FEMC — Forest Ecosystem Monitoring Cooperative

PROCEEDINGS OF THE NOVEMBER 20, 2025
FOREST ECOSYSTEM MONITORING COOPERATIVE
ANNUAL CONFERENCE:

Forest dynamics and stewardship at a crossroads: Science, partnerships, and adaptive strategies for moving forward

Contents

About the Forest Ecosystem Monitoring Cooperative

Providing the information needed to understand, manage, and protect the region's forested ecosystems in a changing global environment.

Established in 1990 and ratified in 1996 via a memorandum of understanding between the Vermont Agency of Natural Resources, the University of Vermont, and U.S. Department of Agriculture (USDA) Forest Service, the Forest Ecosystem Monitoring Cooperative (FEMC, formerly the Vermont Monitoring Cooperative) has been conducting and coordinating forest ecosystem monitoring efforts for thirty-three years.

Originally designed to better coordinate and conduct long-term natural resource monitoring and research within two intensive research sites in Vermont (Mount Mansfield State Forest, the Lye Brook Wilderness Area of the Green Mountain National Forest), FEMC efforts have since expanded to capture relevant forest ecosystem health work across the northeastern region with an expanding list of partners from Maine, Massachusetts, New Hampshire, New York, and beyond.

Today, the FEMC funding stems primarily from a partnership between the USDA Eastern Region State & Private Forestry as part of the Cooperative Lands Forest Health Management Program, the Vermont Department of Forests, Parks and Recreation, and the Rubenstein School of Environment and Natural Resources at the University of Vermont. Staff affiliated with the University of Vermont handle the majority of FEMC operations. While FEMC funding primarily supports ongoing monitoring, outreach and data management, contributions by the larger collaborative network are essential to the advancement of FEMC work. Cooperators participate on advisory committees, contribute to the data archive, and share knowledge across the region.

The current mission of the FEMC is to serve as a hub of forest ecosystem research and monitoring efforts across the region through improved understanding of long-term trends, annual conditions and interdisciplinary relationships of the physical, chemical and biological components of forested ecosystems. These proceedings highlight the breadth of activities undertaken by cooperative contributors and demonstrate the potential of large collaborative networks to coordinate and disseminate the information needed to understand, protect and manage the health of forested ecosystems within a changing global environment.

Online at https://www.uvm.edu/femc/
FEMC Steering Committee and State Coordinators – https://www.uvm.edu/femc/cooperative/committees
FEMC staff – https://www.uvm.edu/femc/about/staff

Proceedings of the November 20, 2025 Forest Ecosystem Monitoring Cooperative Annual Conference:

Forest Dynamics and Stewardship at a Crossroads: Science, Partnerships, and Adaptive Strategies for Moving Forward

Published March 13, 2026
From material presented at the FEMC Annual Conference
November 20, 2025
Davis Center
University of Vermont
Burlington, VT, USA

Introduction to the Proceedings

The Forest Ecosystem Monitoring Cooperative held its 35th annual conference on November 20, 2025 at the Davis Center at the University of Vermont. Options for virtual attendance were also provided, making this the fourth year of offering the conference in a hybrid format. The conference theme was Forest dynamics and stewardship at a crossroads: Science, partnerships, and adaptive strategies for moving forward. As it does every year, the conference convened a diverse array of speakers and participants to discuss recent advancements in research and management of forest ecosystems.

The conference offered a compelling keynote address by Tony D'Amato; updates on key FEMC projects in 2025 and lightning talk presentations by the FEMC State Coordinators on key projects happening in each FEMC

partner state; fourteen tracks for contributed talks, workshops, and FEMC-invited speakers, including remarks from Dr. Anne Jefferson of NSRC and Dr. Beverley Wemple and Dr. James Shanely for a special session on the 25th year of monitoring conducted in a paired watershed study on Mt. Mansfield; and a poster session with a panel- and attendee-selected "best poster" award. This year, the poster session included 22 posters—a record number for the conference.

Will Hochholzer (CT DEEP), FEMC's Steering Committee Vice Chair for 2025 and incoming Chair for 2026-2027, opened the conference with introductory remarks. Alison then described FEMC's work in 2025 and highlights of anticipated 2026 work and growth, and introduced a new FEMC Principal Investigator, Nicholas Aflitto. Dr. Aflitto shared his vision and goals for FEMC. The majority of the plenary session was a keynote address by Tony D'Amato, who described how approaches to and attitudes about forest management have changed over the past several decades, and how forest managers and researchers can work together productively in the face of new challenges ahead.

This year the conference boasted a significant number of presentations focused on wildlife—an area that has been a weakness of the conference in past years. Concurrent session topics also included two full sessions on pest and pathogen research and management, fire in northeastern forest systems, fungal ecology, the importance of language sensitivity in introduced species management, and more.

The conference drew 220 in-person attendees and 30 virtual attendees. The hybrid format once again provided maximum flexibility for attendees, allowing those located further afield to participate in the conference without the additional cost of travel, and also allowing those with health concerns or other considerations to attend.

These proceedings include presentation summaries, abstracts, and outcomes compiled by FEMC staff as a resource for forest professionals from across the region. Additional materials, including presentation recordings and, where available, downloadable PowerPoint presentations are available at the conference webpage: https://www.uvm.edu/femc/CI4/cooperative/conference/2025.

Forest dynamics and stewardship at a crossroads: Science, partnerships, and adaptive strategies for moving forward

As FEMC does every year, the FEMC leadership team formed a conference planning committee to identify potential speakers and themes for the 2025 conference. This year's committee included Gretchen Nareff (Northeastern States Research Cooperative, Lake Champlain Sea Grant), Al Freeman (VT Department of Forests, Parks, and Recreation), Jess Cancelliere (NY Department of Environmental Conservation), Jason Hill (Vermont Center for Ecostudies), Walker Cammack (Smokey House Center) Alison Adams (FEMC), and Elissa Schuett (FEMC).

The committee met in May to discuss conference ideas, using guidance from the 2024 post-conference survey to identify attendees' desire for a 2025 plenary session and conference theme more focused on forest science and management than those in recent years. Tony D'Amato was identified by the committee as the ideal keynote speaker.

Elissa and Alison worked with Tony to develop a plenary session that openly confronted the funding challenges, institutional attacks, and societal division that is affecting people's work across sectors, including in the forest health, forest science, and forest management sectors. Tony described the history of forest management and how different perspectives and approaches have evolved into the main ways people think about and approach forest management today. He also highlighted how identifying shared goals with other individuals and organizations can result in partnerships that will buoy us through challenging waters ahead. In the post-conference survey, many attendees shared that the keynote address was a highlight of the day due not only to Tony's engaging style, but also because they felt the content was relevant to their work and the decisions and challenges they may face in coming months and years.

SUMMARY OF THE 2025 CONFERENCE PLENARY

Forest dynamics and stewardship at a crossroads: science, partnerships, and adpative strategies for moving forward

The 2025 FEMC Annual Conference keynote address was given by Dr. Tony D'Amato, UVM Rubenstein School Professor and Director of both RSENR's Forestry Program and UVM's Research Forests. Dr. D'Amato's talk, titled "Forest dynamics and stewardship at a crossroads: science, partnerships, and adaptive strategies for moving forward," provided a retrospective of how we have approached forest stewardship historically as well as suggestions about how we might approach stewarding our forests into the future.

Forest Dynamics

Dr. D'Amato described how the northern forest climate regime has shifted from one typical of the prior 35 years in northern New England to one more characteristic of southern New England. He also described a pattern of climate extremes and climate-exacerbated disturbance, including the recent "drought" and "deluge" patterns we have experienced across the Northeast, and the marked increase in non-indigenous insects and pathogens in the region. These are affecting our forests in significant ways: since 2010, mortality due to causes other than harvesting has increased sharply.
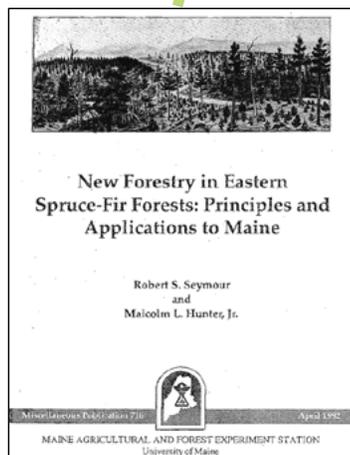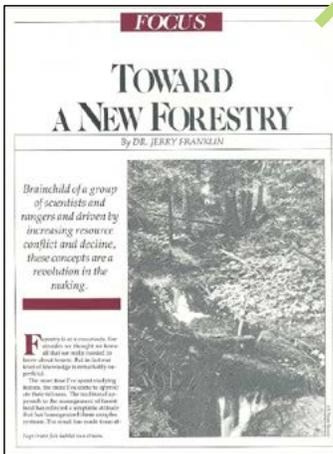
There are three states in the footprint of the FEMC where insects alone have killed more trees than harvesting.

Forest Stewardship

Dr. D'Amato also described trends in forest stewardship since 1960—a starting point he chose because, he asserted, we still hold many of the ideas regarding stewardship that we had in the 60s. At that time, the prevailing belief was that we needed to protect forests from people by establishing more natural areas protected from human use. Managed areas were used almost exclusively to produce wood, and little attention was paid to biodiversity values or other benefits those areas could provide—and the ecosystems paid the price.

The 1980s and 1990s witnessed a turn toward best management practices, ecological forestry, and other more intentional management approaches. This time period was exemplified by a concept called "New Forestry," which sought to find a balance between completely protected areas and managed areas. The "Triad approach" suggested designating different areas for different goals, with some areas for human use, some areas for wood production, and some areas seeking "new forestry" balance with production, social, and ecological goals in balance.

Protect forests from people · **Reduce people's impacts on forests** · **Steward forests for people** · **People as part of forests**

1960　1970　1980　1990　2000　2010　2020
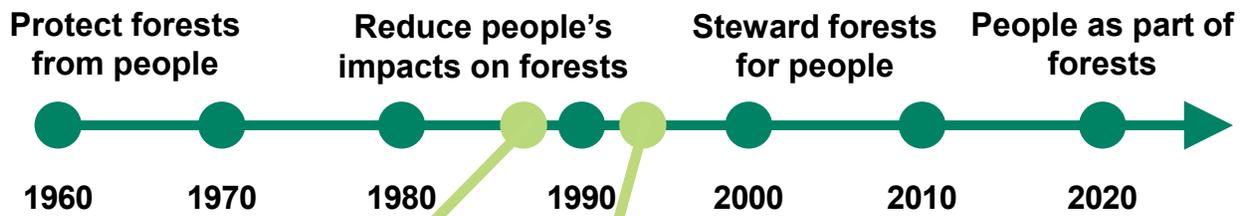
New Forestry

In 1989 and 1992, two seminal papers were published describing "New Forestry" - stewardship applying understanding of structure, function, and dynamics of natural forests to achieve integrated environmental, economic, and social outcomes ("Ecological Forestry").

FOCUS

TOWARD A NEW FORESTRY
By DR. JERRY FRANKLIN

Brainchild of a group of scientists and rangers and driven by increasing resource conflict and decline, these concepts are a revolution in the making.

New Forestry in Eastern Spruce-Fir Forests: Principles and Applications to Maine

Robert S. Seymour
and
Malcolm L. Hunter, Jr.

MAINE AGRICULTURAL AND FOREST EXPERIMENT STATION
University of Maine

Finally, in the early 2000s, there was growing recognition of the plurality of values derived from forests, both material and non-material, and management efforts increasingly focused on supporting this diverse array of values. At the same time, integrations between Western science and Indigenous knowledge increased, and there was increasing emphasis on the importance of adaptation to climate change and other stressors. Today, many foresters tie adaptation to ecological silviculture practices, focusing on cultivating diverse stands as an important pathway for recovery following disturbance.

Forest Science

Dr. D'Amato discussed the fact that we are emerging from a period of historic investment in the infrastructure, experiments, people, and tools needed to better monitor and understand how forests work and how humans affect forest functioning. Although investment in the areas has decreased sharply in recent years, Dr. D'Amato asserted that we are still benefiting from the legacy of this period in our deepened understanding of forests today.

More recently, we have seen a consistent turn toward actionable and inclusive science that incorporates diverse worldviews. This has included a focus on coproduction of research, including frontline communities in project development. This work tends to be more place-based and emphasizes "braiding" Indigenous worldviews with Western science.

Supporting forest into the future

Dr. D'Amato then posed a question to the audience: "What is our role in managing and supporting our forests in the context of adaptation?" Discourse around this topic has become more polarized, with some arguing that we should intervene and others insisting that natural forest adaptation process should be allowed to proceed unimpeded. Dr. D'Amato took the former position, asserting that if we value certain forest states or specific species, proactive adaptation efforts can help support these values for the long term.

