



**Northeastern States Research Cooperative (NSRC) FY2024  
USDA FS Award #: 24-DG-11242311-081**

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

**Table of Contents**

<b>Administration and Information Transfer</b> .....	<b>2</b>
<i>Summary of Progress</i> .....	2
<i>Collaboration with USDA Forest Service</i> .....	5
<i>Next Reporting Period</i> .....	5
<i>Products</i> .....	5
<b>Ongoing Research Projects</b> .....	<b>7</b>
<i>Investigating the Decoupling of Overstory and Understory Trees and Drivers of Forest Regeneration Dynamics in the Northern Forest</i> .....	7
<i>Restoration and Climate Adaptation Potential of Red Spruce in Northern Forests</i> .....	10
<i>Sustaining Basketmaking in Waponahkik through Increased Accessibility, Processing, and Storage Opportunities</i> .....	13
<i>Integrating Ecology and Economy: A Spatial Optimization Framework for Spruce Budworm (SBW)</i> .....	16
<i>Quantifying Forest Carbon Pools and Fluxes Following Partial Harvest in Northern Conifer Forests</i> .....	18
<i>WaYS to Utilize Indigenous Knowledge and Technology</i> .....	20
<i>Eco-Friendly Packaging Innovations – Developing Biocomposites from Nanocellulose, Polyhydroxybutyrate, and Lignin Obtained from Forest Biomass</i> .....	22
<i>Restoration of Culturally and Ecologically Significant Forest Understory Vascular Plants in Haudenosaunee Homelands - Building a Model for Broader Forest Resiliency in the Northeast</i> .....	24
<i>Power in the Patchwork? Summertime Patch-Cutting to Create Diverse and Resilient Uneven-Aged Northern Hardwood Forests</i> .....	25
<i>Trialing Best Management Practices for Preserving or Extending Frozen Ground Condition</i> .....	29
<i>Just How Hard is it Raining?</i> .....	31

<i>Forest Management at the Frontline: Silviculture and Belowground Ecology Foster Eastern Hemlock Vigor and Mediate Responses to an Imminent Invasion of Adelges tsugae</i> .....	33
<i>Forest Stewards Apprenticeship: Bridging Indigenous Knowledge, Research, and Forest Stewardship with the Penobscot Nation</i> .....	35
<i>Next-Generation Wood Products Carbon Estimator: A Tool for Comprehensive Stakeholder Collaboration and Decision-Making</i> .....	38
<i>Climate-Smart Retention in Managed Forest Landscapes</i> .....	41

## 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 funded research 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](http://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 research and Indigenous Forest Knowledge Fund (IFKF) projects.
- Organized a special session at the 2025 Forest Ecosystem Monitoring Cooperative conference in Burlington, Vermont, highlighting research from NSRC 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

Objectives and tasks described in the NSRC 2024 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** RFP was released in 2024, with proposals due in February 2025. The RFP received 50 research project proposals requesting \$11 million in funding. External technical reviews and a full proposal review panel were completed in February – May 2025. 11 projects were awarded totaling over \$1.9 million in federal funding and \$821,000 in matching funds.<sup>1</sup> Decisions on funding were released in May 2025.
  - **The IFKF** RFP was released in May 2025, with proposals due in August 2025. The RFP received 10 proposals requesting \$4 million in funding. A subcommittee of NSRC partners, including tribal members, reviewed the proposals. \$1.4 million in funding<sup>2</sup> was awarded to four projects, with \$193,000 in matching funds. Decisions on funding were released in September 2025.
- Research projects 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.**

- Subawards were made to funded research projects in summer 2025. Funded IFKF projects were issued subawards in fall 2025.
- Annual technical and financial reporting—Ongoing.
- Research outputs, to include scholarly and public-facing publications and activities—Ongoing. This award supported the development of a scholarly article, a presentation, and 6 other communications materials during this reporting period (see “Products” below). Additionally, these research projects supported at least 8 graduate students and 6 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—During the reporting period, this award supported a special session at the FEMC conference, print publications, press releases, and project specific communications materials.
- NSRC website with current list of projects, research outputs—Ongoing. During this reporting period, the website underwent a complete redesign and refresh.
- Engagement with partners and the public—Ongoing. Key partners include the USFS, the universities in the Northern Forest, and members of the EAC.

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<sup>1</sup> This award total includes a project split between two awards (FY23 and FY24). All deliverables and progress updates are found within the FY24 report.

<sup>2</sup> This award total includes an IFKF project selected during the FY23 RFP but funded with the FY24 award.

Table 1: Regional Research and Indigenous Forest Knowledge Fund projects funded through NSRC 2024 (24-DG-11242311-081)

PI / Institution	Lead Institution	Project Title	Project Status
<b>General Fund NSRC 2024 Research Projects</b>			
Bevilacqua, Eddie	SUNY-ESF	Decoupling forest dynamics using overstory: understory similarity indices	Ongoing
Clark, Peter	University of Vermont	Restoration and climate adaption potential of red spruce in the Northern Forests	*Ongoing
Daigneault, Adam	University of Maine	Integrating ecology and economy: a spatial optimization framework for spruce budworm (SBW) management	Ongoing
Fraver, Shawn	University of Maine	Quantifying forest carbon pools and fluxes following partial harvest in northern conifer forests	Ongoing
Kumar, Deepak	SUNY-ESF	Eco-friendly packaging innovations – developing biocomposites from nanocellulose, polyhydroxybutyrate, and lignin obtained from forest biomass	Ongoing
McNulty, Stacey	SUNY-ESF	Strategies for balancing biodiversity and forest resilience	Ongoing
Roberge, Steven	University of New Hampshire	Trialing Best Management Practices for Preserving or Extending Frozen Ground Conditions during Winter Harvesting Operations.	Ongoing
Shanley, James	USGS	Just how hard is it raining?	Ongoing
Smemo, Kurt	Skidmore	Forest management at the frontline: silviculture and belowground ecology drive responses to an imminent invasion of <i>Adelges tsugae</i>	Ongoing
Wei, Xinyuan	University of Maine	Next-generation wood products carbon estimator: a tool for comprehensive stakeholder collaboration and decision-making	Ongoing
Whitman, Andrew	Maine Timber Research & Environmental Education Foundation	Climate-smart structural retention for biodiversity for managed forest landscapes in the Northern Forest Region	**Ongoing
<b>NSRC 2024 Indigenous Forest Knowledge Fund (IFKF) Projects</b>			
Daigle, John	University of Maine	Sustaining basketmaking in Waponahkik through increased accessibility, processing, and storage opportunities	Ongoing
Galipeau, Jennifer	Wabanaki Youth in Science	WaYS to Utilize Indigenous Knowledge and Technology	**Ongoing
McGee, Gregory	SUNY-ESF	Restoration of culturally and ecologically significant forest understory vascular plants in Haudenosaunee Homelands—Building a better model for broader forest resiliency in the Northeast	Ongoing

Swanick, Rachel	Forest Stewards Guild	Forest Stewards Apprenticeship: Bridging Indigenous Knowledge, Research, and Forest Stewardship with the Penobscot Nation	Ongoing
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\* Indicates the project was split between two awards (FY23 and FY24). All deliverables and progress updates are found within the FY23 report.

\*\*Indicates the award was selected during the FY23 Request for Proposals (RFP), but due to changes in the PIs' employment, project onset was delayed. After ensuring that the recipient organizations had appropriate expertise and resources to carry out the original scopes of work, projects were shifted to the FY24 award, to allow sufficient time for high priority research and IFKF activities to occur.

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

## Products

### Scholarly Articles

1. Wei, X., Hayes, D., McHale, G., Zhao, J., Weiskittel, A., & Daigneault, A. (2025). PyFIA: analyzing and visualizing forest attributes using the United States Forest Inventory and Analysis database. *Carbon Balance and Management*. <https://link.springer.com/article/10.1186/s13021-025-00364-7>

### Conferences and Presentations

2. Tamasy, A. (2025). Power in the Patchwork? [Poster presentation] 2025 Forest Ecosystem Monitoring Cooperative conference. (McNulty)

### Other Products

1. [Next-generation Wood Products Carbon Estimator](#) (Wei)
2. [Social media post 02/13/2026](#) (Swanwick)
3. Maine Woodland Owners newsletter article by Ella McDonald (Daigle)
4. Ash Protection Collaboration Across Waponahkik [blog post](#) about the Odanak trip by Lauren Gonzalez (Daigle)
5. Sustaining Basketmaking Project information sheet (Daigle)
6. Cultural Access Invitation information sheet (Daigle)



## Ongoing Research Projects

### Investigating the Decoupling of Overstory and Understory Trees and Drivers of Forest Regeneration Dynamics in the Northern Forest

**Principal Investigator:** Eddie Bevilacqua (SUNY-ESF, [ebevilacqua@esf.edu](mailto:ebevilacqua@esf.edu))

#### Summary of Progress in 2025

In the first five months of this project, a graduate student, Joshua Ogunyemi, was hired to begin the process of downloading, filtering, and cleaning the Forest Inventory and Analysis (FIA) data for forested subplots from the northeastern United States (New York, Vermont, New Hampshire and Maine). Using the rFIA R package, this required the extraction of the required FIA tables (TREES, PLOT, SEEDLING, and COND) for the analysis across the years 2000 to 2024. Existing plot coordinates were used to generate the subplot coordinates with the goal of computing overstory-understory similarity at both the plot and subplot levels using six indices which include Jaccard, Sorensen, Kulczynski, Bray-Curtis, Canberra, and Morisita-Horn. These indices are designed to capture measures of  $\beta$ -diversity at individual subplot locations. Different indices allow us to gain proper perspective on regeneration dynamics using both presence-absence and abundance-based indices. As measurements from individual plots are collected in different panels and remeasured at slightly different time intervals, inventory years were binned into three periods to quantify relatively consistent temporal changes in similarity at the subplot level. Exploratory data analyses were initiated by first evaluating correlations among indices, and visualizing differences in the distributions of indices among states, time periods, and forest types. Preliminary analysis of spatial patterns was conducted using the combined ability of both R and ArcGIS Pro to evaluate spatial heterogeneity and clustering using point-based spatial analysis methods. Data from these milestones will serve as a foundation for subsequent analysis and modelling tasks.

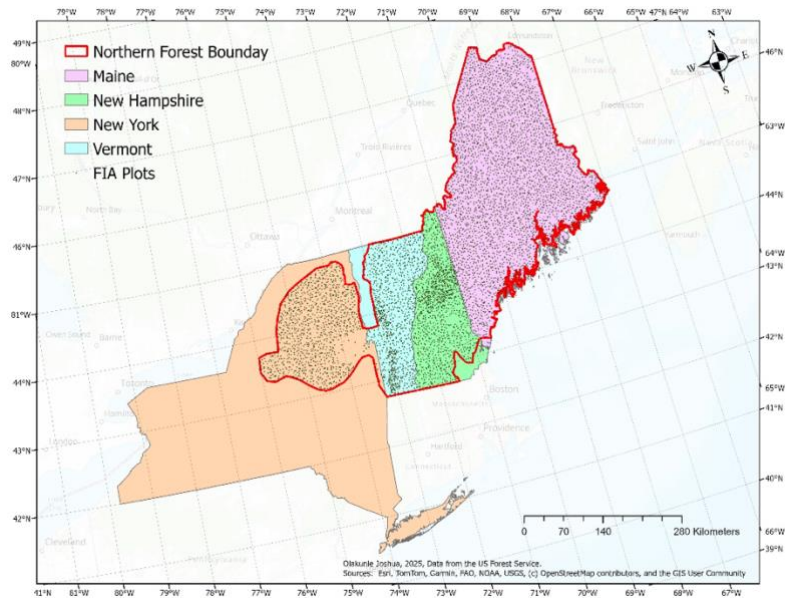


Figure 1. Map showing spatial distribution of forested FIA plots used in analysis.

