures as animals navigate around their fragmented habitat.

Due to the complex and diverse nature of fish habitat in beaver ponds, many different sampling techniques will be employed. A backpack electrofisher will be used in accessible areas to measure fish assemblage. Unwadeable areas inaccessible to the electrofisher will be sampled by cast nets and seines from a canoe. Captured fish will be catalogued to species, and a subset of the first ten individuals of each species will be measured by total length (mm) and weight (g) to create a biological data index.



Figure 53. A beaver walking across the ice at the northern bridge construction site in early December. Photo: Kyle Hubbard

Environmental DNA will be collected in the days leading up to an electrofishing event. This sampling effort will primarily search for Atlantic salmon, American eel, River herring, Sea lamprey, and Brook trout due to their potential to gain from increased habitat connectivity and cultural importance to PN.

Beavers will be live captured in late summer and fall 2026/27 with Hancock traps and a W510 Wildlink GPS Logger will be glued to the beaver's back just above the tail. Tags will be programmed to run from 1700–0700 to reduce battery usage when beavers will be inactive and will take latitude/longitude positions every hour on the hour. The tag will be retrieved after it expires (between 40–60 days), and its data will be uploaded and analyzed into mapping software to create a map of the animal's movements.

Products

- Hubbard, K., Murphy, C., Simpson, B., and Zydlewski, J. (2025). *Effects of road crossing construction on the aquatic community of a beaver-influenced landscape* [Presentation]. 155th Annual Meeting of American Fisheries Society, San Antonio TX., August 11.
- Hubbard, K., Murphy, C., Simpson, B., and Zydlewski, J. (2026). *Effects of road crossing construction on the aquatic community of a beaver-influenced landscape* [Presentation]. Atlantic Salmon Ecosystems Forum, Bangor ME., January 13.

Managing for Tomorrow's Panawahpskek Forests Today: An Integrative Approach to Submerchantable Competition Control

Principal Investigator: Carolyn Ziegra (Appalachian Mountain Club, ctiegra@outdoors.org)

Summary of Progress in 2025

Initial partners met in the fall of 2024 to discuss project goals and objectives. Site visits occurred early in the spring of 2025 on Penobscot Nation (PN) land at Mattamiscontis to discuss silvicultural treatments and quality sites for treatment. Further site visits occurred on Appalachian Mountain Club's (AMC) Barnard Forest in May of 2025.

AMC hired one seasonal intern from the University of Maine to work on this project during the field season of 2025. Additionally, another AMC intern from Colby College also assisted on the project. Support from the PN included their Forest Manager and forest technicians. Sites were selected and inventoried for the first round of treatments in sapling-pole sized northern hardwood stands dominated by American beech on both AMC property and PN land. Eight one-acre plots were installed with fixed-area sample plots installed on each property. All measurements were taken prior to any treatments implemented. The eight research



Figure 54. Pre-treatment photo of American beech dominated northern hardwood stand on AMC's Barnard Forest. Photo Credit: USFS.

blocks contained: two control blocks (no treatment), two precommercial beech cleaning blocks, two commercial patch harvests with retention to be followed with planting/seeding, and two commercial patch harvests with no planting or seeding.

In 2025, the first set of treatments were implemented in the precommercial beech cleaning treatment blocks. All American beech in the blocks were cut or girdled in the two one-acre blocks (four blocks total across both study sites). The focus of this treatment and all treatments is on northern hardwood restoration without the use of herbicides in stands dominated by American beech.

Problems or Changes

Due to unforeseen operational challenges in 2025 with implementing specific treatments, treatments had to be adjusted, and commercial work had to be moved until 2026 on the research blocks. Challenges included operational cost of equipment, availability, and lack of markets for products removed.

The changes in project timeline have resulted in an adjustment to the budget for the project. It was also noted that more support was needed for data collection and site installation through the form of seasonal forestry interns. If permissible, funds remaining from 2025 will be allocated

going into 2026 to help cover the costs of treatments and seasonal intern positions. Staffing challenges at both AMC and the PN posed challenges in 2025, which limited the extent of treatment installation that could occur. Having hired both summer intern positions for AMC and rehired Forest Technician positions at PN, there is a more robust field crew available to move into the summer 2026 season.

Plans for 2026

Two seasonal interns have been hired to work on this project through AMC in the summer field season of 2026. Both are forestry students from the University of Maine and will be located on AMC property while providing technical assistance on both AMC land and PN land. Interns will start mid-to-late May 2026. Post-treatment data collection will take place on the four blocks that were pre-commercially treated in August 2025. Commercial beech sanitation will take place on eight blocks in 2026 (4 on AMC and 4 on PN land) with industrial equipment to mimic patch harvests of American beech. Installation of research plots in the second forest type will take place in 2026. Site selection of the younger, more recently harvested hardwood stands will take place in the spring of 2026. Fixed radius plots will be installed and measured in the early summer and precommercial treatments will take place in August and September of 2026. Treatments will include pre-commercial thinning of northern hardwoods, selective beech cleaning to release more desirable species, and beech sanitation cleanings. Post-treatment measurements will take place in 2027.



Figure 55. AMC Forest Manager and AMC Forestry Intern hired for NSRC project inspecting potential sites for treatment in the summer of 2025. Photo Credit: USFS

Collaboration or Alignment with USFS, Partners, or the Public

Collaboration on the project has included meetings, consultations, and site visits with Dr. Laura Kenefic of the US Forest Service and partnership with Ben Stevens and Chuck Loring of the PN. Other partners have included Dr. Nicole Rogers of the Maine Forest Service, consultation from Huber Resources Corporation, and the University of Maine School of Forest Resources and Cooperative Forest Research Unit. Site visits were held on AMC and PN lands with Dr. Kenefic to guide research objectives and project design. Additional staff support was provided by the USFS with seasonal crew support for data collection.

Products

- Killea, F. (2025). *Managing for compositional diversity in American-beech dominated stands: a tribal collaboration* [Poster presentation]. Northern Hardwoods Conference, Syracuse, NY. <https://docs.google.com/document/d/16foFjBk6h1qUAj0v-nKIcObWPOSR8IxZ/edit>

The Northeastern States Research Cooperative operates through funding from the United States Congress made available by the USDA Forest Service. The conclusions and opinions in this paper are those of the authors and not of the Forest Service or USDA.

Non-Discrimination Statement: In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotope, American Sign Language, etc.) should contact the State or local Agency that administers the program or contact USDA through the Telecommunications Relay Service at 711 (voice and TTY). Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at [How to File a Program Discrimination Complaint](#) and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Mail Stop 9410, Washington, D.C. 20250-9410; (2) fax: (202) 690-7442; or (3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.