To illustrate his point, Dr. D'Amato mapped approaches to forest management along two axes: passive to active intervention, and low to high impact of climate change on priority values. He acknowledged that we need all four "quadrants" on the chart to mount an effective response to climate change, but suggested that we often get only one or two.
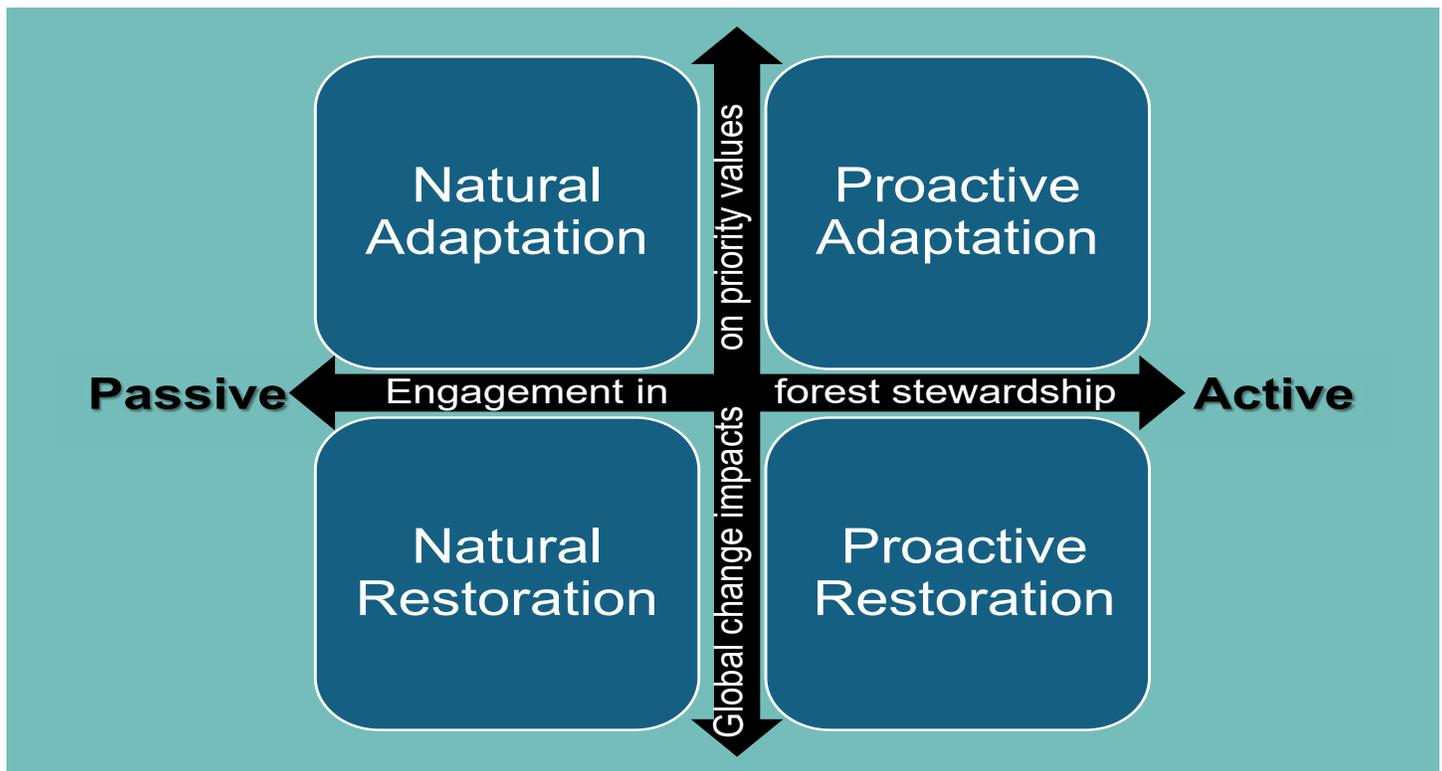
Natural adaptation may allow the forest to shift into a novel, stable alternative state, but that state may not provide our desirable range of values; if the goal is for the forest to continue to support the values we desire, we may need to identify turning points where action is needed to help that forest adapt.

Science guiding future stewardship

Finally, Dr. D'Amato acknowledged that future forest stewardship can be significantly bolstered by emerging technologies, including remote sensing technologies and new approaches to analyze large datasets.

"Digital forestry tools can enhance understanding of human relationships with the forest and one another, but they can't replace them"

However, he argued, we also need to rely more deeply on each other: resilient forest partnerships can provide critical for support for forest stewardship efforts as we move into increasingly uncharted territory. The forest research and management community is united in its committed to "forest conservation, forest stewardship, and adaptation irrespective of funding level and whether it's politically popular or not." Relying on partnerships where we focus less on "what's in it for me" and more on "how can I help achieve this shared goal" can buoy us through this challenging time, said Dr. D'Amato.
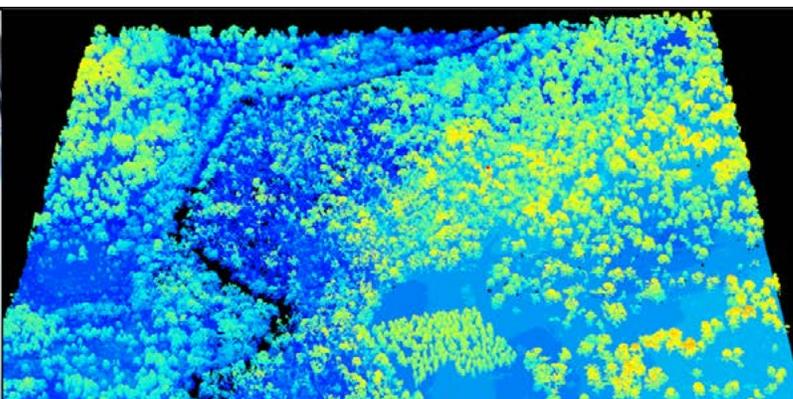
Northeastern States Research Cooperative

Tools for rehabilitative silviculture in degraded hardwood stands

John Foppert, Paul Smith's College

Neal Maker, Forest Biometrics Research Institute

Alex George, Paul Smith's College

Bruno Silva, University of Georgia

Nathaniel Andersen, U.S. Forest Service

Justin Waskiewicz, Paul Smith's College

Abstract

Across the Northern Forest, millions of acres of northern hardwoods languish in a degraded condition while, simultaneously, critical early-seral habitats and the wildlife populations that depend on them are in decline. Rehabilitative silviculture strategies to restore productivity, diversity, and resilience to degraded hardwood stands are fairly well developed and if more widely implemented would significantly enrich habitat quality throughout the region. However, significant barriers stand in the way of their implementation. Rehabilitative silviculture requires foresters to assess conditions at tree-, group- and patch-scales in non-uniform, mixed-species stands with highly variable timber quality. They must then assimilate that information into the design and implementation spatially explicit treatments. Few tools exist to support this complicated management decision process, to quantify the prospective gains of the approach, or to guide its implementation if a forester were to put it into practice. This presentation will describe the effort underway to develop management tools to support this important, challenging silvicultural approach. We are developing a decision support toolkit that can specify the optimal spatial arrangement of rehabilitative treatment types within a degraded northern hardwood stand. It combines improved, spatially-explicit empirical models of harvesting costs and residual stand damage, optimized crop tree selection guidelines, and a novel procedure for optimizing the spatial delineation of treatment type using digital elevation models, mapped crop tree locations, and summarized stand-level inventory information.

Figure 1 Fieldwork for rehabilitative silviculture to enrich habitat and restore productivity in degraded hardwood stands.

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

Lucas B. Harris, University of Vermont

Melissa Pastore, USDA Forest Service, Northern Research Station, Forest Inventory & Analysis

Anthony D'Amato, University of Vermont

Abstract

Tree regeneration is foundational to forest health and resilience, yet regional assessments of tree regeneration patterns in the northeastern USA suggest widespread and varied challenges related to climate change, herbivory, shifting disturbance regimes and non-native pests and pathogens. In this project supported by the Northeastern States Research Cooperative, we are using data from the national forest inventory to examine tree regeneration patterns across the Northern Forest region and their implications for future forest dynamics and management. In particular, we are building upon recently developed methods to assess bottlenecks in seedling survival and sapling recruitment using a regional dataset called the Regeneration Indicator in which seedlings are surveyed in six different height classes rather than the single size class otherwise used by the national forest inventory. Recently-completed work highlights the growing importance of browsing by white-tailed deer (Odocoileus virginianus) on seedling survival, and how browse impacts vary both by seedling size and species palatability. In ongoing work, we are (1) identifying trends in tree regeneration since 2003 and its implications for climate change vulnerability, forest resilience and departure from historical composition; and (2) examining response of tree regeneration to natural disturbances and timber harvests. We have found declines in sapling recruitment for some northern tree species such as Abies balsamea that are projected to fare poorly in future climates, yet also persistently low sapling abundance of species that are more resilient to disturbance and pests and pathogens including Acer rubrum, Acer saccharum and Quercus species. An emerging theme of our work is that composition of the small seedling layer (<30 cm tall) is more favorable than the large seedling and sapling layers in terms of overall resilience as well as abundance of key species, suggesting the utility of management targeted at survival and growth of already-established seedlings.
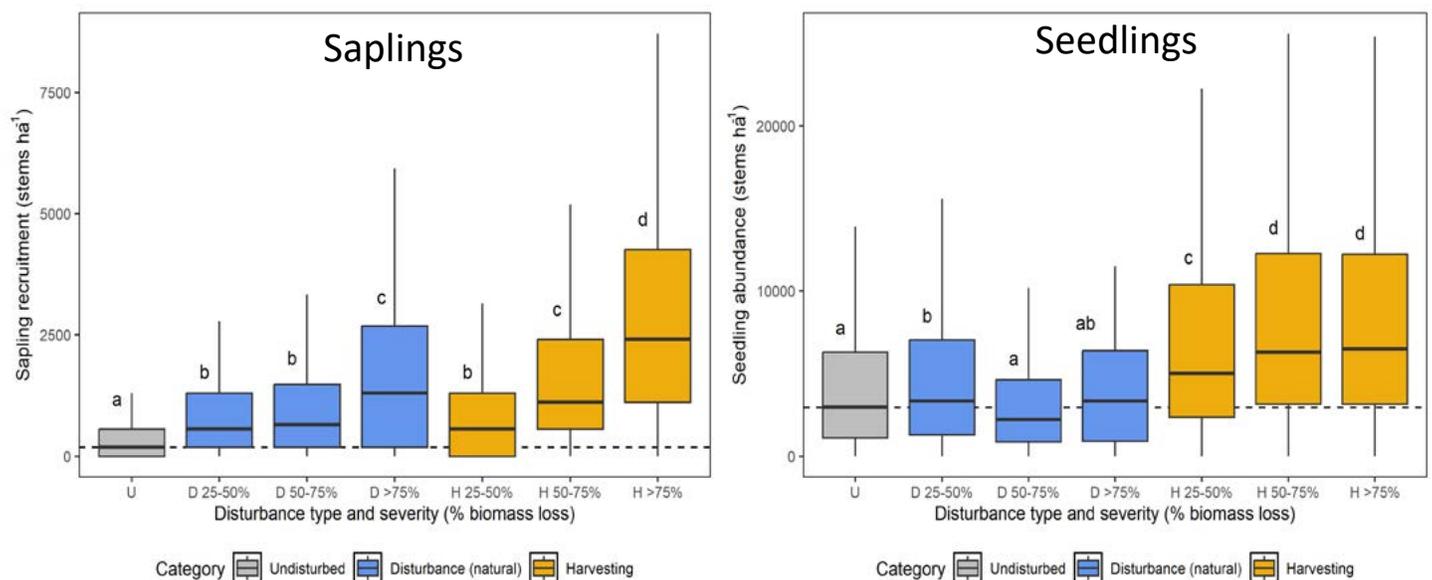
Figure 2 Regeneration response to disturbance.