#### Collaboration or Alignment with USFS, Partners, or the Public

This ongoing research aligned closely with the mission of the U.S. Forest Service (USFS) especially the one focusing on developing and providing scientific and technical knowledge aimed at improving our capability to protect, manage, and use forests and rangelands. More importantly, through extensive use of the FIA program as all analyses are based on FIA data

products and sampling protocols, that ensures methodological consistency with USFS standards for forest monitoring, assessment, and reporting. Joshua has been receiving support from Andrew Lister, Research Forester at USDA Forest Service, regarding details on the data within the FIA data tables. The use of the rFIA R package directly supports reproducible and transparent engagement with FIA datasets and facilitates integration of results with other datasets. While the project is independently conducted, it complements ongoing USFS priorities related to forest regeneration, compositional change, and long-term forest resilience under climate and disturbance pressures. The project also aligns with broader scientific and public interests by emphasizing open-source tools, reproducible workflows, and transparent methods. All data processing and analysis are conducted using publicly available FIA datasets and the R opensource software, enabling potential reuse by researchers, land managers, and educators. Preliminary findings from this work have already been disseminated at the NY SAF Annual Meeting.

*Table 2. Number of FIA forested plots and subplots by state and temporal period.*

<b>State</b>	<b>Year Period</b>	<b>FIA Forested plots</b>	<b>Forested subplots</b>
ME (23)	Period 1 (2006 - 2014)	2960	18252
ME (23)	Period 2 (2015 - 2019)	2865	10058
ME (23)	Period 3 (2020 - 2024)	2835	10068
NH (33)	Period 1 (2006 - 2014)	910	5027
NH (33)	Period 2 (2015 - 2019)	709	2528
NH (33)	Period 3 (2020 - 2024)	645	2286
NY (36)	Period 1 (2006 - 2014)	922	5524
NY (36)	Period 2 (2015 - 2019)	597	2150
NY (36)	Period 3 (2020 - 2024)	585	2107
VT (50)	Period 1 (2006 - 2014)	821	4902
VT (50)	Period 2 (2015 - 2019)	588	2052
VT (50)	Period 3 (2020 - 2024)	558	1933

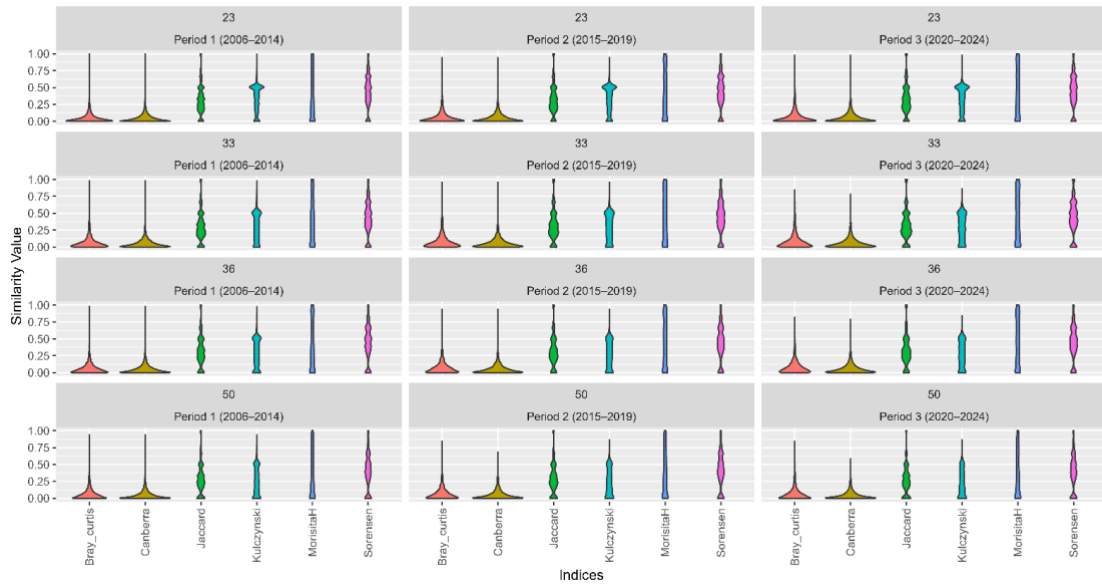


Figure 2. Map showing spatial distribution of forested FIA plots used in analysis.

# Restoration and Climate Adaptation Potential of Red Spruce in Northern Forests

**Principal Investigator:** Peter Clark (University of Vermont, peter.clark@uvm.edu)

## Summary of Progress in 2025

In 2025 progress was made toward project objectives by advancing both knowledge transfer to practitioners and capacity for new red spruce research. First, the *Reforestation Guide: Tree Planting to Enrich, Restore, and Adapt Northern Forests* was published. The guide has been well received: over 1,600 hard copies have been mailed and freely distributed among individual landowners and foresters (1–2 guides requested) as well as larger organizations and agencies (dozens or hundreds requested), the online PDF has been downloaded extensively (see links below), and >700 individuals have participated in [a series of 1-hour webinars](#) and discussions. Second, two M.S. students were recruited to support this work using leveraged cost-share commitments from UVM’s Rubenstein School for Environment and Natural Resources (RSEN). The initial focus of these students will be on installing, maintaining, and monitoring field trials and elevating and expanding the existing red spruce research. Third, the experimental network was expanded by securing partnerships with four research sites in 2025 (in Vermont, New Hampshire, and Maine, on federal, non-profit, and private lands) as well as relationships for four new sites scheduled for 2026 (in Vermont and New Hampshire, on state, non-profit, and private lands) to evaluate red spruce performance across various silvicultural systems, ecological conditions, and climates. Land was secured at the UVM Wolcott Research Forest to establish a long-term provenance trial, enabling high-resolution repeated measures over years to decades. Lastly, the growth and survival of many thousand red spruce plantings was monitored throughout the regional network, including the oldest installations, an 8-year-old mixed species experiment as part of the Adaptive Silviculture for Climate Change project.

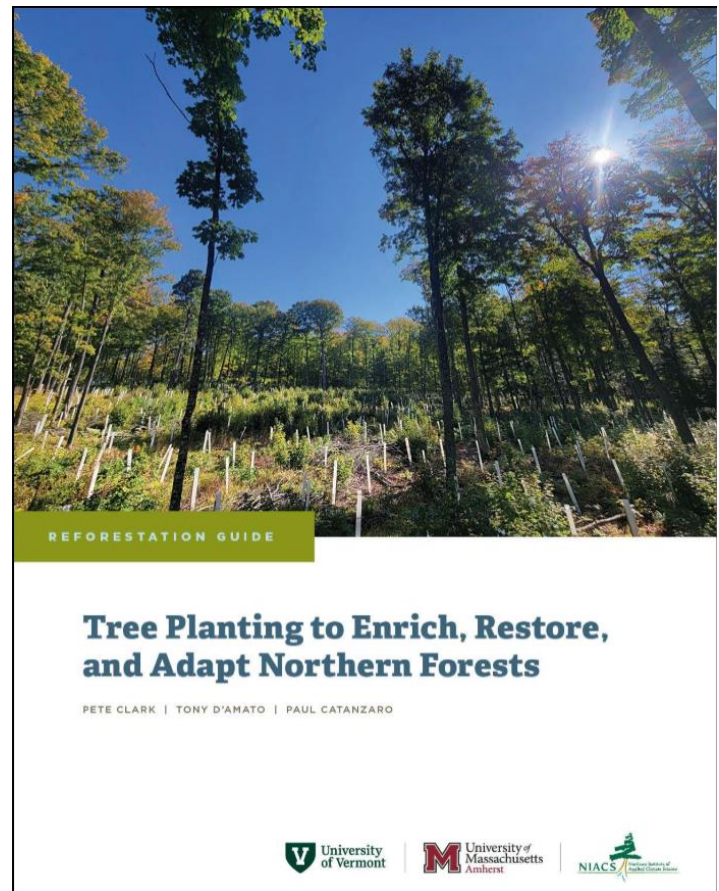


Figure 3. Cover art for the published *Reforestation Guide*.

## Problems or Changes

Due to internal administrative delays related to splitting the initial grant into two projects (at the request of NSRC), funds have been delayed. Despite the delay, this will not negatively affect how these funds will be used and allocated to achieve project goals and deliverables

## Plans for 2026

In 2026, two newly hired M.S. students will begin work (April 2026). Their work will focus on establishing, maintaining, and monitoring the network of red spruce research sites. Additionally, they will focus on graduate level tasks such as their research proposal development and project management (e.g., DNA extractions, refining measurement protocols, coordinating logistics, and early data analysis). Project progress and lessons learned will be shared with practitioners and partners by presenting at the New England Society of American Foresters (NESAF) meeting and the Forest Ecosystem Monitoring Cooperative (FEMC) annual meeting. These venues will help broaden feedback, identify co-production opportunities, and strengthen regional coordination. Building from connections made through these conferences, engagement will be expanded through a newly formed *Resilient Reforestation* working group. This group will convene collaborators from federal (USFS, USFWS, NIACS, RNGR), state (VT FPR), non-profit (TNC, VLT), and private (Intervale Nursery, Redstart Forestry, Weyerhaeuser) to develop strategies for scaling climate- and ecologically informed reforestation, including identifying needs and pathways to increase nursery capacity and seedling supply to meet regional adaptation and restoration goals.

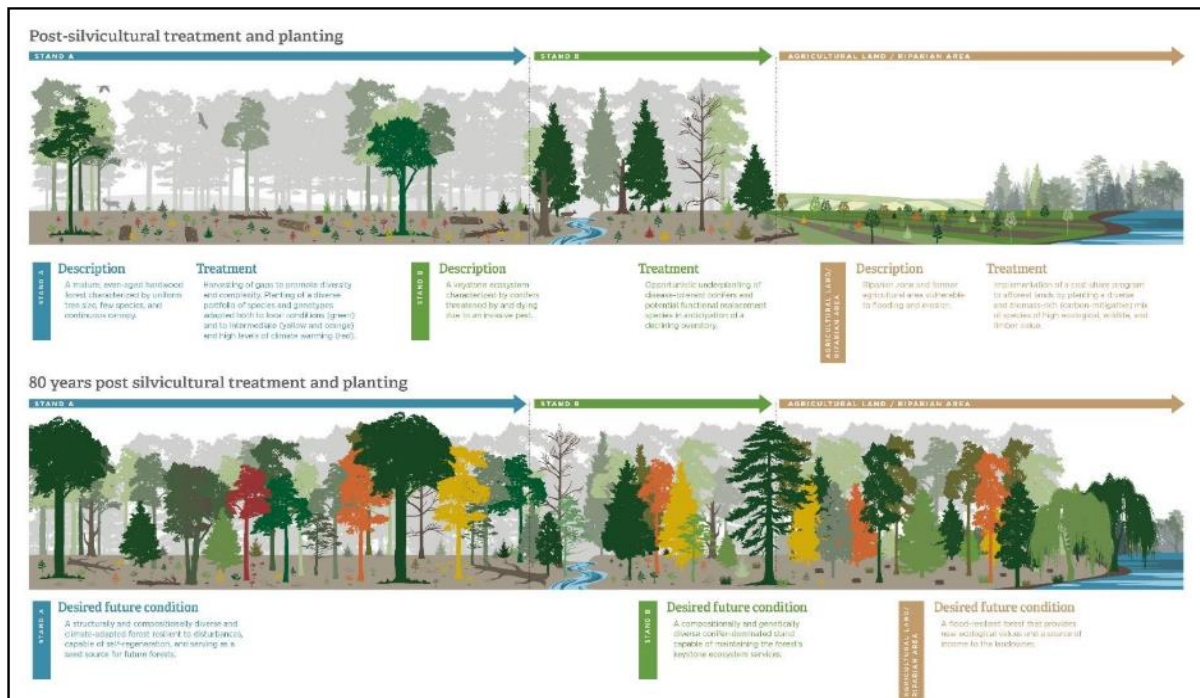


Figure 4. Example of original graphics designed as part of the Reforestation Guide. Here, a hypothetical property illustrating various stands is managed using tree planting to achieve different desired future conditions.

## Alignment or Collaboration with USFS, Partners, or the Public

The project is aligned with and supported by collaborations across USFS, state agencies, non-profit organizations, academic, private, and other agencies. To date, the Reforestation Guide has been central to this engagement. For instance, the guide was reviewed by 10 external experts, including 4 USFS employees, 4 state agency staff (New Hampshire, New York, Minnesota, Wisconsin), 2 private-sector practitioners, and 1 academic reviewer. This review process strengthened both scientific and operational relevance. The guide also includes five case studies that ground recommendations in real-world implementation. These case studies were co-written and developed with partners representing a diversity of land stewardship perspectives, including Tribal members (the Stockbridge-Munsee Community), nonprofit organizations (The Nature Conservancy, Vermont Land Trust, Great Lakes Land Trust), and private-sector collaborators. To broaden public and practitioner engagement, webinars and presentations were hosted by multiple partner networks and agencies, including: (1) the USDA Northern Institute for Applied Climate Science (NIACS) (approx. 40 attendees), (2) the Massachusetts Ecosystem Climate Adaptation Network Forest Work Group (in partnership with UVM, TNC, and NIACS), an event that was available for SAF CFE credit (approx. 500 attendees); (3) the New York State Parks Division of Stewardship and Planning monthly biology meeting (approx. 100 attendees); and (4) the USFS Region 9 Climate Change Coordinators quarterly meeting, which includes unit-level forest planners, silviculturists, and NEPA specialists (approx. 60 attendees). Finally, two USFS employees, Dr. Carrie Pike and Maria Janowiak, are key collaborators in this work and are maximizing synergy between outputs of this project and larger USFS goals around reforestation.



Figure 5. An 8-year-old mixed-species planting including red spruce was remeasured in October 2025 as part of the Adaptive Silviculture for Climate Change project.

## Products

- Clark, P. W., D'Amato, A. W., & Catanzaro, P. F. (2025). Reforestation guide: Tree planting to enrich, restore, and adapt northern forests. University of Massachusetts Extension, <https://masswoods.org/planting>
- Clark, P., & D'Amato, A. (2025). *Tree planting best practices in the Northeast* [Video]. [YouTube](#).
- Several newsletters were sent out via internal and external-partner listservs to share information and links about the Guide and associated webinars. >10,000 email addresses were contacted regarding this information. [This newsletter was sent to over 4,000 recipients.](#)

# Sustaining Basketmaking in Waponahkik through Increased Accessibility, Processing, and Storage Opportunities

**Principal Investigator:** John Daigle (University of Maine, Orono, [jdaigle@maine.edu](mailto:jdaigle@maine.edu))

## Summary of Progress in 2025

All project Tribal Nation, organizational, and individual partners were notified of the award. In November, the first meeting of project partners was convened, and monthly meetings have continued to support project execution. As of March 2026, four research team meetings have been held. Additional team-building activities have also occurred outside these meetings, including travel to a brown ash stand with Gabe Frey to observe tree selection and harvesting practices. Instruction on processing ash into splints was also conducted on Indian Island.

Collaboration with Wabanaki Youth in Science (WaYS) has been ongoing to develop recruitment materials and hire a WaYS intern. Seven applications were received for the intern position, and interviews were conducted. During the first week of March 2026, an offer was extended to the top candidate, who accepted and plans to begin work in April 2026. Duties for the position include evaluating brown ash sites for basket-quality characteristics and assisting with coordination of ash-protection events in Tribal communities.

The PhD student lead, Ella McDonald, completed and submitted an IRB application to conduct interviews during summer site visits on issues related to access, processing ash, and storage.

Through webinars and educational efforts with landowner outreach nonprofits, Ms. McDonald has secured 17 invitations for cultural harvest on private land across Maine. Additional connections have been established with Tribal community members in Maine, New York, and New Brunswick who have expressed interest in supporting processing and storage initiatives.

## Problems or Changes

Although grant identification for the creation of a mobile pounder prototype remains underway, progress in securing a partner able to complete the work at a reasonable cost has been slow. Several potential engineering partners and funders are currently being pursued; however, this activity may need to be postponed to the second year of the project. In the interim, plans are in place to visit existing pounding machines in Akwesasne and New Brunswick in the Fall and to conduct interviews with basketmakers regarding preferences for such equipment during these visits. Information gathered through these interviews will guide future funding applications.



*Figure 6. Members of the research team including Gabe Frey and PhD student Ella McDonald harvesting and carrying brown ash in Mt. Vernon, Maine.*



Figure 7. Members of the research team learning how to process ash: Two WaYS staff and Gabe Frey.

## Plans for 2026

To increase Wabanaki access to sites where they can harvest brown ash, Ms. McDonald is working with Dr. Suzanne Greenlaw to create a Wabanaki Data Trust where harvesters can visualize site data from 17+ cultural access parcels. Interviews will be held with basketmakers about how to make sure the distribution of these access invitations is equitable. At least ten site visits in 2026 will be held, and Ms. McDonald will interview at least one basketmaker at each of these sites. The WaYS intern will help coordinate and join these visits to learn from experienced basketmakers.

To advance the second goal of understanding community preferences around brown ash processing technology, two trips will be organized out of Maine (Akwesasne and Wolastoqey territory), and one within Maine to Indian Island, in 2026 to visit with the owners of three ash pounding machines. Basketmaker travel will be funded and supported by this project.

To advance the third goal of planning for long-term ash storage, a webinar series will be hosted featuring Indigenous people who have experimented with ash material storage. The first will be held with Mike Benedict (Saint Regis Mohawk Tribe) in May 2026 and a second in September 2026 with Richard Silliboy (Mi'kmaq Nation). All Tribal Nation partners from Wabanaki Tribal and First Nations, and well as Tribal Nations in NY will be invited to attend and exchange learning about storage. Knowledge gained through these webinar discussions will inform future ash storage experiments.



Figure 8. Basketmaker Richard Silliboy demonstrating his ash pounding machine for research team members.

## Collaboration or Alignment with USFS, Partners, or the Public

Holding hybrid meetings with project partners on a monthly basis, including WaYS staff, basketmakers, and researchers, has kept the collaboration moving. This core collaboration has helped identify mobile pounders and contact their owners, identify people who are experienced in ash material storage, and build a list

of basketmakers in Maine who are potential research participants. The core project team has been keeping our Tribal Nations partners updated via email; there is a plan to have a meeting to present plans to Tribal Natural resource staff members soon. Connections are being made with other Wabanaki-led nonprofits to distribute ash access invitations, such as Niweskok and Wabanaki Public Health and Wellness who have expressed interest in the project. Maine Woodland Owners, Rural Aspirations, and Maine Organic Farmers and Gardeners Association have given the team platforms via webinars, events, and newsletters to talk about the importance of cultural access to ash and solicit invitations for harvesting.

Outside of Maine, collaborations have been ongoing with the Saint Regis Mohawk Tribe to develop a brown ash harvest plan for material storage experiments conducted in partnership with the USFS. Results from this experiment will inform the planning of log storage efforts in Waponahkik. In October, members of the research team travelled to Odanak to present about Ash Protection Collaboration Across Waponahkik (APCAW) and the goals of this project and made connections with basketmakers in the community. Lauren Gonzalez, a postdoctoral scholar involved in this project, also presented at the Canadian Forest Pest Conference in November

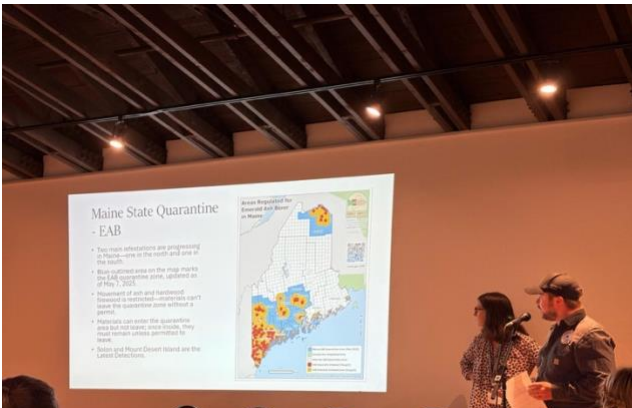


Figure 9. PhD students Tyler Everett and Ella McDonald presenting at Odanak about APCA's sustaining basketmaking project.



Figure 10. John Daigle presenting about APCA's sustaining basketmaking project at the Forest Ecosystem Monitoring Cooperative meeting held at the University of Vermont, Burlington

2025 about our efforts to sustain basketmaking in Waponahkik. In November, John Daigle made connections with state agencies and conversation organizations in Vermont and discussed efforts on ash protection efforts and he presented on sustaining basketmaking in Waponahkik as part of an organized NSRC session at the Forest Ecosystem Monitoring Cooperative in Burlington, Vermont.

## Products

Maine Woodland Owners newsletter article by Ella McDonald (page 10–11)

[Ash Protection Collaboration Across Waponahkik blog post about the Odanak trip by Lauren Gonzalez:](#)

Sustaining Basketmaking Project information sheet

Cultural Access Invitation information sheet

# Integrating Ecology and Economy: A Spatial Optimization Framework for Spruce Budworm (SBW)

**Principal Investigator:** Adam Daigneault (University of Maine, adam.daigneault@maine.edu)

## Summary of Progress in 2025

The first year of the project was dedicated to reviewing the literature on spruce budworm (SBW) impacts and management in the northeast United States and eastern Canada, collecting data on the costs and benefits of spruce budworm management, and developing a prototype SBW Benefit–Cost Calculator (see images below) that will be made publicly available and accessible online. A graduate student was also recruited to join the project; Naresh Khanal began work as a research assistant in January 2026 and will examine the socio-economics of SBW impacts and management, with particular emphasis on financial and community-level outcomes under varying severity and intervention scenarios

## Plans for 2026

Data collection and calibration of the growth and yield functions for the decision support tool are already underway. Work in 2026 will center on data integration, tool development, testing, and stakeholder engagement. The objective is to produce an operational tool that integrates the core optimization model and LANDIS-II growth outputs with cost-revenue subroutines. Development will also begin on the spatial spillover function designed to capture SBW spread dynamics. Initial management scenarios will be created to compare baseline (no action), spraying-only, and salvage-only strategies across multiple outbreak severities, generating preliminary outputs for timber volumes, net present value, and carbon stocks. Early results will be shared with project collaborators to obtain feedback on cost parameters, operational feasibility, model assumptions, and the tool interface. This validation loop will guide refinements to harvest scheduling constraints, salvage capacity estimates, and discount rates. After, sensitivity analyses will be conducted to assess the stability of optimal solutions under varying spray costs, carbon prices, and discount rates. Results will guide advanced scenario modeling incorporating combined strategies and thinning treatments.