Comprehensive Utilization of Forest Residue Biomass for Fermentative Bioproducts and Solid Biofuels

Ankita Juneja, State University of New York College of Environmental Science and Forestry

Sushant Gawali, State University of New York College of Environmental Science and Forestry

Mohit Kumar, State University of New York College of Environmental Science and Forestry

Deepak Kumar, State University of New York College of Environmental Science and Forestry

Timothy Volk, State University of New York College of Environmental Science and Forestry

Abstract

Forest residue biomass (FRB), an abundant yet underutilized lignocellulosic resource, holds significant potential for the sustainable production of bioplastics and biofuels. This study investigates the comprehensive utilization of FRB through a dual approach: valorization of the carbohydrate fraction for fermentative bioproducts and hydrothermal carbonization (HTC) of the lignin-rich fraction for solid biofuels. Residues from Cherry, Ash, and Maple were characterized individually and as a 1:1:1 mixture to evaluate their suitability for bioproduct generation. Distinct bioconversion efficiencies among hardwood species affected overall sugar yields, while the mixed-species feedstock showed promising conversion performance, suggesting improved flexibility for industrial utilization. Varying the mixing composition demonstrated the potential to maximize sugar yields by leveraging the strengths of each species, thereby supporting the development of more robust and adaptable biorefineries aligned with circular bioeconomy principles. The lignin-rich fraction was valorized through HTC, performed on loblolly roundwood residue (LRR) as a representative feedstock. Experiments conducted at 180-280 ?C with a fixed reaction time of one hour revealed that hydrochar yield decreased by 26.26% with increasing temperature, accompanied by marked improvements in fuel quality. The maximum higher heating value at 280 ?C was 1.75 times greater than that of raw LRR, confirming the suitability of the hydrochar as a green solid fuel. The Van Krevelen plot further showed progressive enrichment of carbon and reduction of oxygen, aligning the hydrochar properties with those of conventional coals. Characterization demonstrated that the specific surface area peaked at 2.66 m2/g at 200 ?C before declining at higher temperatures, suggesting trade-offs between fuel densification and surface functionality. This integrated approach highlights the feasibility of complete FRB utilization for advancing resource-efficient biorefineries, enhancing feedstock flexibility, and promoting sustainable strategies for valorization of FRB.
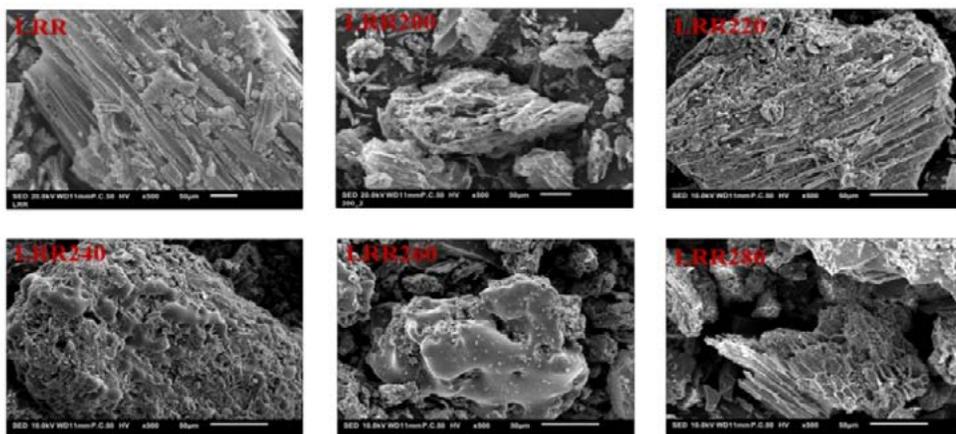
Figure 3 Forest residue biomass for fermentative bioproducts and solid biofuels results.

Sustaining basketmaking in Waponahkik through increased accessibility, processing, and storage opportunities

John Daigle, Ash Protection Collaborative Across Waponahkik (APCAW) at the University of Maine

Darren Ranco, Professor of Anthropology and Director of the Wabanaki Center University of Maine

Abstract

With the onset of EAB in forests where Wabanaki basketmakers harvest, our project goal is to advance basketmaker stewardship of remaining healthy ash and develop technologies that support the processing and storage of ash splints before widespread mortality. Ultimately, this will sustain the material supply for Wabanaki basketry. Woven into each component of this project are experimental learning and involvement opportunities for youth in the Wabanaki Youth in Science (WaYS) program at sites of cultural access, demonstrations of harvesting technologies, and planning workshops for long-term ash storage.

This project takes a community-driven approach that prioritizes participation of Wabanaki ash harvesters. We will partner with Tribal Nations, nonprofits, and an intertribal data trust to further Indigenous-led adaptation responses to EAB. Wabanaki ash harvesters identified three bottlenecks in their basketmaking processes, which will be addressed through the methods below:

1. Access: Gather Wabanaki ash harvesters on funded trips to locations in the Northeast forest region with healthy brown ash, where landowners permit Wabanaki harvesting. After these trips, hold semi-structured discussions with participants to understand their preferences for accessing sites and data sovereignty.

2. Processing: Travel with Maine-based Wabanaki ash pounders to other Northeastern Indigenous communities to learn from other mobile pounding machine models. Hold demonstrations of a local mobile pounder machine, before holding a workshop with Wabanaki harvesters to plan its governance.

3. Storage: Host public community sessions with Tribal Nations beyond Maine to discuss ash storage efforts. Bring together interested individuals and Tribal Natural Resource staff to workshop a Maine Wabanaki community ash storage center.

Each of these project methodologies will strengthen Wabanaki people's connection to ash by providing access to brown ash stands, technologies for processing brown ash, and direct material supply, thereby supporting intergenerational cultural knowledge transfer.

Figure 4 Program activities of the Ash Protection Collaborative Across Waponahkik (APCAW).

Evaluating the utility of static stand structure-derived estimates of forest demographic change in the wake of nonnative insect pests and disease

Jeff Garnas, University of New Hampshire; Carlisle Bascom Jr., University of New Hampshire, Virginia Tech; Carrie Fearer, Virginia Tech; Andrew Liebhold, Czech University of Life Sciences; Songlin Fei, Purdue University

Abstract

Nonnative insect pests and diseases (NNPDs) have reshaped forest ecosystems across northeastern North America and globally, yet the long-term impacts of these sustained biotic disturbances on forest structure and composition remain poorly understood. We applied de Liocourt's Law, a log-linear, forest-scale model of the tree size-density relationship, to assess how six major NNPDs have altered host tree demography across the eastern U.S. Using Forest Inventory and Analysis (FIA) data and historical invasion records at that county or multi-county scale, we calculated baseline relative mortality (BRM) and estimated sapling abundance (ESA) for host species across gradients of invasion duration.

Among the six NNPD-host systems studied, only American beech (Fagus grandifolia) exhibited a sustained demographic shift in response to beech bark disease (BBD), with a 38-fold increase in ESA and roughly a doubling of BRM across the invasion gradient. This pattern reflects the strong mortality-recruitment feedbacks characteristic of the beech-BBD pathosystem. In contrast, other systems--including hemlock-hemlock woolly adelgid, ash-emerald ash borer, and oak-spongy moth interactions--showed minimal or inconsistent changes in host tree BRM and ESA, despite clear evidence of elevated empirical mortality (EM) in some cases. Butternut and American chestnut densities were insufficient to effectively estimate de Liocourt-derived demographic rates.

ESA was positively correlated with empirical sapling density (ESD) across systems (r = 0.81; P < 0.0001) suggesting that de Liocourt-derived metrics can serve as useful proxies for recruitment potential. However, BRM and EM were generally uncorrelated, highlighting the complexity of interpreting structural change from static size distributions. Our findings demonstrate that NNPDs do not uniformly disrupt forest structural equilibria, even for highly impacted host species, and that recruitment dynamics--in addition to mortality alone--are critical to understanding long-term forest trajectories. This work highlights a plausible framework for assessing forest resilience and demographic change in response to biotic disturbance.
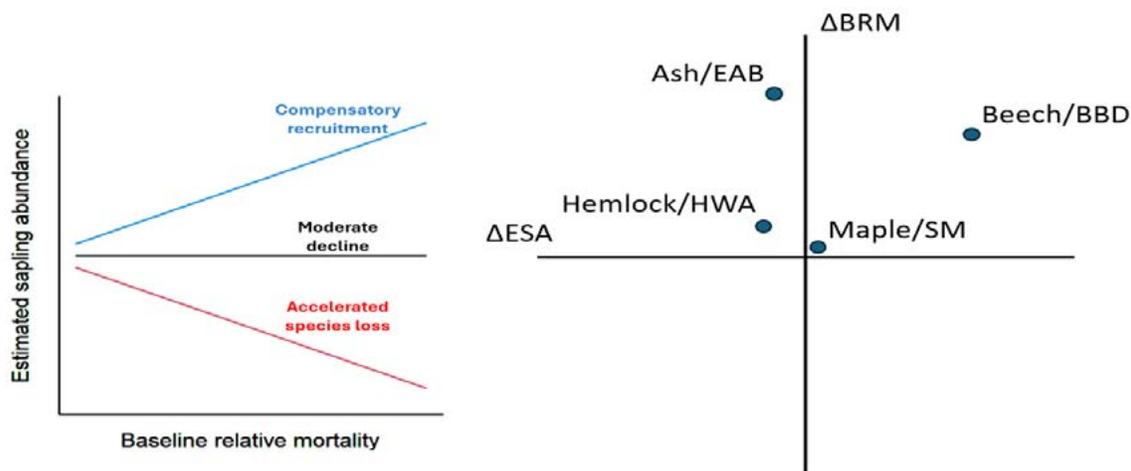
Figure 5 Estimated sapling abundance as related to baseline relative mortality for four tree species.

Tree Rings and Mud: An (ongoing) Collaborative Reconstruction of Historical fire regimes in Northern New Hampshire

Simon Pendleton, Plymouth State University; Lisa Doner, Plymouth State University; Christopher Guiterman, Cooperative Institute for Research in Environmental Sciences, University of Colorado at Boulder and NOAA's National Centers for Environmental Information; John Neely, New Hampshire Department of Natural and Cultural Resources; Virginia Moore, Plymouth State University; Maggie DelBove, Plymouth State University; Oliff Doiron, University of Arizona; Elizabeth Hastings, Plymouth State University; Alex Hynes, Whitman College; Aidan Gifford, Plymouth State University; Gabriel Talon, University of Maine; Mathew Coleman, Plymouth State University

Abstract

The presence and use of fire in northern forests is an increasingly important topic in light of ongoing climate, land use, and population changes. While the displacement of Indigenous populations, a gradually wetter and more humid climate, and the implementation of fire suppression have dramatically decreased the frequency and severity of wildfires in New England over the last century, it has also, in part, driven changes in forest composition, health, and fire risk. In particular, fire adapted ecosystems have shrunk and become fragmented. Recently, land managers have begun to embrace the need for restoration of fire adapted forest types and have begun to integrate prescribed fire into management plans but lack direct actionable data on past fire regimes. To fill this need, we assembled a broad collaborative group that includes paleoecologists, managers, and Indigenous partners engaged in reconstructing past fires in the Saco and Swift River basins of northern New Hampshire. Tree-ring records from fire-adapted red pine stands, along with charcoal and pollen analyses from nearby lake and bog sediments are being used to build comprehensive regional records of fire from modern to pre-colonial times. Preliminary lake sediment charcoal analyses reveal copious but variable charcoal concentrations following deglaciation through ~7.5 ka, followed by lower but more consistent charcoal concentrations. Over a dozen tree-ring fire scar sites, most extending into the 1700s or earlier, from the study area reveal patterns of recurrent, low to moderate severity fire on 10-20-year intervals. In some areas, scarred trees document extensive, landscape-scale fires through the 18th and 19th centuries, ending after 1909 when the state passed its first forest protection laws. Already in this nascent endeavor we are finding unequivocal evidence that contradicts the northern forests as purely "asbestos" and, moreover, that there is value in preserving and using fire to maintain relic red pine communities that have experienced fire for thousands of years until the recent century.

Figure 6 Fire scars on white and red pine at several locations in New Hampshire.

Red pine, Green Hills Preserve
North Conway, NH

White pine, Lyme Hill
Lyme, NH

Red pine, Mou
Bartlett,

Shifting the Conversation: Building Shared Purpose Across Vermont's Landscape

In-person panel discussion

Emilie Inoue, VT Agency of Agriculture, Food and Markets

Pieter van Loon, Vermont Land Trust

Noah Hoffman, VT Department of Forests, Parks and Recreation

Abstract

What becomes possible when institutions and individuals choose to lean toward one another with curiosity, care, and honesty to face shared challenges? We are living in a time that calls for real and honest conversation if we want to move toward shared understanding and lasting change.

Grounded in the context of invasion biology, this story explores how language can both harm and heal, and how reframing it invites accountability, belonging, and transformation. Vermont's scale, culture, and spirit of collaboration offer a unique opportunity to explore what this shift can look like in practice.