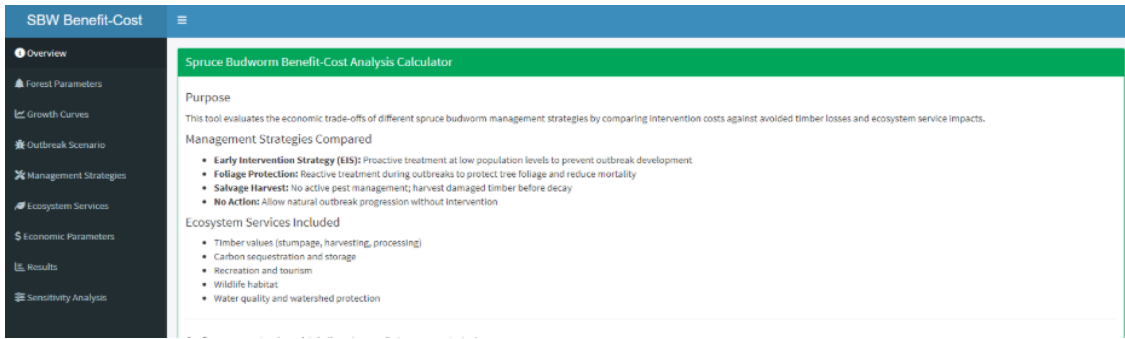


Figure 13. Overview page of the Spruce Budworm Benefit-Cost Analysis Calculator

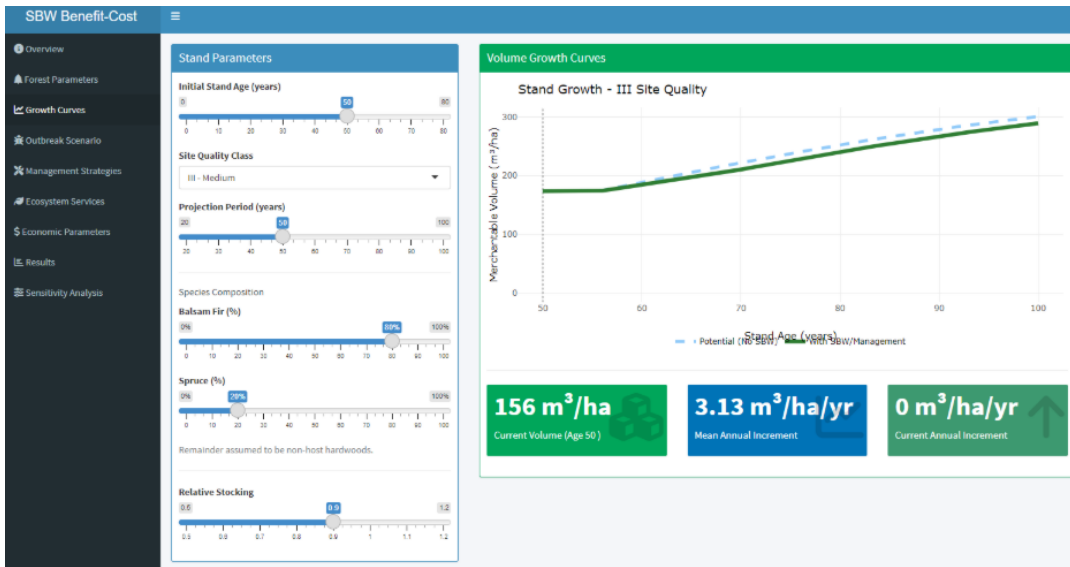


Figure 12. Growth and yield module of the Spruce Budworm Benefit-Cost Analysis Calculator

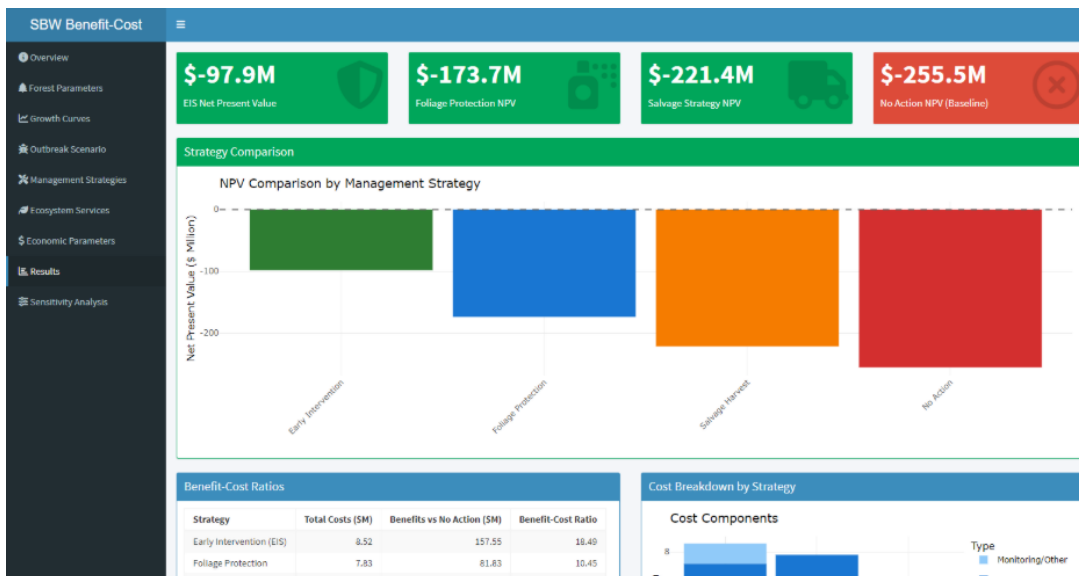


Figure 11. Illustrative results from example scenario in Spruce Budworm Benefit-Cost Analysis Calculator

# Quantifying Forest Carbon Pools and Fluxes Following Partial Harvest in Northern Conifer Forests

**Principal Investigator:** Shawn Fraver (University of Maine, shawn.fraver@maine.edu)

## Summary of Progress in 2025

The summer 2025 field season was productive. As proposed, inventories of overstory trees (living and dead), saplings, coarse woody debris, and fine woody debris were conducted on recently established plots surrounding Howland’s East tower prior to the harvest. The harvest was completed in October 2025. These data have been entered, proofed, and data-checked. Three rounds of soil CO<sub>2</sub> flux have been collected from both the East tower and the Main tower (the unharvested control site). We also collected and processed soil samples, pre-harvest, which are now being analyzed for macronutrients. Importantly, we collected terrestrial laser scanning (TLS) forest-structure data, prior to harvest, from the forest surrounding the East tower; these provide detailed structural information to which the post-harvest TLS data from the same locations will be compared. The University of Maine graduate student dedicated to this project (Max Wegner, funded through a NASA grant) has been actively involved in this work.

## Plans for 2026

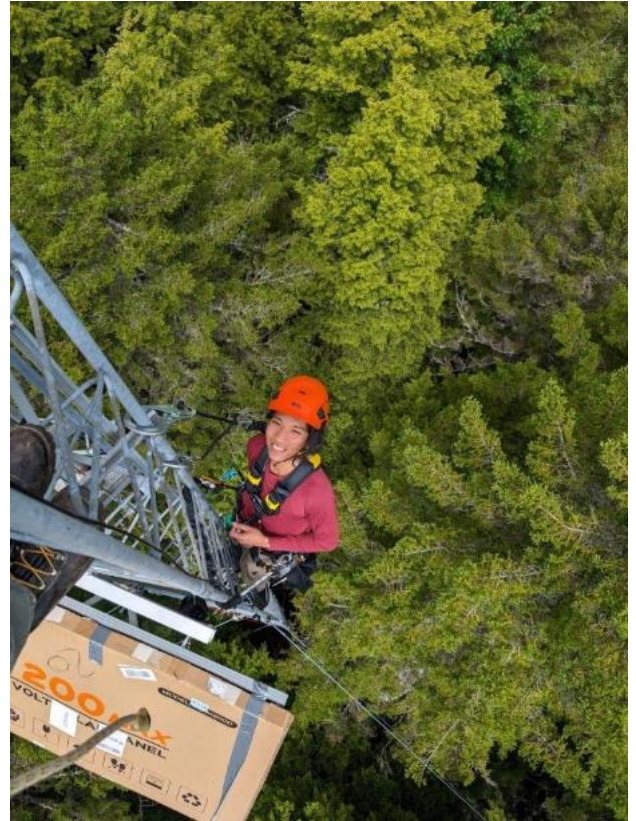
In 2026, forest inventories, soil sampling, and TLS acquisition described above will be repeated for the East tower site, this time post-harvest. TLS forest-structure data from the Main tower site (unharvested control) will be collected for comparison. CO<sub>2</sub> flux sampling will be intensified—both at the East and Main tower sites—now including fluxes from soil, coarse woody debris, and cut stumps. Each of these substrates will have at least 10 replicates at each tower site, and at each of these substrate locations, sensors will be installed to continuously record soil moisture, air temperature, and relative humidity. An additional University of Maine graduate student (Marleyla Wiltz, funded through the Maine Agricultural and Forest Experiment Station) will join the research team at this time. Simulation modelling of carbon storage dynamics (employing the Community Land Model) for both the harvested and control sites will begin in fall 2026, based on the inventory data that will be finalized by that time. This modelling approach will allow the project team to assess the short- and long-term consequences of carbon reduction from harvesting within this ecosystem.

## Collaboration or Alignment with USFS, Partners, or the Public

This project is conducted in collaboration with Dr. Andrew Ouimette, U.S. Forest Service, Northern Research Station, and forest managers from American Forest Management (AFM). The project directly aligns with the U.S. Forest Service’s and AFM’s goals related to sustainable forest management.



*Figure 15. Technicians Cory Johnston and Logan Quinn collecting soil samples from Howland Forest's main tower site.*



*Figure 14. Howland Forest Site Manager Roel Ruzol installing new solar panels on Howland's East tower prior to harvest.*

## WaYS to Utilize Indigenous Knowledge and Technology

Principal Investigator: Jennifer Galipeau (Wabanaki Youth in Science, [jalipeau@wabanakiyouthinscience.org](mailto:jalipeau@wabanakiyouthinscience.org))

### Summary of Progress in 2025

During 2025, Wabanaki Youth in Science (WaYS) initiated implementation of this multi-year award starting in September 2025 by establishing the governance, staffing, and technical infrastructure necessary to integrate drone technology into our Indigenous-led environmental monitoring forestry program. Foundational activities included structured FAA Part 107 preparation, regulatory review, and safety training. Staff are now prepared to schedule certification examinations. WaYS drafted a formal Drone Use Policy and developed detailed Standard Operating Procedures (SOPs) addressing flight planning, equipment maintenance, airspace compliance, data management, privacy protections, and risk mitigation.

Planning meetings ensured the drone program aligns with Tribal land stewardship priorities, forest health monitoring objectives, and youth workforce development pathways. Drone programming is being intentionally grounded in Indigenous Knowledge systems and community-based environmental priorities. Governance structures emphasize Indigenous data sovereignty, ensuring that imagery, spatial datasets, and derivative products remain under WaYS stewardship, with controlled access, culturally informed use protocols, and safeguards for sensitive ecological or cultural information. Overall, 2025 focused on building durable infrastructure technical, administrative, and ethical to support expanded implementation beginning in 2026.

### Problems or Changes

No significant deviations from the original project scope have occurred. Implementation during 2025 emphasized foundational capacity-building more heavily than initially projected, prioritizing policy development, compliance readiness, and governance structures before initiating field deployment. This sequencing strengthens long-term sustainability and reduces operational risk. Minor timeline adjustments were made to allow sufficient time for FAA certification preparation, SOP drafting, and equipment calibration prior to live ecological monitoring flights.

### Plans for 2026

From January–December 2026, WaYS will transition from planning to applied implementation. Certified staff will conduct supervised test flights followed by operational drone missions supporting forest health monitoring, stewardship documentation, and ecological mapping across Wabanaki homelands. Drone-derived imagery will be incorporated into GIS workflows for canopy assessments.

The Drone SOP manual will be finalized based on field-based refinements. Data governance procedures, including storage protocols, access controls, metadata standards, and culturally informed review processes.

Planning meetings will continue to ensure alignment with Tribal leadership priorities and ecological stewardship goals. By the end of 2026, WaYS anticipates a fully operational, Indigenous-governed drone monitoring program supporting both technical workforce pathways

WaYS programming supports forest monitoring objectives relevant to the U.S. Forest Service (USFS), particularly in areas of forest health assessment, invasive species awareness, and long-term stewardship documentation. Drone-derived mapping will complement existing forestry and conservation efforts by providing high-resolution spatial data that can inform planning and restoration work.

The program also engages Tribal natural resource departments and community partners to ensure monitoring activities are locally relevant and responsive to Tribal priorities. Youth participants gain exposure to environmental careers while contributing to real-world stewardship initiatives.

By combining Indigenous Knowledge systems with modern geospatial tools, WaYS strengthens collaborative land stewardship and expands access to technical pathways within historically underserved communities. All collaboration is grounded in Indigenous governance principles, ensuring that externally aligned efforts remain accountable to Tribal priorities and community-defined outcomes.

# Eco-Friendly Packaging Innovations – Developing Biocomposites from Nanocellulose, Polyhydroxybutyrate, and Lignin Obtained from Forest Biomass

**Principal Investigator:** Deepak Kumar (State University of New York College of Environmental Science and Forestry, dkumar02@esf.edu)

## Summary of Progress in 2025

This project developed an integrated, multi-product biorefinery approach for valorizing sugar maple (*Acer saccharum*) forest residue biomass (FRB). Approximately 10 kg of biomass was collected, dried to <10% moisture, and milled to a 2 mm particle size. Chemical composition of raw FRB showed 42.7% glucan, 19.9% xylan, 23.4% lignin, 4.1% extractives, and 0.9% ash on a dry matter basis.

- *Task 1.1* has been completed and focused on hot water extraction (HWE) for hemicellulose recovery. HWE was conducted under varying temperature and time conditions, with the optimal condition identified at 180 °C for 0.5 h. Under these conditions, 56% xylan solubilization was achieved, producing a hydrolysate containing 21.5 g/L xylose with minimal inhibitor formation (furfural <1.5 g/L, 5-HMF <0.5 g/L, and acetic acid <6 g/L), making it suitable for downstream fermentation.
- In *Task 1.2*, 1,4-butanediol (BDO)-based organosolv delignification of HWE solids was performed at 195 °C for 1 h using a 7:3 (v/v) BDO:water ratio. This process removed 48.05% of lignin while retaining 98.77% of glucan in the pulp. Further experiments are ongoing to improve lignin recovery.
- As part of *Task 2*, the C5-rich hydrolysate was used for polyhydroxybutyrate (PHB) production without detoxification using recombinant *E. coli* LSBJ. At an initial sugar concentration of 10 g/L, 29.35% PHB content in cell biomass were achieved.
- In *Task 3*, the cellulose-rich pulp was converted to cellulose nanocrystals (CNCs) via sequential bleaching and acid hydrolysis, yielding 41.1% CNCs based on delignified pulp, with properties comparable to commercial-grade CNCs.

## Plans for 2026:

1. Investigate conditions for organosolv pretreatment for enhanced lignin removal and recovery.
2. Optimize fermentation to enhance xylose utilization and PHB productivity.
3. Production of CNC from delignified pulp.
4. Characterization of CNC, lignin, and PHB.
5. Synthesis of biocomposites.
6. Presentation of results at conferences and submission of manuscripts.

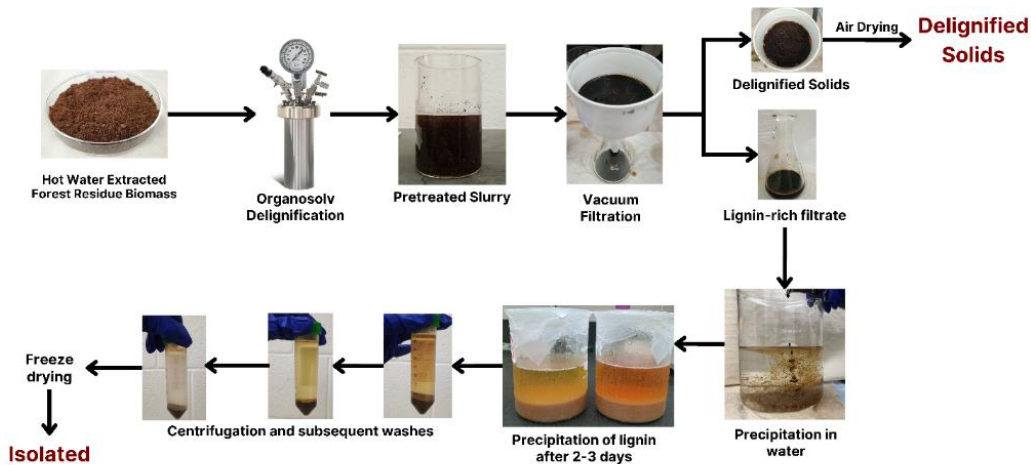


Figure 18. Process flow diagram of organosolv delignification process.

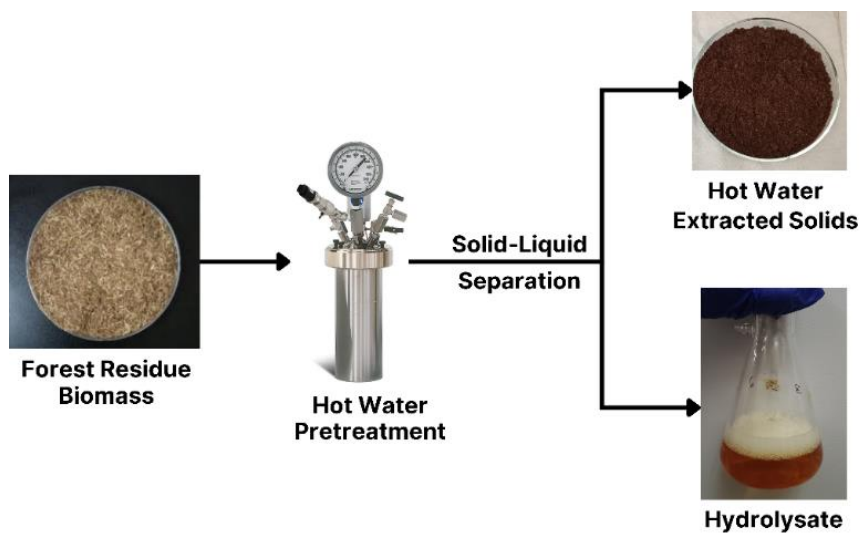


Figure 17. Hot water extraction process flow diagram

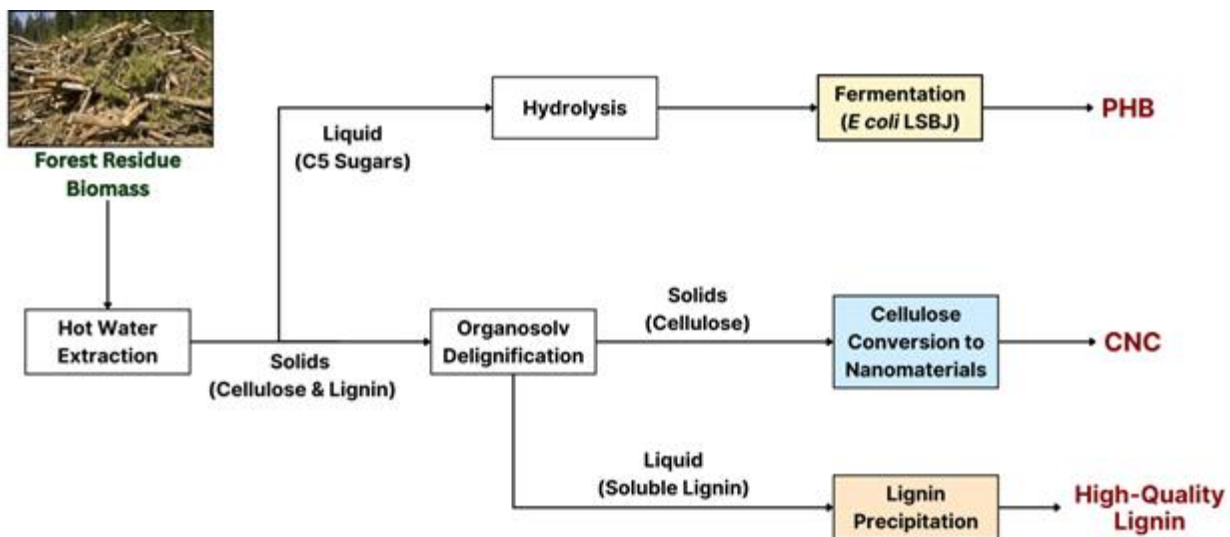


Figure 16. Process flow diagram of sequential fractionation strategy for forest residue biomass conversion to bioproducts

# Restoration of Culturally and Ecologically Significant Forest Understory Vascular Plants in Haudenosaunee Homelands - Building a Model for Broader Forest Resiliency in the Northeast

**Principal Investigator:** Gregory McGee (SUNY-ESF, ggmcee@esf.edu)

## Summary of Progress in 2025

The August 2025 proposal was accepted but only with substantial modifications to reduce the award amount. The subaward was fully executed on Feb. 6, 2026. No work was initiated until the subaward was executed.

- Beginning in February we began selection of study sites at Onondaga and at nearby NY State Forests and Central New York Land Trust properties.
- We have prepared invitations to teachers, resource managers and leaders across the Haudenosaunee nations to invite them to participate in the initiative. Informational meetings to introduce details of the initiative are being planned.
- We have recruited two graduate students who will receive partial funding on this project. One student matriculated in January 2026; the second will matriculate in August, 2026.

## Problems or Changes

The original proposal was not funded at the requested level. We adjusted the proposal budget by eliminating all summer salary for the PI, the co-PIs and salary support for staff, reducing the level of graduate student and undergraduate technician support, and reducing travel reimbursements, per diems, and consulting fees that would support travel and compensation for indigenous workshop participants. The scope of work has not changed.

## Plans for 2026

We will establish ten post-agricultural forest sites at which to carry out restoration trials. Restoration sites will consist of (deer-exclosed) ‘propagation gardens’ intended to establish long-term sources of seed/cuttings/divisions, and to monitor for local deer browse impacts. The sites will also include 1- to 2-ha focal areas on which we will co-develop and implement methods for restoration and long-term monitoring. Survival and reproductive status of out-planted material will be compared to deer-exclosed material to guide local decisions on necessary deer harvesting levels. These activities will inform the preparation of two MS theses.

## Collaboration or Alignment with USFS, Partners, or the Public

This work is being conducted in collaboration with Haudenosaunee Nations, and with land/forest managers with the Central New York Land Trust (CNYLT) and the NY Division of Lands and Forests.