This presentation tells the story of how an intentional focus on language, rooted in care and connection, has opened space for greater alignment of shared values, goals, and purpose across Vermont's state agencies and non-governmental organizations. Representatives from the Vermont Land Trust, Vermont Agency of Agriculture and the VT Department of Forests, Parks and Recreation share how language became a bridge between boundaries and a catalyst for trust and collaboration.

Figure 7 Messaging examples that use different framing strategies.

Fungal Ecology

Restoring Multi-Functional Riparian Forested Buffers

Jess Rubin, UVM

Josef Gorres, UVM

Luca Kolba, UVM

Carol McGranaghan, Abenaki Artist Association

Abstract

A restoration project, grown from a previous pilot, tested whether mycorrhizae can improve phosphorus (P) mitigation, and pollinator functions of degraded riparian forested buffers (RFBs) on a local farm in Vermont while facilitating Abenaki access to ancestral lands. Six plots within a degraded RFB were restored with a multi-functional plant community. Three restored plots were inoculated with endemic mycorrhizae (RVM), three restored plots were not inoculated (RV), and an additional three control plots (OIV) remained in their degraded state, dominated by aggressive nonnative shrub Rhamnus cathartica. The restoration palette consisted of 42 (10 tree, 6 shrub, 16 herbaceous,10 groundcover) species which were all pollinator hosts and beneficial to Abenaki, offering P removal opportunities through honorable harvest. While Total soil P in restoration treatments were not significantly different, concentrations in the control were significantly higher than in the RV and RVM (p < 0.001) plots. This pattern was mirrored in the Mehlich III extractable P and the water extractable soluble reactive P data. While there was no statistically significant difference in treatment for plant P uptake, there was for both category and species (p < 0.001) respectively. Herbaceous and fruiting plants uptake more P than shrubs. The correlated patterns across the above three soil/water P metrics suggest restoring a degraded riparian buffer with a diverse, multi-synusial palette can mitigate P while providing food and medicine. Phytoextraction with cyclical harvest has promising implications for reducing P concentrations in runoff and percolate. There were statistically significant differences in plant diversity between the control and restored plots (p < 0.001), as expected, but not between restored plots. A mean of 52 volunteer species were detected in the restored plots within a year of restoration, doubling plant species richness, indicating succession. Design and installation of diverse native, polyculture palettes, non-chemical removal of R. cathartica, and strategically timed harvest of P accumulating plants maximizes RFB's multi-functional support for trophic resilience; and begins socio-ecological reconciliation of colonial agriculture's legacy.
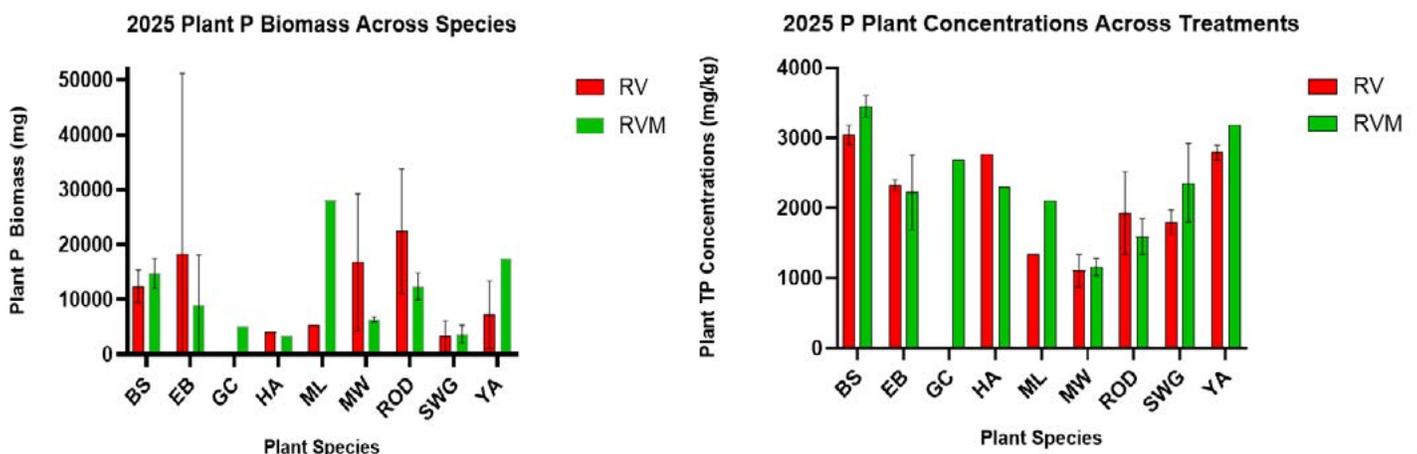
Figure 8 Total plant P biomass and concentration. Phosphorus uptake significantly differs across the three plant categories (herbaceous, fruit, and shrub).

Fungi of Vermont

Bethany Beech, VT Mycological Society/ Fungal SAG

Savannah Ferreira, VT Forests, Parks and Recreation/ Fungal SAG

Annabelle Langlois, VT Mycological Society/ Fungal SAG

Rick Van de Poll, Ecosystem Management Consultants/ Fungal SAG

Dave Muska, Ondatra Adventures/ Fungal SAG

Jess Rubin, MycoEvolve/ Fungal SAG

Abstract

The kingdom Fungi contains an estimated 2.2- 3.8 million species worldwide and is one of the most widely distributed organisms on Earth (Hawksworth and Lucking, 2017). Fungi can live in soil or water and often form a spectrum of symbiotic relationships with other organisms, including animals, protists, bacteria, plants, algae, and even other fungi. Despite their cosmopolitan range and broad habitat, only approximately 144,000 species of Fungi have been described worldwide with only 1,165 macrofungi species being observed and reported in Vermont as of 2023 (Willis 2018, VT Atlas of Life). Thus, their diversity remains largely unknown, especially in rare and threatened natural community types. A Fungal Scientific Advisory Group (Fungal SAG) was established in 2023 to elevate the importance of fungi and perform the necessary tasks of documenting their diversity, rarity, sensitivity to current and further development in Vermont, their contribution to forest ecosystems in the Northeast, and their crucial role in natural communities. Fungal SAG received funds from FEMC for the creation of the Vermont Fungi Atlas, an online and publicly available database that will allow the Fungal SAG group to analyze historical trends, create a baseline data set from which to track future trends, and explore landscape patterns of fungi in Vermont and subsequently surrounding states. This database compiled disparate datasets from over 37,000 records and provided a baseline of 3,826 species of fungi in Vermont. In addition, this database will continue to serve as a backbone for data storage and comparison for future fungal forays in rare, threatened, and endangered natural communities in Vermont.
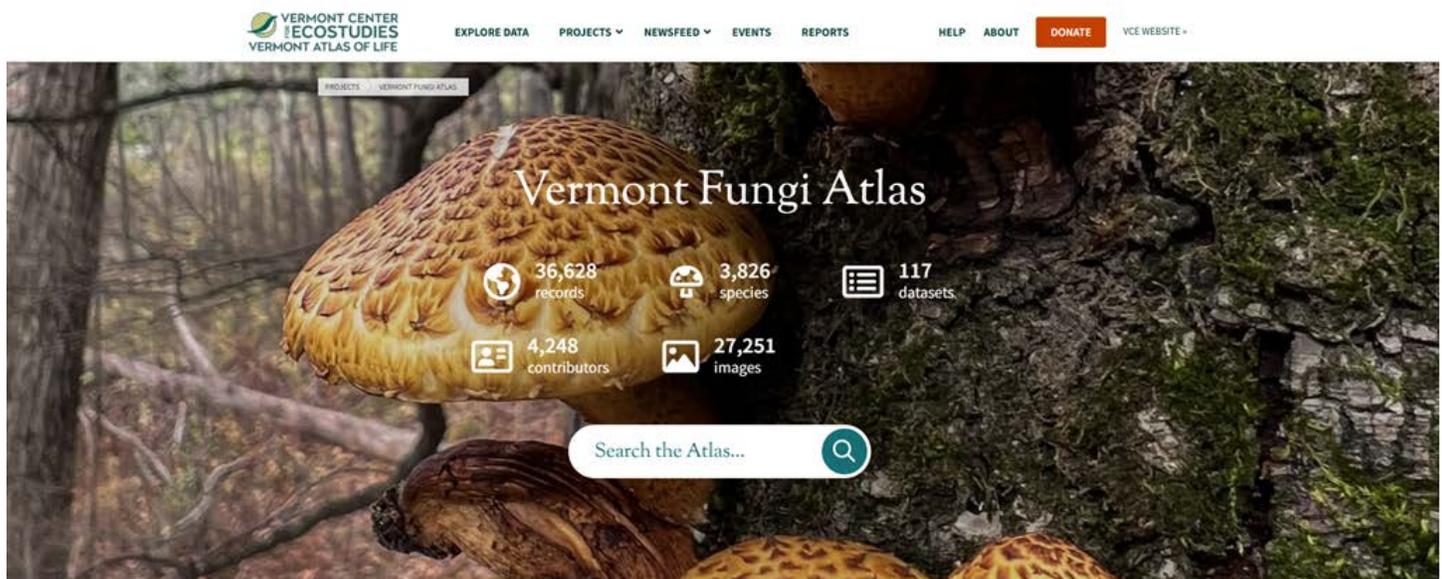
Figure 9 The Vermont Fungi Atlas website is available in the Vermont Atlas of Life through the Vermont Center for Ecostudies

Forest Planning

Planting with Purpose: Lessons from Vermont's New Guidelines for ANR Lands

Danielle Owczarski, Vermont Department of Fish and Wildlife

Al Freeman, Vermont Department of Forests, Parks & Recreation

Grace Glynn, Vermont Department of Fish and Wildlife

Abstract

How we plant today shapes Vermont's forests for decades to come -- but until recently, state-owned lands lacked a consistent framework to guide when, where, and what we plant. From 2022 to 2024, the Vermont Agency of Natural Resources developed the Planting Guidelines for ANR State Lands, the first set of unified principles designed to improve the success, ecological value, and climate resilience of restoration projects across state properties.

These guidelines were built through a collaborative process involving staff from multiple ANR departments, scientific literature review, and lessons in the field. They provide practical recommendations for species selection, seed sourcing, microsite considerations, planting timing, survival benchmarks, and adaptive management. They are intended as a living resource -- grounded in science but flexible enough to be applied across Vermont's diverse landscapes.

Figure 10 The Planting Guidelines for Agency of Natural Resources Lands is available for resource managers.

Equally important is what the guidelines do not do. They are not prescriptive planting lists that replace site-level judgment, nor do they provide a one-size-fits-all monitoring framework. They also do not instruct practitioners in the mechanics of planting -- such as how to dig holes, handle seedlings, or prepare stock for planting. And sometimes, the best action is restraint: the guidelines remind us that in many cases, natural regeneration, soil seed banks, and resilient ecosystems may accomplish restoration more effectively than intervention.

This presentation will share the story of the guidelines' development, explore the challenges of balancing flexibility with standardization, and highlight early lessons from implementation. I will also pose a broader set of questions for the FEMC community: How do we balance simplicity and usability with ecological nuance? How can guidelines like these better link to long-term monitoring data? And most importantly, how do we act as responsible stewards today so that future generations in Vermont inherit resilient forests -- and not additional problems?

By presenting this work, I hope to spark discussion not just about Vermont's planting guidelines, but about how we -- as a region -- can think differently about the role of planting (and not planting) in sustaining resilient, biodiverse, and climate-adapted forest ecosystems.

Thirty Years of Organic Family Forestry in Vermont's Center-West Ecoregion

David Brynn, Vermont Family Forests Foundation

Abstract

Vermont Family Forests was established as a 501c3 non-profit forest conservation organization in 1995 as an alternative to industrial forestry.

Forty landowners in Chittenden and Addison Counties attended an initial meeting at the Old Bristol High School. The VFF Optimal Conservation Practice (OCP) checklist in its original form was presented. It was informed by the intention to seek FSC certification. The OCPs have been updated and revised but still focus on maintaining and enhancing forest ecosystem health as inspired by Aldo Leopold: "Health is the capacity of the land for self-renewal!"

Rewilding practices to protect our ecological commons were given top priority. These include water quality, wildlife species richness, atmospheric carbon sequestration and storage, and forest ecosystem resilience in the face of a rapidly changing climate and culture.

The brief talk will explore VFF's approach to sustainable forestry, which seeks to be ecologically feasible, economically viable, and socially responsible. Practices such as uneven-aged management by area regulation, access roads as 'lines of grace', log forwarding, 'lump sum plus' logging contracts, local value adding, and creating a 'portfolio of what the forest is willing to yield'. VFF Projects such as the McCardell Bicentennial Hall at Middlebury College, the Green Mountain Club's headquarters, UVM's Rubenstein School renovation, and more will be featured.

Figure 11 Vermont Family Forests support private landowners in forest-centered conservation and management of their lands.

Forest Ecology

Where the Wildlands Aren't: Expanding Ecological Representation in the Northeast

Brian Hall, Wildlands, Woodlands, Farmlands & Communities

Liz Thompson, Wildlands, Woodlands, Farmlands & Communities

Robert Zaino, Vermont Fish and Wildlife Department

Shelby Perry, Northeast Wilderness Trust

Jason Mazurowski, Northeast Wilderness Trust

Abstract

Wildlands--self-willed lands--are places where natural ecological processes prevail. Wildlands were the dominant land cover in the Northeast prior to European settlement. Today, around 6% of the northeast (NY and New England) is currently conserved as Wildland. But where exactly are those wildlands located, and what do they protect? We assessed the distribution of Wildlands across the Northeast, and the natural communities that are represented in Wildlands. While the mountains and high-elevation natural communities are relatively well-represented in Wildlands, most ecoregions of the northeast essentially have no Wildlands, and many widespread natural community types are very poorly represented in Wildlands. We propose that Wildlands should be distributed across all ecoregions of the northeast, and should represent all the natural communities of the region. To assist in future conservation, we present a draft web map tool that identifies ecoregions and natural communities that are poorly represented in Wildlands.
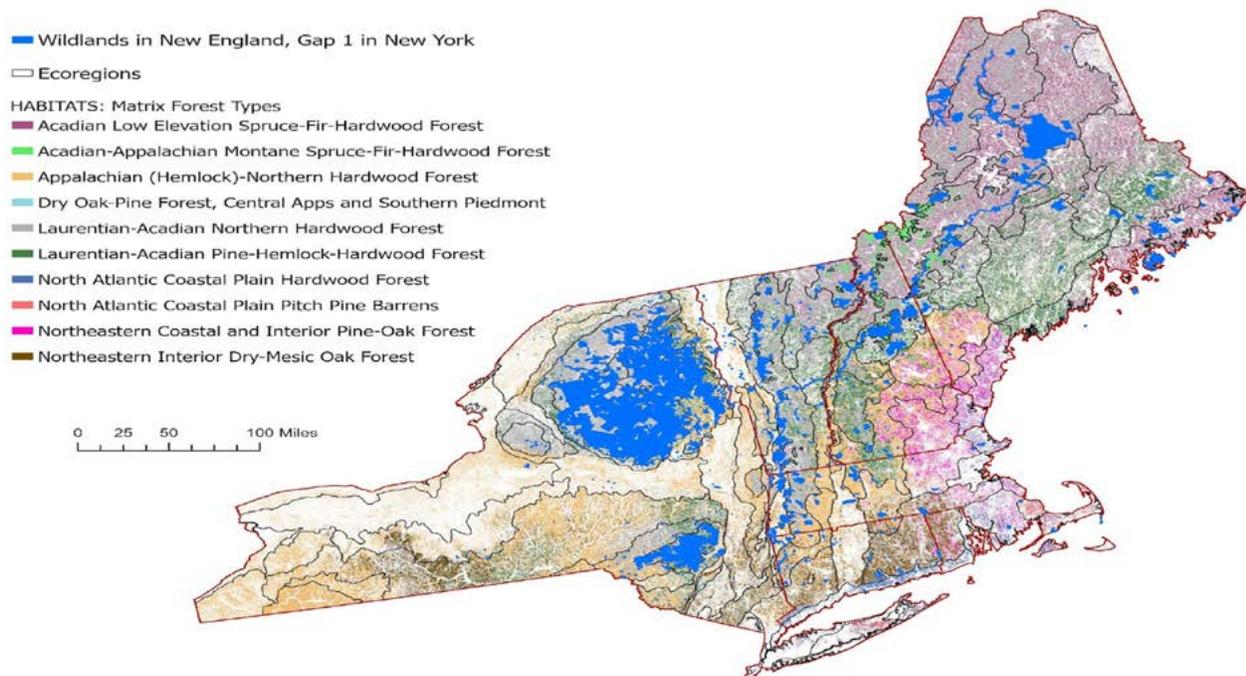
Figure 12 Wildlands (in blue) overlaid on ecoregion and habitat (Eco-Hab) layers to determine what percent of each EcoHab is Wildland.

Caterpillar abundance in a northern hardwood forest: exogenous effects, endogenous feedbacks, and multidecadal trends

Miranda Zammarelli, Dartmouth College

Matthew Ayres, Dartmouth College

Michael Hallworth, Vermont Center for Ecostudies

Richard Holmes, Dartmouth College

Sara Kaiser, Cornell Lab of Ornithology

Nina Lany, U.S. Forest Service

Nicholas Rodenhouse, Wellesley College

Scott Sillett, Smithsonian Migratory Bird Center

Michael Webster, Cornell University

Abstract

In many ecosystems, caterpillars (Lepidoptera larvae) are the dominant primary consumers and serve as conduits for energy flow to other invertebrates, birds, bats, and other higher order consumers. As such, fluctuations in caterpillar abundance can influence ecosystem processes such as energy flow and material cycling. We measured caterpillar abundance in a north-temperate hardwood forest for 50 years. Caterpillars varied by > 20-fold among years. The fluctuations involved concordant dynamics of different Lepidoptera clades. There was density-dependence in aggregate abundance with a noisy equilibrium that declined from about 50 to 20 caterpillars / 8000 leaves from 1970 to 2021. We tested mechanisms for determination of caterpillar abundance that included weather, host plant quality, and predator abundance. We found no relations between caterpillar abundance and thermal sum, minimum winter air temperature, date of leaf-out, temperature during leaf expansion, or foliar nitrogen. Nor were there relations with abundance of birds or Hymenoptera. Precipitation was the only putative mechanism we found. High precipitation in water-year t-1 and in the summer of t-1 was associated with fewer caterpillars in year t. Furthermore, average annual precipitation increased from 1355 to 1568 mm between 1965 and 2023, so we hypothesize that precipitation favors fungal entomopathogens, which negatively affect caterpillars. Although poorly known and rarely studied, fungal entomopathogens might be rising or falling in importance in any ecosystem where precipitation is changing. Future studies need to evaluate the effect of fungal pathogens on caterpillar populations to understand the impact of changing caterpillar abundance on ecosystems.
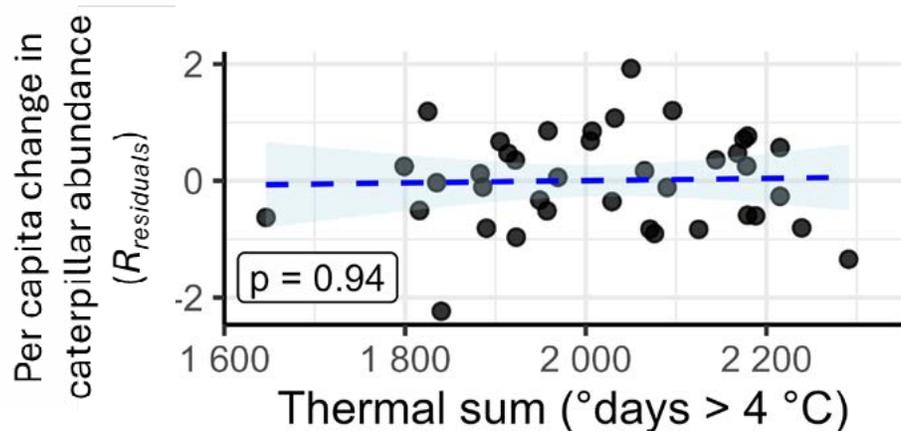
Figure 13 Change in caterpillar abundance based on thermal sum.

Protecting birds in protected areas: a multi-scale analysis of forest structure on avian occurrence

Bruna Amaral, Michigan State University

Jeff Doser, North Carolina State University

Aaron Weed, National Park Service

Kate Miller, National Park Service

Elise Zipkin, Michigan State University

Abstract

Protected areas are critical for conserving biodiversity, but their effectiveness may depend on conditions beyond their boundaries. In the Northeastern US, 40% of the land is forested across protected, private, and public ownerships, yet several National Parks in the region have experienced avian declines. Understanding how habitat structure across spatial scales influences bird occurrence is key to evaluating the role of protected areas in long-term conservation.

We used bird point counts and forest structure data from eight National Parks to assess how tree density, basal area, conifer cover, late-successional forest, and shrub cover influence the occurrence of 16 forest-interior bird species. Using a multi-park, multi-scale removal-sampling model, we tested how these forest structure effects at the local, park, and county levels affect bird occurrence.

Forest structure within parks was more frequently selected than regional-scale covariates (23 vs. 10 times), underscoring the strong influence of habitat inside protected areas. Local-scale factors had the greatest support, affecting 13 species, while county-scale variables influenced 12, showing that surrounding landscapes also shape occurrence. Tree basal area was the most influential variable (nine species). Late-successional basal area was generally positive, except for black-throated blue warblers, reflecting their use of intermediate-age and early-successional habitats. Shrub cover supported several species, while high tree density favored red-eyed vireos and black-throated green warblers. Although park size affected relatively few species, larger parks benefited ground-foraging birds and bark-nesters.

Our findings highlight that even relatively small protected areas (28 - 1,156 ha) provide essential breeding habitat for forest-dependent birds. However, species' presence was often affected by broader landscape conditions, underscoring the need to integrate landscape context into conservation strategies. These insights can help managers identify species most vulnerable to land-use change and design management actions that support the persistence of forest bird communities.
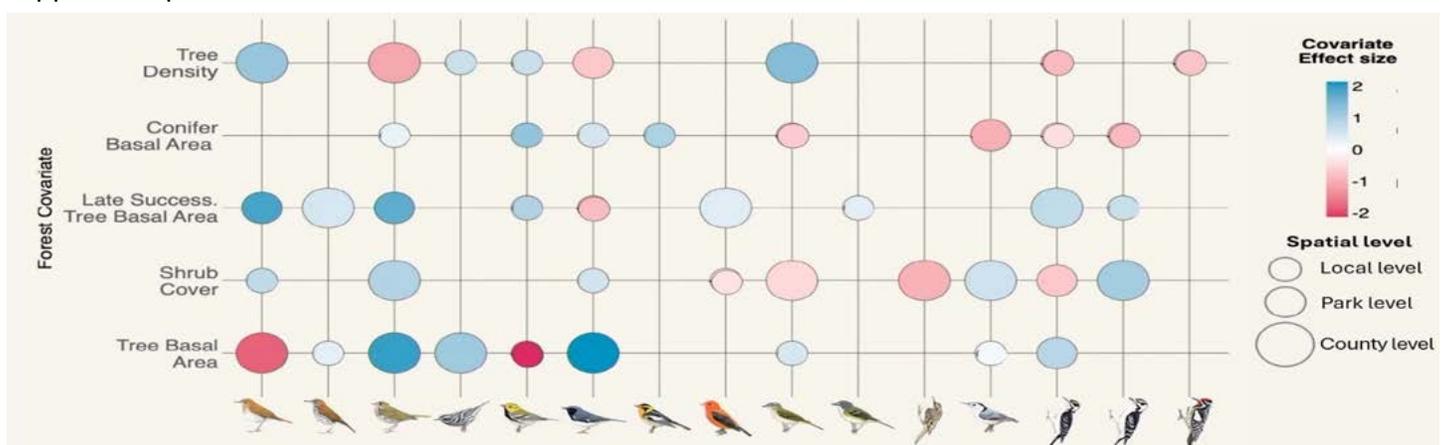
Figure 14 In analyzing spatial levels and several covariates, there was not an optimal scale for all species, but different scales and covariates that are important to each species.