## Power in the Patchwork? Summertime Patch-Cutting to Create Diverse and Resilient Uneven-Aged Northern Hardwood Forests

**Principal Investigator:** Stacy McNulty (SUNY ESF, [smcnulty@esf.edu](mailto:smcnulty@esf.edu))

### Summary of Progress in 2025:

- Recruitment and onboarding of a Master’s student (Audrey Tamasy). The graduate student’s committee will include Dr. Jonathan Cohen (ESF) and Cameron McIntire (US Forest Service) as their expertise in forest ecosystem modeling and disease will contribute to the success of our research.
- The first partner meeting was held in September 2025 with partners Claire Mann and Suzanne Treyger (Audubon NY), Luke McNally (Ruffed Grouse Society), Mike Federice (ESF Forest Properties), and Andrew Vander Yacht, Stacy McNulty, and Audrey Tamasy (ESF). The new graduate student was introduced and partners discussed timelines, general methodology, and project goals.
- To meet objective 1, exclosure and control plots established on the patch-cut site in 2003 were remeasured in 2025 and the data analyzed by the graduate student to understand trends in plant growth and impacts of white-tailed deer and moose herbivory. The “new” 2026 patch cuts were delineated by forestry personnel and the harvest work was contracted out to a private company to begin onsite in July 2026.
- To meet objective 2, Autonomous Recording Units (ARU) were acquired and a preliminary sampling scheme was designed.
- To meet objective 3, in November 2025 over 300 American beech (*Fagus grandifolia*) bud samples were collected across three sites and sent to project partner Cameron McIntire to undergo molecular analysis which will test for the presence of dormant nematode vectors of Beech Leaf Disease.
- A poster was presented by the graduate student at the 2025 Forest Ecosystem Monitoring Cooperative conference.
- Six undergraduates were trained in beech bud collection protocols and field sampling.

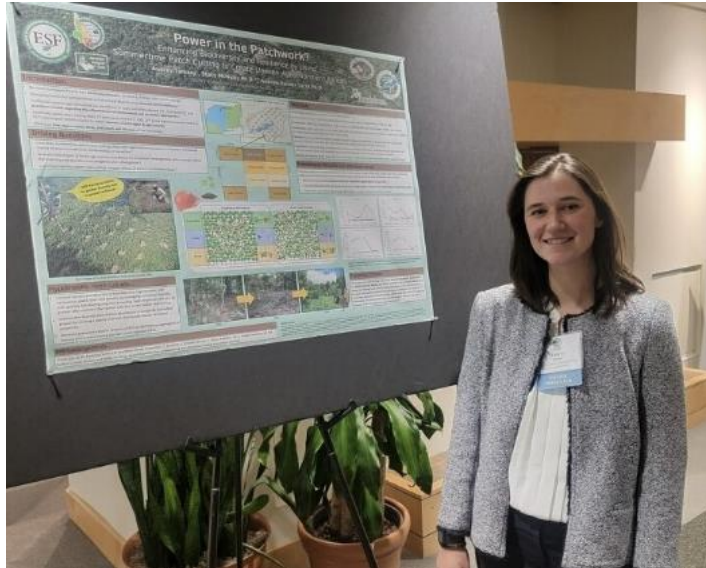


Figure 19. Master's student Audrey Tamasy presenting her poster on the NSRC funded project *Power in the Patchwork?* at the 2025 Forest Ecosystem Monitoring Cooperative conference.

## Problems or Changes

- The experimental design was expanded to include a third “no management” treatment to compare to the patch-cut treatment and “business as usual” shelterwood site. This is significant for regions such as the Adirondack State Park and New England that may have legal, administrative, or cultural restrictions on applied forest management. The master’s thesis will include three chapters: 1) vegetation, 2) wildlife – specifically songbird and Ruffed Grouse communities, and 3) disease – specifically Beech Leaf Disease. Variables associated with these three topics will be measured across each of the three treatments prior to patch-cut harvest and one-year post-patch-cut harvest.
- The bird monitoring design has expanded to include a combination of active point-counts and passive ARUs to estimate diversity and abundance with an expanded dataset at three sites/treatments.
- The project will include testing Best Management Practices in the patch cut site to control erosion, limit damage to sensitive areas, and improve understanding of impacts from the harvest technique.
- The Ruffed Grouse Society representative project changed; RGS remains committed.



Figure 20. Description of three treatment areas being studied in Power in the Patchwork? including the additional No Action site.

## Plans for 2026

- Present a poster on patterns of tree regeneration in the historical patch cuts and deer exclosures at the 2026 NY Society of American Foresters conference in late January.
- Present a Master's thesis proposal to the graduate thesis committee at the end of April.
- Hold a partner team meeting in late winter.
- Conduct field work in June through August with any additional fieldwork completed in autumn.
- Confirm data methodology for comparative harvest data analysis and share preliminary results associated with pre-harvest data with project partners in late 2026.

## Collaboration or Alignment with USFS, Partners, or the Public

- The project's experimental approach to forest management will help stakeholders "connect the dots" between forest dynamics, vegetation, disease, wildlife, and ecosystem health. This research will provide insight into a novel silvicultural application as a tool to mitigate threats currently facing northern hardwood ecosystems.
- This proposed treatment will provide information to landowners and managers and options for promoting resiliency and biodiversity on small parcels where commercial forest management practices may be limited or inapplicable.
- Collaboration with Dr. Cameron McIntire, USFS, includes early detection of Beech Leaf Disease, assessing cellular damage on beech bud scales as an indicator of

disease, molecular diagnostics for nematode and other pathogen presence, and sharing research findings with federal, state, local, private, and tribal forestry networks.

- The Ruffed Grouse Society (RGS) and Audubon New York will guide and support bird surveys, collaborate on outreach programming, share results across chapter networks and conservation partners, and engage the public via forest walks, publications, webinar series, and social media content. Results will be integrated into the established Audubon Forester Training and Endorsement Program and via RGS activities with forest owners and managers in the region.
- Upon completion, project dissemination will include creation of interpretive materials which will be made available to the thousands of annual visitors to the SUNY ESF Newcomb Campus and beyond.

## Products

Tamasy, A. (2025). Power in the Patchwork? [Poster presentation] 2025 Forest Ecosystem Monitoring Cooperative conference.

# Trialing Best Management Practices for Preserving or Extending Frozen Ground Condition

**Principal Investigator:** Steven Roberge (University of New Hampshire, steven.roberge@unh.edu)

## Summary of Progress in 2025

Implementation of this grant has been on track and the team at UNH is accomplishing planned activities in the project timeline. In 2025, the project team has:

- Coordinated research sites with foresters and logging contractors. This involved the project team meeting with the foresters and logging contractors to explain the research and experimental design of the project. Specific sites were identified and laid out for trialing best management practices.
- In September Shannon Van Hise started a master's program at UNH to help implement this project.
- In November and December, Shannon Van Hise and the lab team installed the control and treatment plots at 3 separate sites in Madbury NH, Henniker NH, and Marlboro VT. This included the installation of temperature sensors, frost tubes, and collection of pre-treatment soil samples for aggregate data, bulk density, and other attributes.
- Plots are regularly monitored and data collected.

## Problems or Changes

Two problems have been identified in Fall of 2025, but team has worked through them and is in a good position to meet project deliverables. The first issue was the need for a refined plot and sampling design for the control and treatment sites and installing sampling that needed to take place before harvesting started at each site. The work was completed, but it was a compressed timeline. The second issue was the availability of one logging contractor identified in the proposal could not work with the project this winter. To solve this problem and to ensure the project had three sites, the project used a harvest planned on UNH Woodlands in Madbury NH. Plots were installed at the site to collect the necessary pre-treatment data.

## Plans for 2026

In 2026, the team plans work with foresters and logging contractors to identify and install another round on corduroy sites on new harvest areas and collect the data from those plots. Soil samples from 2025 will be analyzed at UNH following collecting of data recording equipment in spring 2026, along with data from year 1's corduroy plots. These BMPs will be showcased with harvest and BMP demonstration tours for foresters and other professionals. Van Hise will continue to work towards her master's with an expected graduation in Spring 2027.



Figure 21. Soil sensors (iButtons) to be installed below grade under a corduroy crossing (photo by Shannon Van Hise)



Figure 22. Soil sensors installed below corduroy crossing in Henniker NH (photo by Shannon Van Hise)



Figure 23. Corduroy installation at Marlboro VT site (photo by Shannon Van Hise)

## Just How Hard is it Raining?

**Principal investigator:** Jamie Shanley (U.S. Geological Survey, [jshanley@usgs.gov](mailto:jshanley@usgs.gov))

### Summary of Progress in 2025

In 2025 the process of organizing the precipitation data files was initiated. Daily precipitation at the Sleepers W-9 catchment has been calculated as an elevation-weighted blend of two stations on a day-by-day basis for each year. An Automated Precipitation Correction Program (APCP) has been adapted to convert cumulative total precipitation (the datalogger output) into amounts per specified timestep. Accurate daily totals for each station enable verification that the program reproduces daily totals faithfully. The existing version of the program is known to overly smooth fine-scale variations. Although this smoothing was not problematic for the original purpose of recording daily total precipitation, it defeats the purpose for looking at fine-scale intensity. A meeting was held with the USGS collaborator Kevin Ryan to obtain previously evaluated hourly precipitation data files generated by electronic Belfort weighing-bucket gages operating at the sites through approximately 2020. Kevin Ryan also provided scripts used for data preprocessing (R) and for the APCP (MATLAB). The original APCP code has been reviewed line-by-line alongside the publication describing the program's development, and the source of the over-smoothing has been identified. A subsequent meeting was held with on-site USGS collaborator Serena Matt, who maintains the more recent precipitation datasets (2020–present) collected using the Ott Pluvio rain gauge, which has an internal algorithm analogous to the APCP, to determine if we could replicate how it corrects for 'negative noise' prior to a rain event without over-smoothing.

### Problems or Changes

The 6-week U.S. Government shutdown in October/November delayed the project analysis, but otherwise the project is on track. Because of the delay, fine timestep data could not be presented on a poster at the AGU meeting in New Orleans in mid-December; the existing daily record was used to make some preliminary analyses and comparisons to Hubbard Brook.

### Plans for 2026

The program will be refined and applied to two individual site datasets. Verification will be done to confirm that the cumulative daily totals match the published datasets. Any residual program glitches will be resolved by focusing on a single year before applying the program to the entire time series. The focus will be primarily on R-29, the precipitation station near the W-9 weir, and secondarily on R-1A, the high-elevation station. While the record at R-29 begins in October 1991 as digital data, R-1A data were recorded on paper strip charts from 1991 to 2001, at which time the site converted to digital, but at an hourly (not 5-minute) timestep. Station R-29 is expected to have the best record for analyzing intensity. Once satisfied with an accurate fine timestep precipitation timeseries, combination with the more current Ott Pluvio time series will be done and assessment of precipitation intensity for various time scales (e.g. 5-min, 15-min, 30-min, hourly, etc.) to determine at which intensity intervals temporal trends exist. When it is confirmed that the program is reproducing daily totals and accurately capturing the fine-scale intensity it will be converted from Matlab to R. At that point a decision will be made whether to

retain the native 5-minute data timestep or fall back to the 15-minute interval adopted by Hubbard Brook, retaining the 5-minute step if possible. The team will interact with the Hubbard Brook group and assess how intensity metrics at the two sites compare and differ, collaboration will be done on a journal paper.

### Collaboration or Alignment with USFS, Partners, or the Public

Collaboration has been done with the Forest Service (Amey Bailey, Nina Lany, and FS-associate Mark Green) from the outset, including discussions before and during the proposal writing. A workplan was modeled after their experience, and collaboration will be done fully when results are ready for comparison. In preparation for our AGU poster in December, having lost the six weeks of shutdown, the team decided to focus on temporal trends and seasonal patterns in the daily data we had already at hand. The project team interacted with Mark and compared plots of both daily and seasonal data and worked out interpretation with them for an AGU poster, on which they were co-authors.