Tracking spring wildflower temporal niche across the microclimatic gradients of northeastern temperate deciduous forests

Morgan Southgate PhD, Research Team, Appalachian Mountain Club

Jordon Tourville PhD, Research Team, Appalachian Mountain Club

Abstract

In the temperate deciduous forests of eastern North America, spring-active wildflowers are vulnerable to climate change based on their strategy for seasonal light acquisition. This diverse group of plants is characterized by their temporal niche, emerging after snowmelt but before canopy leaf-out to assimilate a significant portion of their yearly carbon budget. This shade-avoidance strategy, known as phenological escape, is particularly important for the spring ephemerals, which rely entirely on the spring light window for their yearly growth. As canopy trees leaf out earlier with warmer spring temperatures, is wildflower phenology keeping pace with this shift? This study is the first year of a long-term monitoring effort aimed at tracking the temporal niche and seasonal growth dynamics of a diverse set of spring wildflowers at fine spatial scales. In the spring of 2025, we established 32 plots across Mt. Equinox (in southern Vermont) and Mt. Moosilauke (in central New Hampshire). We determined plot location by stratifying across gradients of topography and elevation: specifically, we 1) identified warm and cool aspect slopes, 2) separated each slope into increments spanning 200 ft of elevation gain, and 3) identified exposed and sheltered microsites within each slope aspect and elevational band combination. We resampled all plots nine times, following National Phenology Network protocols to generate more than 7000 phenological observations of 110 species of understory plants. We measured physiological parameters for a subset of spring wildflower taxa using a LI-COR LI-600, estimated percent canopy cover with a spherical densiometer, and measured photosynthetically active radiation using a MQ-500 quantum light meter. We stationed a TOMST TMS-4 datalogger at each plot, generating measurements of soil moisture, soil temperature, and air temperature at sub-daily temporal scales. We used a Bayesian generalized additive mixed modeling framework to assess temporal variation in spring wildflower phenological and physiological traits, with functional group, light availability, and microclimate as population-level effects. Preliminary results demonstrate significant differences in physiology by functional group, with proxies for photosynthetic rate highest for the spring ephemerals, indicating an aggressive growth strategy to compensate for their short growing season. Microclimate varied significantly along gradients of elevation and topography; adjacent sheltered and exposed microsites exhibited strong differences in soil moisture and subtle differences in soil and air temperature. We will leverage results to assess the possibility of identifying microrefugia for spring wildflower biodiversity - microclimates where the extremes of macroclimatic warming are buffered, potentially providing vulnerable taxa with more time for adaptation and migration and helping to prioritize conservation efforts.

Figure 15 Images on the ground an of the canopy showing wild leeks present when the canopy was open, but mostly gone as the canopy closed.

Pests and Pathogens

Terrestrial eDNA surveys for forest and plant pest detection: a trial using spotted lanternfly as a test species in Rhode Island

Alana Russell, Rhode Island Department of Environmental Management

Donna Coutu, Rhode Island Department of Environmental Management

Abstract

Terrestrial environmental DNA (eDNA) sampling is an emerging survey technique that has enhanced the detection and monitoring of cryptic or emerging pest species, especially in areas where there are barriers to conventional sampling. These surveys involve the collection of minute traces of DNA left behind by target species (such as insect molts, frass, or honeydew) on bark or foliage, and performing highly sensitive lab assays to confirm presence/absence of eDNA. In the fall of 2023 and 2024, the Rhode Island Forest Health Program conducted a state-wide eDNA survey for the invasive plant pest spotted lanternfly (SLF). Objectives were two part: (1) to assist the RI Division of Agriculture with SLF detection and (2) use SLF as a test species to advance program and partner skills for future eDNA surveys of forest health threats. We will discuss the results of the two-year SLF eDNA survey, including strengths and weaknesses of using eDNA sampling in detection of a fast-spreading plant pest. We will also discuss the potential for using terrestrial eDNA surveys for other forest pest detection efforts and summarize current research efforts and protocol development for other target species.

Figure 16 Four counties had positive detections for spotted lanternfly eDNA surveys in Rhode Island.
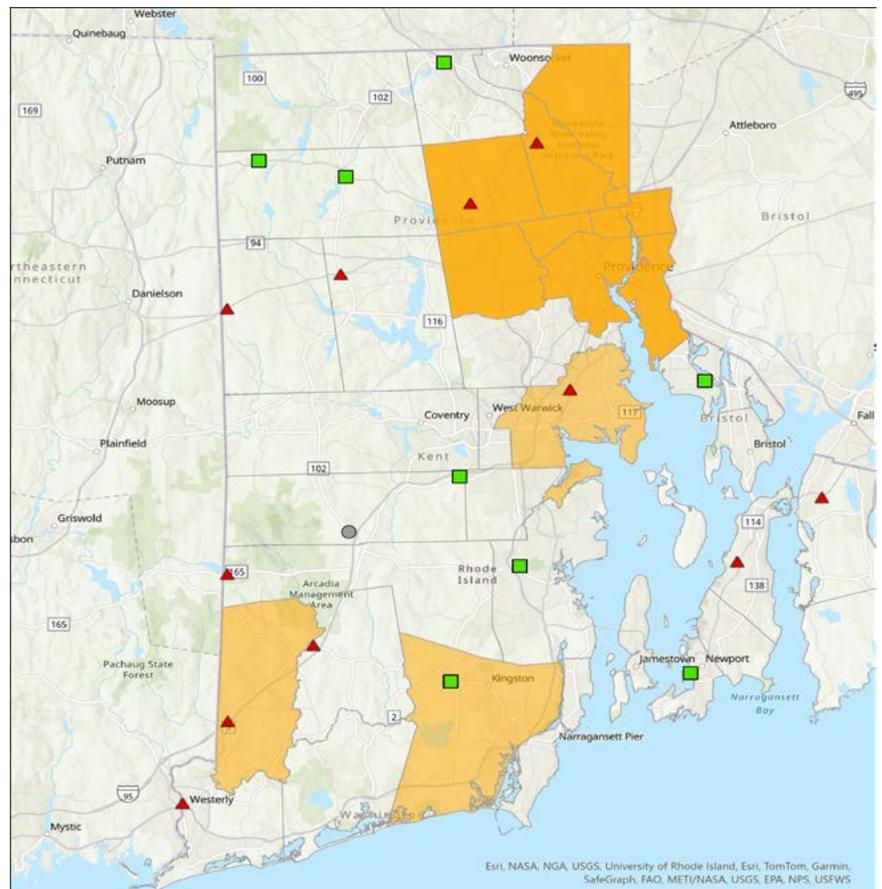
A resurgence of red pine scale in New York

Amanda Dillon, New York State Department of Environmental Conservation

Liam Somers, NYSDEC; Erica Culbert, NYSDEC

Jessica Cancelliere, NYSDEC

Rob Cole, NYSDEC

Abstract

In August 2024, NYSDEC staff morphologically confirmed red pine scale infestations inside the Adirondack Park after conducting surveys of declining red pine on islands in Lake George and in a nearby red pine plantation. Red pine scale was first discovered on Long Island in 1950 after which it is believed to have quickly wiped out all red pine south of Westchester County. It continued to expand its range northward up the Hudson valley with the next most recent report from Dutchess County in 1985. After that, reports are silent either because of difficulty in survey and identification or cold winter temperatures precluding further northward expansion. In 2025, NYSDEC staff conducted surveys of red pine stands from a radius centered on the 2024 detections to determine the extent and severity of red pine scale across the northern part of the state. At each site we collected samples for microscopic examination and morphological confirmation of red pine scale. We also characterized red pine health at randomly located plots recording live crown ratio, crown transparency, and severity of dieback via a flagging score. To date, it looks like this most recent infestation may be limited to the immediate vicinity around the 2024 detection, sites to the north and west are, so far, clear of red pine scale infestations. Preliminary results suggest that in the presence of red pine scale, red pine health is worse in plantations than in natural-occurring red pine stands. As single-species, even-aged plantations have matured, they've become increasingly stressed from competition, poor site conditions, and climate extremes like drought and heat. The stress weakens the trees' defenses and allows opportunistic pests, like red pine scale, to successfully attack. We have also identified other insects taking advantage of weakened red pines including pine gall weevil, red pine cone beetle, and red pine adelgid. Further complicating this study is the fact that genetic testing of specimens collected in 2024 confirmed the insect was not the same species as the red pine scale introduced from Japan. It is unknown if this species has diverged genetically over the past 80 years from feeding on a novel host or if this is an entirely different insect altogether. Collaboration this summer with the Canadian Forest Service in trapping individuals for a population genetics study will hopefully elucidate what exactly we are dealing with and how best to manage it on the landscape.
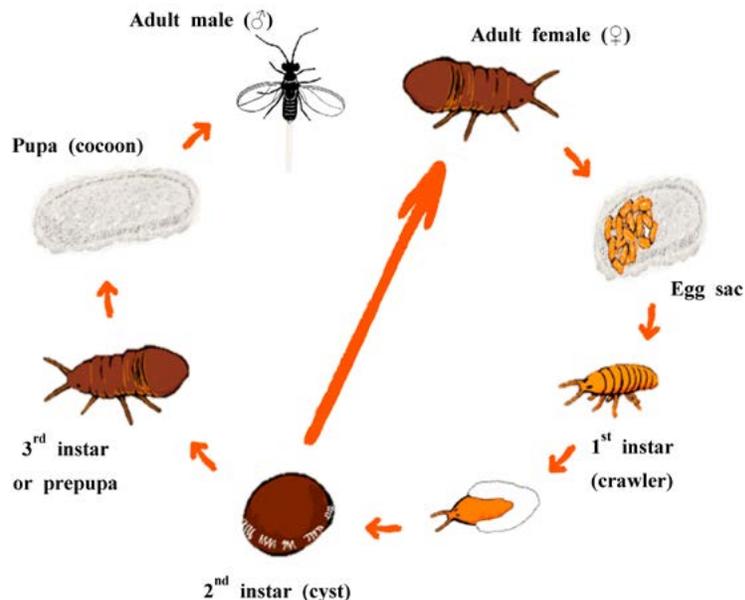
Figure 17 The life cycle of red pine scale.

The New Kid on the Block: Laurel Wilt in New York State

Kelsey McLaughlin, New York State Department of Environmental Conservation

Abstract

The New York State Departments of Environmental Conservation (DEC) and Agriculture and Markets, Cornell Cooperative Extension of Suffolk County, and the Cornell University Plant Disease Diagnostic Clinic confirmed the presence of laurel wilt on Long Island in September 2025. The invasive ambrosia beetle that vectors the disease, the redbay ambrosia beetle, was also discovered in the diseased area. This represents a jump of over 580 miles and is the first record of the pathogen infecting trees in the northeast. DEC has responded by surveying over 3,000 host plants (sassafras and spicebush) throughout New York State. This presentation will cover the history of the initial detection, what we've learned since through surveys, the biology of the pathogen and its vector, and survey tips and tricks to help other states be on the lookout for this pathogen.
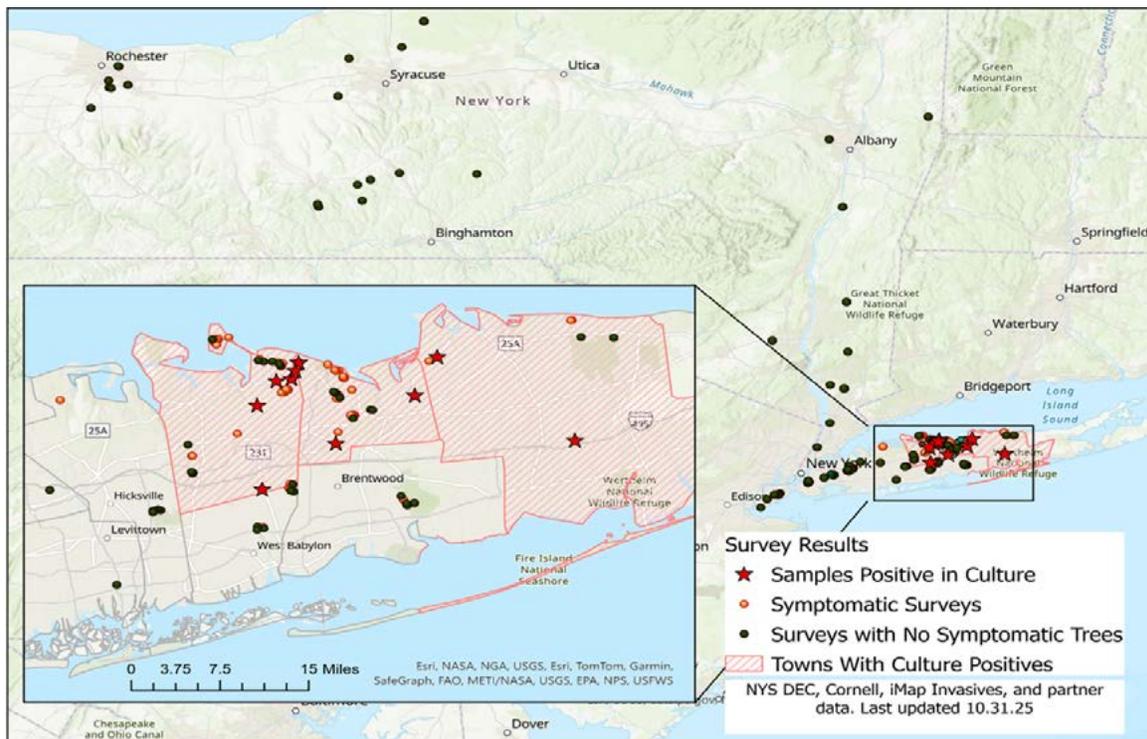
Figure 18 Map of sampling locations on Long Island; symptomatic plants exhibiting laurel wilt.

Jumping worm monitoring at FEMC forest health monitoring plots

Ben Porter, FEMC

Matt Rios, FEMC

Abstract

Jumping worms (Amynthas spp.) are an emerging invasive threat to northeastern forests, altering soil structure, nutrient cycling, and forest regeneration. Distribution of these invasive worms in the forested landscape is somewhat unknown in our region. To address knowledge gaps in their prevalence and distribution in northeastern forests, the Forest Ecosystem Monitoring Cooperative (FEMC) has integrated jumping worm surveys into its existing regional forest health monitoring protocol. This addition leverages FEMC's established network of 196 long-term monitoring plots located across forests in New England and New York to collect data on jumping worm presence/absence and habitat conditions. Preliminary findings provide insight into the spatial extent of infestations across the northern forests.

Figure 19 Jumping worms were found in 8 of 171 plots sampled by FEMC in 20225.
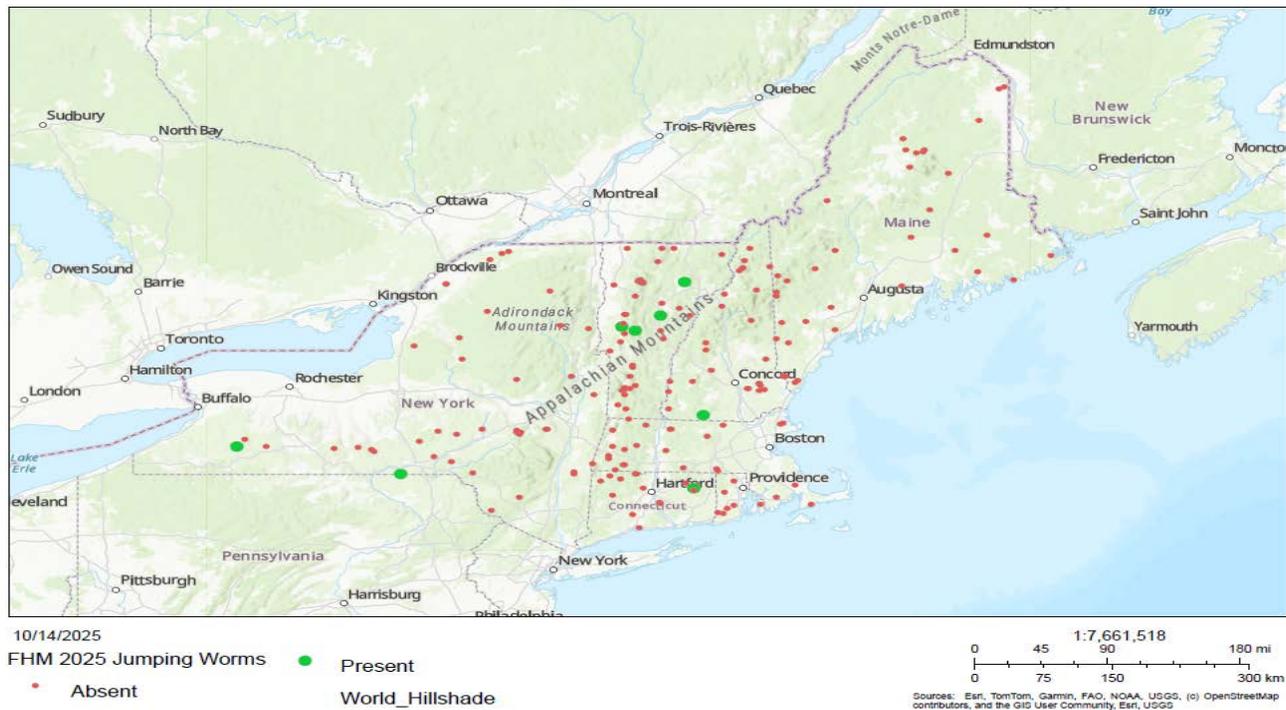
2025 Maine Spruce Budworm Update

Allison Kanoti, Maine Forest Service; Brittany Schappach, Maine Forest Service

Abstract

Spruce budworm (SBW) is a native moth that defoliates balsam fir and spruce trees during the larval phase. SBW is capable of periods of widespread outbreaks that can cause extensive damage and mortality to spruce-fir forests after several years of feeding.

In 2023 and 2024, monitoring data suggested SBW populations were building toward an outbreak in northern Maine. With the increase of SBW in this area, timberland owners and managers in Maine formed the Maine Budworm Response Coalition (MBRC). The coalition collaborates with the MFS, the University of Maine at Fort Kent, the Cooperative Forest Research Unit, the Maine Forest Products Council, and others to reduce the impacts of SBW as it builds toward outbreak conditions. Coalition leadership successfully advocated for funding to implement an Early Intervention Strategy (EIS), a method developed and tested in New Brunswick, Canada, to reduce SBW populations below the outbreak threshold.

The Early Intervention Strategy (EIS) for spruce budworm (SBW) is an integrated pest management approach that targets and controls small, growing SBW populations (hot spots) before they cause widespread damage to forests. It aims to prevent outbreaks from developing into major events by using tools like monitoring, early detection, and targeted insecticide applications. When growing SBW populations are reduced, natural enemies and other mortality factors can keep SBW populations from erupting.

Approximately 242,000 acres of spruce fir forest in Maine were treated with lepidopteran-specific insecticides containing active ingredients tebufenozide (Mimic) or Btk (Bacillus thuringiensis kurstaki, Foray) in 2025. Applications were made by helicopter or fixed-wing aircraft using modern technologies.

2025's treatment program appears to have been a successful implementation of EIS. Field observations in treatment zones showed:

1. SBW that succumbed to insecticide after consumption of treated foliage,

2. SBW feeding on foliage of lower branches, in the shadow of the upper canopy, were unaffected by insecticide,

3. Activity of insect, other invertebrate, vertebrate and fungal natural enemies against SBW that did not succumb to insecticide,

4. Evidence of survival of non-target lepidopteran larvae(such as the later developing black-headed budworm) that fed after the insecticidal activity declined.

L2 monitoring in fall 2025 will help quantify treatment efficacy and identify areas that may be considered for treatment in 2026.

EIS is a new tool for SBW management in addition to those that have been used traditionally. Land managers are encouraged to continue to prioritize management of high-risk stands before significant SBW populations build; to consider EIS where it is practical; and in areas where EIS is not practical, managers can plan to apply insecticides following a foliage protection strategy, conduct salvage or pre-salvage harvests, or take no action.
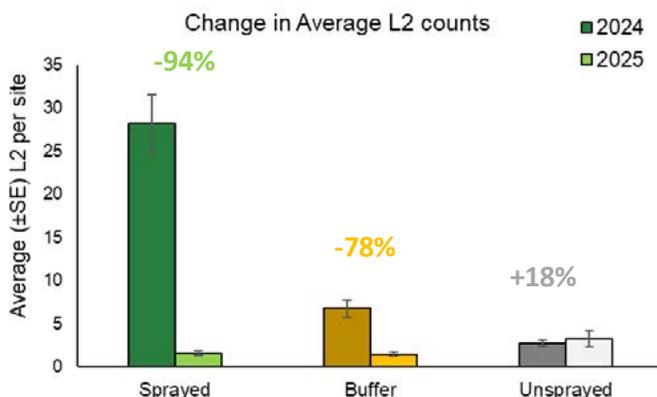
Figure 20 Preliminary analysis of LT monitoring shows a year over year reduction in the treated and buffer areas.

Beech Leaf Disease Monitoring and Mitigation via Silvicultural Treatments

Kelsey McLaughlin, New York State Department of Environmental Conservation

Abstract

The New York State Department of Environmental Conservation (DEC) has been surveying for and researching beech leaf disease (BLD) since it was first found in New York in 2018. The DEC is researching how the disease progresses with the US Forest Service monitoring plot program, and has up to seven years of data at the oldest plots. Changes in leaf cover, symptom expression, and mortality over time will be discussed. While various chemical treatments for beech leaf disease are being studied, treatments for beech in the forest have largely been unaddressed. DEC, the US Forest Service, and SUNY-ESF are studying silvicultural treatments on 210 acres across New York State to look at the effects of canopy thinning and understory removal on BLD progression. While the project is still ongoing, the pretreatment data, project setup, and current year's data will be discussed. This presentation will provide attendees with an overview of ongoing statewide beech leaf disease research in New York.
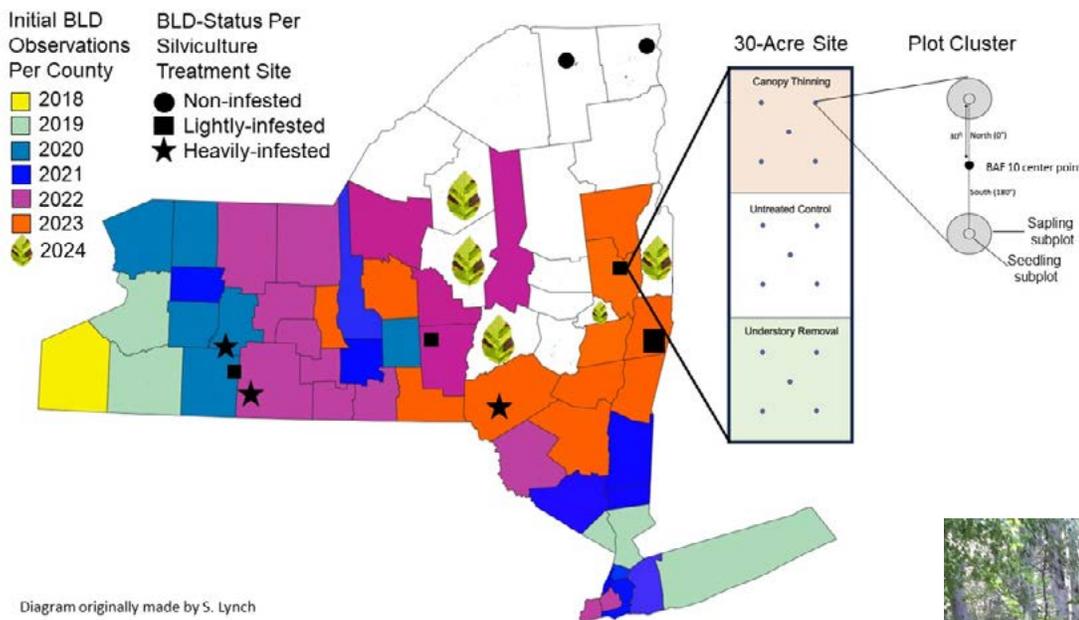
Figure 21 Observations of BLD across NY and the location of silvicultural treatment sites to test management effectiveness.

15 Years of White Pine Needle Damage: What Have We Learned?

Nicholas Brazee, University of Massachusetts

Abstract

Eastern white pine (Pinus strobus) has an outsized importance throughout New England as the region's most abundant conifer. For the past 15 years, white pine needle damage (WPND) has stressed and weakened white pines across natural and managed forests. This talk will briefly summarize what we have learned about this disease and how landowners and stewards can best manage WPND. Specific topics will include: (1) the native fungal needle blight pathogens responsible for the disease; (2) the role that climate change has in stimulating disease development; (3) how eastern white pines are responding and adapting to the chronic stress of premature needle loss; and (4) specific management strategies that can reduce disease severity. With no end in sight, forest managers must actively incorporate WPND mitigation into their management plans to maximize the health of white pines.

Figure 22 Examples of white pine needle damage.

Hemlock woolly adelgid biological control: Signs of hope for eastern forests

Nicholas Dietschler, Cornell University

Abstract

The hemlock woolly adelgid (HWA, Adelges tsugae) is a non-native pest threatening eastern and Carolina hemlock forests across eastern North America. Multiple management strategies are being implemented throughout the invaded range, with classical biological control showing the greatest promise for long-term suppression. Two predatory beetles, Laricobius osakensis from southern Japan and La. nigrinus from western North America, and two predatory flies Leucotaraxis argenticollis and Le. piniperda from western North America are currently the most promising agents.

The Laricobius species have become widely established and dispersed widely across parts of HWA southern introduced range, often being successfully integrated with chemical treatments. Until recently, beetle establishment was under-studied in the Northeastern US, with previous research indicating establishment is limited by winter temperatures. However, new surveys have confirmed Laricobius populations at release sites in Pennsylvania, New York (NY), and Maine, with La. nigrinus now spreading naturally across NY suggesting beetles may be more suitable to northeastern climates than previously thought.