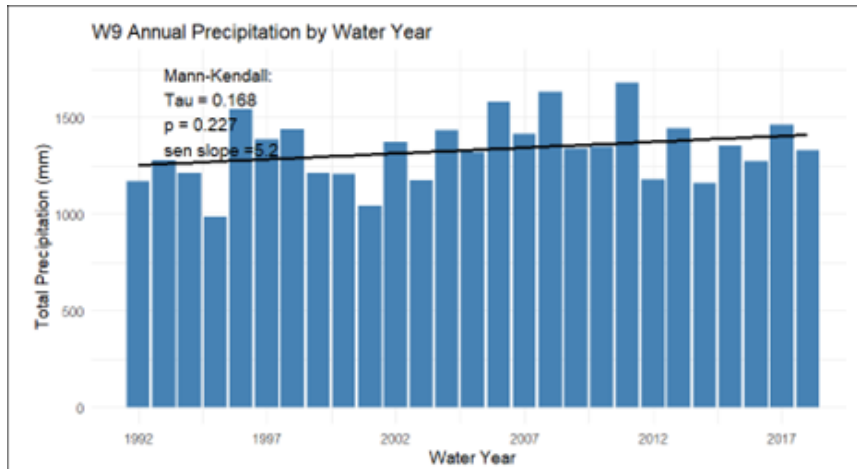


Figure 25. Sleepers River has an upward but non-significant trend in annual precipitation. Hubbard Brook does have a significant upward trend for their longer timeseries (1956-2022) but it lacked a significant trend for the period that overlapped with Sleepers River.

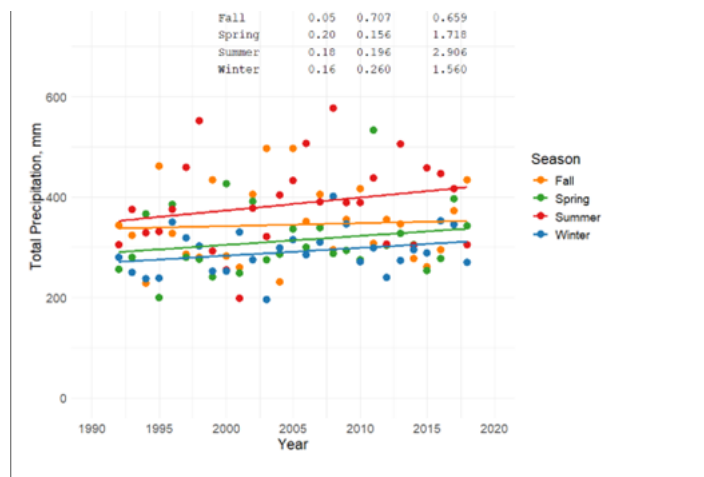


Figure 24. Sleepers also has no trend in precipitation for individual seasons. The longer-term Hubbard Brook record does show significant upward trends in all 4 seasons (not shown).

# Forest Management at the Frontline: Silviculture and Belowground Ecology Foster Eastern Hemlock Vigor and Mediate Responses to an Imminent Invasion of *Adelges tsugae*

Principal Investigator: Kurt Smemo (Skidmore College, XXX)

## Summary of Progress in 2025

2025 represented the first year (starting June 1) of the project. The goals were to establish plots within our management units and, prior to the logging and silvicultural treatments, 1) measure within those plots a) overstory tree communities, b) herbaceous vegetation cover, and c) soil nutrients, soil carbon, and soil calcium, and 2) install sensors to measure soil moisture and temperature, air temperature, and light. Tree, vegetation, and soil sampling was completed by the end of August. A new GIS database was created for the project and the plot locations geolocated using high precision GPS. Soil biogeochemical analyses were completed by end of November, and 3 Skidmore students presented those data at the Skidmore research symposium in December. In September, the logging treatments and commercial timber sale commenced in the units. By the end of December all of the sensors had been pulled from the field in order to escape damage during the harvest. Given current progress, the logging will be completed by mid-February and we can begin looking at treatment responses and prepare for the arrival of the Adelgid.

## Plans for 2026

2026 will be a busy year since the harvesting and treatment establishment will be completed. Our goals are to

1. Reinstall all the sensors in the plots as soon as the snow melts (sensors remained on plots in control units),
2. Collect hemlock foliage from the top of canopy of focal hemlocks prior to leaf out to assess baseline tissue chemistry,
3. Measure, barcode, tag, and geolocate all trees in the sixty 15-m radius plots that were previously established in order to assess changes in basal area and stem density from the treatments,
4. Collect height and health data on focal hemlock trees in each plot,
5. Collect soil from two depths in each plot and install root in-growth cores,
6. Measure nutrient and carbon concentrations post-treatment,
7. Conduct soil microbial community analysis led by our newly recruited graduate student (Kayla Cameron) at Michigan State,
8. Begin analysis of massive amounts of sensor data, and
9. Constant monitoring, with the help of Cornell, for the arrival of HWA.

A total of 5 Skidmore students will be working on the project and gaining research experience this year. Four of those students will be working full-time in the summer and spending significant time in the field at the Pack Forest. As mentioned before, we will also be training a new graduate student at Michigan State.



*Figure 26. Chris Blackwood from Michigan State with recently installed sensors in a monitoring plot.*



*Figure 27. Collaborator Andrew Cortese in a recently harvested unit at the Pack Forest.*



*Figure 28. Skidmore environmental science major Holly Staats poses in front of the largest tip-up mound ever at the Pack Forest.*

# Forest Stewards Apprenticeship: Bridging Indigenous Knowledge, Research, and Forest Stewardship with the Penobscot Nation

**Principal Investigator:** Rachel Swanwick (Forest Stewards Guild, [rswanwick@forestguild.org](mailto:rswanwick@forestguild.org))

## Summary of Progress in 2025

The Forest Stewards Guild (the Guild) assembled a three person Forest Stewards Apprenticeship (FSA) crew to collaborate with Penobscot Nation’s (PN) Department of Natural Resources (DNR). The apprentices received training, education, and mentorship in forest, fire, and cultural resource management. The FSA crew earned their Wildland Firefighting certifications and a “Red Card,” enabling participation in a two-week Prescribed Fire Training Exchange (TREX). Giving the FSA crew the training needed to be called on to support PN in future prescribed burns. Following TREX, apprentices participated in the Certified Logging Professionals program, gaining training to safely manage forest resources. They also completed certifications in First Aid, CPR, and First Aid for Severe Trauma. After completing their training, the FSA crew was mentored by Ben Stevens, Forest Manager at PN DNR. Through field days they deepened their understanding of forest resiliency, silviculture, and applications of Traditional Ecological Knowledge on PN lands. The FSA-PN crew significantly increased PN’s workforce and stewardship capacity. The crew supported 16 forest stewardship projects including forest thinning across 12.75 acres, flagging 3 miles of timber harvest boundaries, clearing 3.9 miles of roads and trails, surveying 1,000 acres of timber, and felling over 45 trees for restoration and commercial use. Collectively, these efforts advanced PN’s stewardship goals, strengthened workforce capacity, and improved forest resiliency in the Northern Forest Region. We also supported crew members’ ongoing workforce development post-program; the Guild rehired a 2025 Tribal crew member to lead the 2026 Forest Stewards Youth Corps with PN.



*Figure 29. Forest Stewards Apprenticeship crew members participated in the Maine TREX prescribed fire training, building skillsets for the crew based near Indian Island, Maine to help increase prescribed fire capacity across the region. Left to right: Jacob Baker, Gabe Stewart, Peyton (Agenor) Duhon. Photo credit: Polly Weigand, Forest Stewards Guild, 09/2025*

## Problems or Changes

This was the pilot year of the FSA-PN program and there was uncertainty during early planning stages about whether we would be successful in securing the NSRC Indigenous Forest Knowledge Fund award. These limitations in early planning resulted in the cooperative prescriptive burn and Intertribal exchange being postponed in 2025 and instead being prioritized for the 2026 FSA season. Additionally, heavy snowfall, repeated freeze/thaw cycles, and the remote location of the Nation’s Beech Study Plots prevented the crew from assisting with the experimental hardwood treatments with the Appalachian

Mountain Club. Road conditions were unstable, and the remote forest access routes couldn't be plowed, making the site inaccessible. This project has been prioritized for the 2026 FSA season.

## Plans for 2026

The Forest Stewards Apprenticeship project will continue as planned for the 2026 season.

Trainings will be offered in forestry and fire management activities such as tree identification for



*Figure 30. Apprentice crew member Peyton (Agenor) Duhon celebrates a successful tree felling with crewmate Gabe Stewart (right). Felling at this site was aimed at creating space to allow access for logging equipment in preparation for a shelterwood harvest on Tribal lands in Lakeville, Maine. Photo credit: Jacob Baker, Forest Stewards Guild 12/2025*

forest inventory, introduced species removal, prescribed and wildland fire, Certified Logging Professionals, and cultural knowledge. FSA crew members will assist with management for timber harvests, pre-commercial thinning operations, ash monitoring and seed collection, and forest road maintenance. The 2026 FSA team will start slightly earlier, in August rather than September, allowing more time during the dry season to access and care for remote research sites for experimental treatments of hardwood competition.

In August 2026, our FSA crew will participate in a Tribal-led ash seed collection training hosted by the Guild's Sustaining Ash Partners Network and the Ash Protection Collaboration Across Waponahkik on PN's lands. The workshop will focus on sharing the cultural values of ash preservation while building a community of practice for ash seed collection. The FSA crew will also partner with the Wabanaki Youth in Science (WaYS) Ancestral Lands Trail Crew in training and stewardship activities to holistically improve Tribal workforce development opportunities

in the community. We are also planning for the FSA crew to travel to New Mexico to participate in a cooperative prescribed burn through collaborative partnerships with the New Mexico Tribal Fire and Forestry Working Group and the Pueblo of Jemez this fall.

## Collaboration or Alignment with USFS, Partners, or the Public

Since establishing the program in 2025, we continue to build partnerships that strengthen the experience of project participants, PN workforce capacity, and community supported forest resiliency in the Northern Forest Region. The success of the training offered, and certifications received in the 2025 FSA crew cohort came through partnerships with the Maine Timber Research and Environmental Education Foundation, Maine National Guard, The Nature Conservancy, the North Atlantic Fire Science Exchange, and the USDA Forest Service.

In the upcoming 2026 FSA-PN crew season, we are expanding upon this collaborative foundation to enhance project outcomes and community building. This includes working with the University of Maine's Ash Protection Collaboration Across Waponahkik, the Guild's USFS supported Sustaining Ash Partners Network, and WaYS, and the Saint Regis Mohawk Tribe's

Restoring Tribal Relations and Forest Knowledge program. FSA-PN crew participation on the intertribal cooperative prescribed burn is facilitated through collaboration with the New Mexico Tribal Fire and Forestry Working Group and the Pueblo of Jemez.

All stewardship projects for the FSA-PN crew centered collaboration with PN staff and community members. One participant noted in their exit interview, “I really enjoyed seeing [forestry] from a Tribal perspective. It’s completely different than how I’ve ever looked at it. Being able to look at it from...your point of view is an...eye-opener.” Their comment highlights the program’s effective emphasis on centering Indigenous knowledge and Tribal priorities to advance forest resiliency and workforce development with PN.

## Products

[Social media post 02/13/2026](#)



*Figure 31. FSA-PN crew members Jacob Baker and Peyton (Agenor) Duhon work together to process a tree they felled as part of a timber harvest with the Penobscot Nation. This uneven-aged silvicultural treatment is being implemented by hand, through careful selection, to ensure the harvest will provide quality timber that supports economic development for the Tribe and enhances structural diversity in the forest. Photo credit: Gabe Stewart, Forest Stewards Guild 01/2026*

# Next-Generation Wood Products Carbon Estimator: A Tool for Comprehensive Stakeholder Collaboration and Decision-Making

**Principal Investigator:** Xinyuan Wei (University of Maine, [xinyuan.wei@maine.edu](mailto:xinyuan.wei@maine.edu))

## Summary of Progress in 2025

In 2025, the online version was developed of the *Next-generation Wood Products Carbon Estimator*, a web-based tool designed to quantify carbon flows and dynamics associated with harvested wood products. The estimator includes core functionality to track carbon storage and emissions associated with wood product disposal, recycling, and waste wood decomposition processes. The estimator is implemented with a user-friendly online interface that allows users to easily parameterize, calibrate, and apply the model without requiring advanced programming skills. To demonstrate model functionality and assess performance, we developed two default example applications at the Maine and United States scales to estimate carbon stored in wood products. In addition, a default parameter set was compiled for the Northern Forest region, enabling users to conduct regional-scale assessments using standardized assumptions. To support estimator testing, validation, and further development, two MS students were hired in 2025. Grant Daniels is developing a model testbed using the Penobscot Experimental Forest as a case study. He is integrating airborne LiDAR data with multiple machine learning models to estimate forest volume, and these volume estimates will be used to test and verify the performance of the carbon estimator. Shambhu Katel is focused on collecting, synthesizing, and organizing additional parameter data from the literature and existing databases. His work will expand the availability of parameter sets and improve the estimator's applicability across different regions, forest types, and management scenarios.

## Plans for 2026

In 2026, the current estimator will be enhanced to represent the full wood products carbon flow pathway. Specifically, modules will be incorporated that track the processing of harvested timber into lumber, wood chips, panels, and other wood products at mills. This expansion will enable a more complete accounting of carbon transfers and storage across the entire wood products supply chain. We will also develop a module to assess the effects of technological advancements on wood products carbon flow and storage. This module will evaluate the influence of emerging wood products, improved manufacturing processes, and enhanced timber utilization efficiency on carbon residence time and emissions. By representing these innovations, the estimator will provide wood industry professionals with quantitative information on how technological improvements affect carbon dynamics, supporting the optimization of production practices and the sustainability of wood product systems. We will design and implement a substitution assessment module to evaluate the carbon implications of increased timber use as a substitute for more carbon-intensive materials. This module will quantify changes in the size and persistence of the wood products carbon pool associated with material substitution scenarios and will generate outputs relevant for policy analysis and carbon mitigation planning. By the end of 2026, we will release Version II of the *Next-generation Wood Products Carbon Estimator*. In addition, a comprehensive testbed will be completed to verify and evaluate model performance, and

detailed user documentation will be released concurrently to support transparent and effective application of the estimator.

### Collaboration or Alignment with USFS, Partners, or the Public

The development of the *Next-generation Wood Products Carbon Estimator* is closely aligned with the needs and priorities of the U.S. Forest Service (USFS), academic partners, and other stakeholders involved in forest carbon assessment and sustainable wood utilization. The current version of the estimator has been tested by stakeholders, including researchers and practitioners with expertise in forest management and wood products carbon accounting. Their feedback has played a central role in guiding future development. Stakeholders have identified several priorities for improvement, including the need to represent the complete carbon flow pathway from standing trees through harvesting, processing, product use, and end-of-life stages. In response, future development will incorporate a full life-cycle representation of wood products carbon dynamics. Additional feedback highlighted the importance of enhanced visualization tools to support interpretation and communication of results. Accordingly, new visualization functions will be developed to improve transparency and usability for both technical and nontechnical users. Another key recommendation from stakeholders was the expansion of parameter datasets. The current parameter sets limit the estimator’s applicability across regions, forest types, and management scenarios. We are collaborating with partners to compile and integrate additional parameter data from the literature, existing databases, and applied studies. Through continued engagement with USFS scientists, academic collaborators, and local stakeholders, this estimator advances forest carbon accounting, informs policy development, and promotes sustainable forest and wood product management.

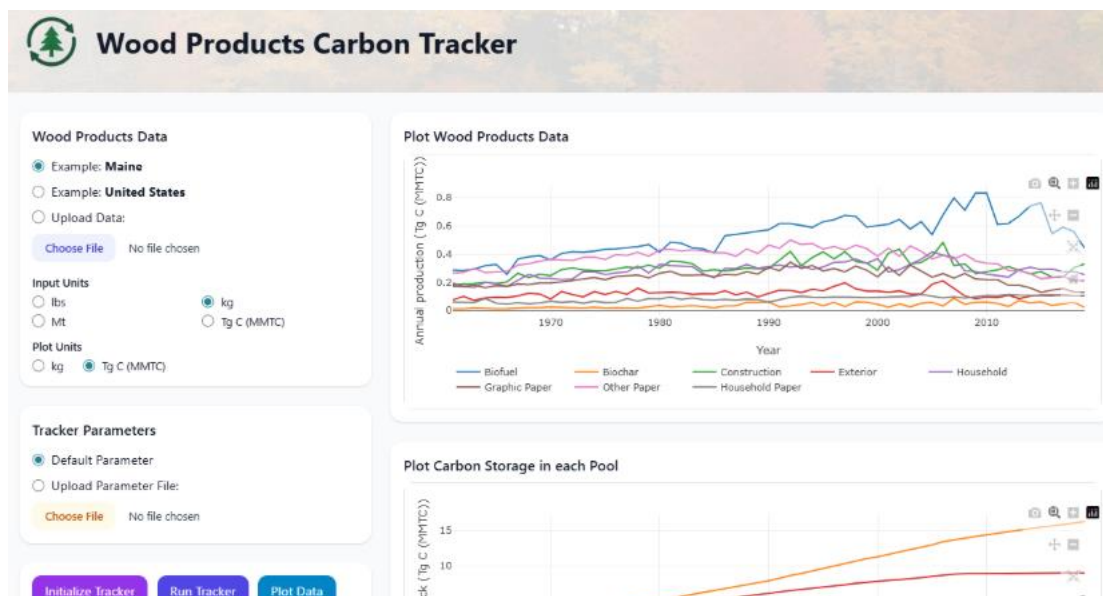


Figure 32. Web-based user interface of the Next-generation Wood Products Carbon Estimator, which allows users to parameterize and apply wood products carbon accounting through an online platform (<https://xinyuanwylb19.github.io/xinyuanwylb19-Wood-Products-Carbon-Tracker/>).

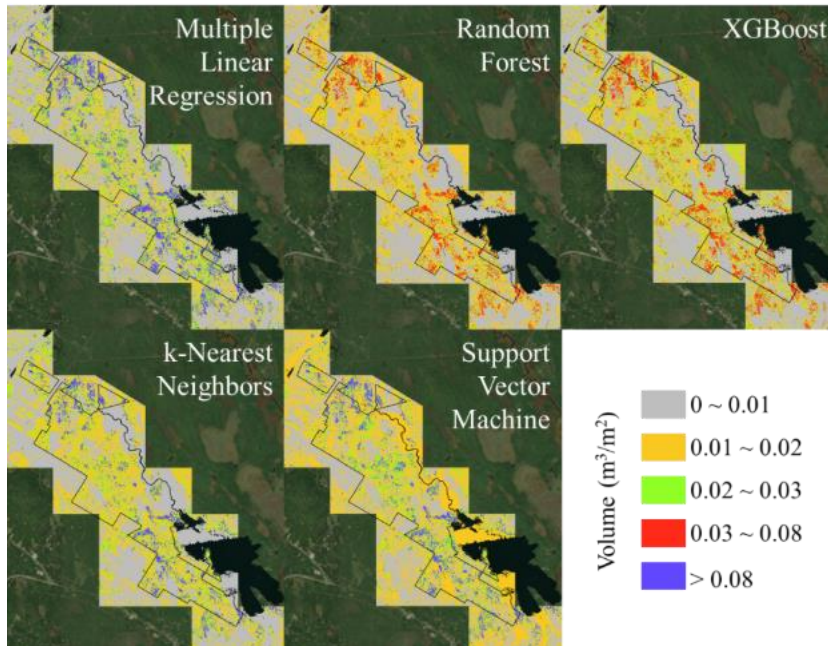


Figure 33. Volume maps of the Penobscot Experimental Forest derived from five machine learning models. These maps will serve as the basis for developing a testbed to evaluate and verify the estimator.

## Products

Next-generation Wood Products Carbon Estimator,

<https://xinyuanwylb19.github.io/xinyuanwylb19-Wood-Products-Carbon-Tracker/>

Wei, X., Hayes, D., McHale, G., Zhao, J., Weiskittel, A., & Daigneault, A. (2025). PyFIA: analyzing and visualizing forest attributes using the United States Forest Inventory and Analysis database. *Carbon Balance and Management*. <https://link.springer.com/article/10.1186/s13021-025-00364-7>

# Climate-Smart Retention in Managed Forest Landscapes

**Principal Investigator:** Andrew Whitman (Maine Timber Research and Environmental Education Foundation, [awhitmancornus@gmail.com](mailto:awhitmancornus@gmail.com))

## Summary of Progress in 2025

- Field assistant was hired in May.
- All old retention patches identified in satellite imagery, noting sites lost to harvest.
- Fieldwork was conducted from June–August 2025 at 67 sites. Data collection included tree, log, and shrub regeneration sampling. A subset of plots included microclimate (temperature and relative humidity) data.
- Deployed 60 microclimate data loggers in July; returned and downloaded data in October and redeployed the data loggers to complete a year-round cycle of temperature and humidity data
- Downloaded and proofed data (QAQC).
- Preliminary data analysis was initiated for vegetation data
- Abstracts submitted for scientific presentations at NE Society of American Foresters (NESAF; Portland, ME), North American Forest Ecology Workshop (Missoula, MT), and International Boreal Forest Research Association (Québec City, Canada).



*Figure 34. Field crew in 2025. Left: Kiernan Tierney, field technician. Middle: Olivia Tomasello, field technician. Right: Molly Taylor, field crew leader.*

## Problems or Changes

Due to personnel changes, a budget revision was submitted on September 17, 2025. Details of the accepted revisions are included below:

1. **Salary and Wages:** Personnel (e) Year 1 Federal salary was adjusted from \$10,000 to \$6,250.
2. **Fringe:** Personnel (e) Year 1 Federal fringe was adjusted from \$1,000 to \$625.
3. **Domestic Travel:** Adjusted from \$23,935 to \$18,060.
4. **Consultant and Contract Services:** The funds from Personnel salary (\$3,750) and fringe (\$375), and Domestic Travel (\$5,875) were allocated to Year 1 Federal Consultant and Contract Services (\$10,000).

## Plans for 2026

- Molly Taylor to present a talk on this research at NESAF, March 2026.
- Molly Taylor to present poster at North American Forest Ecology Workshop, NAFEW, June 2026.
- Collect remaining field data in Big Reed Forest Preserve and downloading temperature probe data in Kibby, Skinner, and Hammond townships in July and August.

- Proof the data, conduct data analyses.
- Write and prepare two academic papers for submission.
- Generate a best-practices document for retention patches.

### Collaboration or Alignment with USFS, Partners, or the Public

Field research was conducted in collaboration with Baskahegan Company (Kyle Burdick), 7-Islands Land Company (Ryan Smith), Weyerhaeuser Corporation (Rick Ary), and ME Bureau of Public Lands.



*Figure 36. Interior of the patch shown in Figure 33.*



*Figure 35. Edge of an experimental patch created in 2000, on left, and harvested area, on right.*

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