Although Laricobius predation on the overwintering (sistens) generation of HWA is substantial, long-term suppression has been constrained by density-dependent rebound of the spring (progrediens) generation, highlighting the need for complementary predators. The Leucotaraxis fly species show strong potential to fill this role. Leucotaraxis argenticollis has demonstrated suitability to eastern conditions in field trials, and early signs of establishment have been documented in NY and Virginia. In summer 2025, Le. argenticollis was recovered from a NY site four years post-release, the first confirmed evidence of wild establishment. As HWA continues its northward spread, these advances in biological control provide renewed hope for the future of northeastern hemlock forests.

Figure 23 Leucotaraxis releases and establishment in New York.
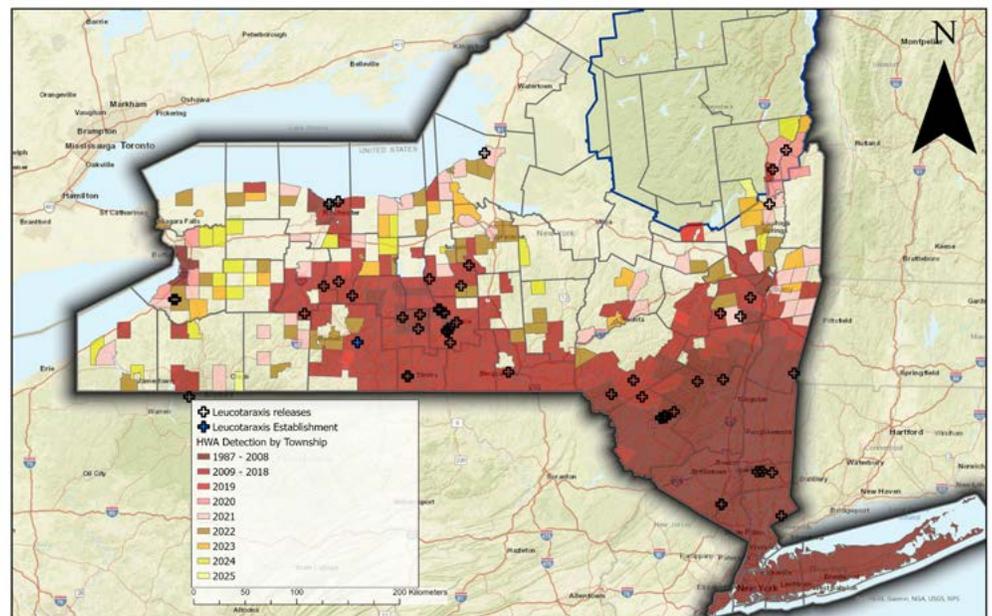
Wildlife

AMMonitor: A case study in automated detection for invasive Cuban Treefrog with a two-stage machine learning approach

Kaitlin Huber, Vermont Cooperative Fish and Wildlife Research Unit

J. Hardin Waddle, U.S. Geological Survey, Wetland and Aquatic Research Center, 700 Cajundome Blvd, Lafayette, LA, USA

Brad M. Glorioso, U.S. Geological Survey, Wetland and Aquatic Research Center, 700 Cajundome Blvd, Lafayette, LA, USA

Therese Donovan, U.S. Geological Survey, Vermont Cooperative Fish and Wildlife Research Unit, Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT, USA

Abstract

The AMMonitor package is a data storage and analysis ecosystem that can be utilized to improve automated detection and adaptive management of target species. In a case study of AMMonitor, we illustrate one method of automated detection for the Cuban treefrog, an invasive species in the southern United States of particular management interest. We used a two-stage approach for detecting these treefrogs. In the first stage, audio data is screened for initial detections using template matching, in which the detections contain both true and false positives. In the second stage, false positives are filtered out using machine learning classifier algorithms. We used this method to process 139,985 audio recordings collected at 13 locations in Louisiana and Florida from 2014-2022. From the stage 1 template matching, we detected 83,191 Cuban treefrog signals across recordings. The stage 2 machine learning model was able to identify stage 1 false positive detections with a testing accuracy of 98.46% and a testing false positive rate of 1.116%. After pruning false positive detections, a total of 20,271 individual Cuban treefrog detections remained, distributed mainly across 3 sites in an area with known presence. Incorporated into ongoing acoustic monitoring programs, our automated detection approach may help expedite removals and slow the dispersal and establishment of this species into new areas. Additionally, we provide a short introduction to the upcoming AMSDM R package, which includes a collection of tools for both "structured decision-making" and "species distribution modeling" in wildlife management within the AMMonitor system.

Figure 24 Cuban tree frog detection using audio monitoring and machine learning to remove false positive detections. Audio detections correspond to known presence at three sites.

Acoustic Monitoring Informs Ruffed Grouse Habitat Management in Northeastern Forests

Kayley Dillon, Vermont Cooperative Fish and Wildlife Research Unit, University of Vermont, Burlington, VT, USA

Katherina Gieder, Vermont Department of Fish and Wildlife, Rutland, VT, USA

Robert Abrams, U.S. Forest Service, Green Mountain National Forest, Manchester Center, VT, USA

Christopher Bernier, Vermont Department of Fish and Wildlife, Springfield, VT, USA

Joseph Cahill, U.S. Forest Service, Green Mountain National Forest, Rochester, VT, USA

Susan Statts, U.S. Forest Service, Green Mountain National Forest, Rochester, VT, USA

Scott Wixsom, U.S. Forest Service, Green Mountain National Forest, Manchester Center, VT, USA

Therese Donovan, U.S. Geological Survey, Vermont Cooperative Fish and Wildlife Research Unit, Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT, USA

Abstract

Ruffed Grouse are a charismatic bird species that thrives in early successional forests in the northeast. As young forests have become increasingly scarce in the region, grouse populations have declined, fueling interest in forest management efforts to create suitable habitat for early successional species. We used passive acoustic monitoring and machine learning to document Ruffed Grouse distribution patterns, analyze their habitat associations, and inform future forest management efforts. Over the past 3 years, we monitored 62 sites in Green Mountain National Forest (GMNF) and collected over 15,000 hours of audio recordings. We identified both drumming males and vocalizations made by other grouse such as females and nonbreeding individuals. In this talk, we present preliminary results from multi-season, multi-state occupancy models to better understand the effects of forest structure and composition on grouse distribution and inform habitat management efforts in GMNF.

Figure 25 Ruffed grouse detections at locations in the Green Mountain Forest, blue dots indicate positive detection; red dots indicate no detection.
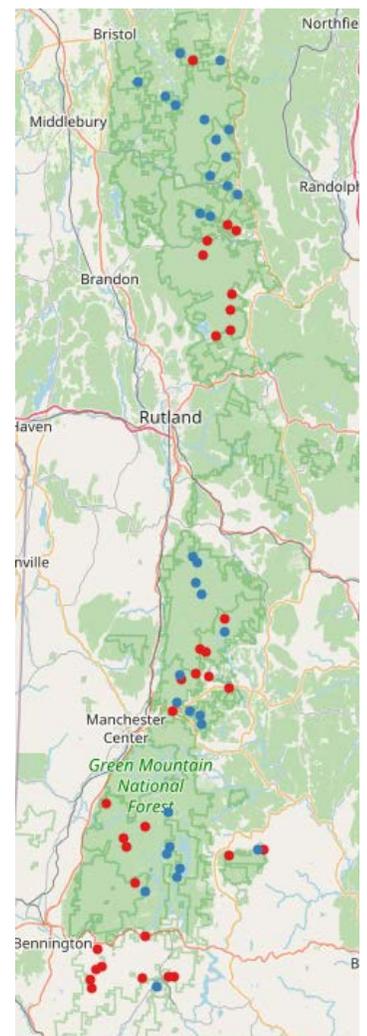
DeepFaune New England: Building a regional trail camera species classifier

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Abstract

Trail cameras allow for the rapid collection of troves of images that traditionally require manual annotation to identify animals. This manual labeling can be labor intensive, requiring substantial resources and potentially delaying analysis and management/conservation actions. Recent advances in image classification have allowed machine learning models to achieve high (>90%) performance in identifying species from trail camera imagery. Here, we describe the process of training DeepFaune New England, a model for classifying 24 taxa (including the "no-species" label to indicate the absence of animals) from the northeastern United States. The model achieved 97% accuracy when tested on out-of-sample images. We describe the formation of a training dataset, model training via transfer learning, evaluation of model performance, and areas for future development.
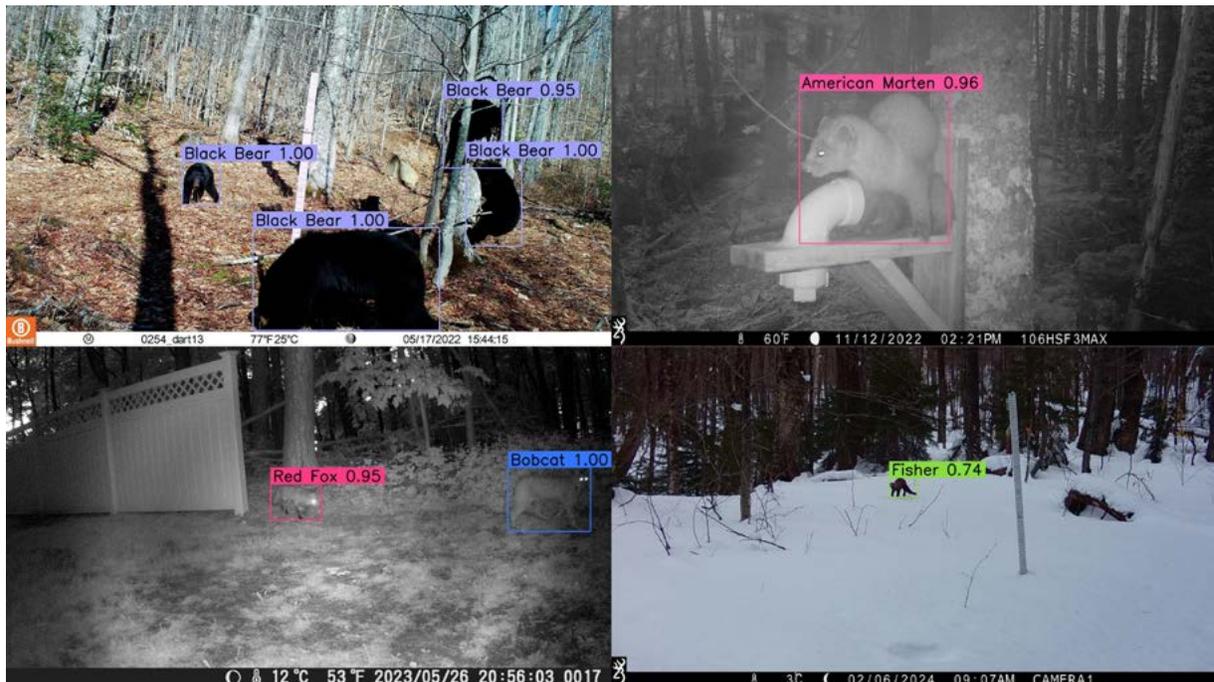
Figure 26 Wildlife classifications using the DeepFaune New England model.

Analyzing habitat factors consistent with river otter (Lontra canadensis) abundance in the Lewis Creek watershed

Lydia Emry, University of Vermont

Elizabeth Doran, University of Vermont

Brittany Mosher, University of Vermont

James Murdoch, University of Vermont

Lilo Schultz, University of Vermont

Margreta Grady, University of Vermont

Abstract

Human encroachment, development, and land-use change degrade the quality and functionality of floodplains throughout North America. River otters are often considered to be an indicator species of the health of freshwater and floodplain ecosystems, and a keystone species due to their effects on other species and ecosystem function. In Vermont, river otters are widespread, but are sensitive to environmental change such as habitat alteration, conversion, and loss. Habitat associations in the state are poorly understood and important for better understanding the species' ecology and responses to environmental change. We collected otter detection/nondetection data using camera traps at 49 sites located every 1.5-kilometers along a stream network in the Lewis Creek Watershed from May, 2024, to December, 2024. We predicted that river otter presence would be associated with conifer forests, silty soils, and incised banks, which provide sources of prey and shelter. Logistic regression and a model selection approach were used to determine the factors that had the greatest impact on river otter presence. The top model indicated that bank vegetation protection (+), the presence of agriculture (+), and medium intensity developed lands were the best predictors of river otter presence (+). It is possible that the increased implementation of riparian buffers and best management practices in Vermont's agricultural areas may result in an increase in vegetative protection around the entrance of river otter dens, reduce nutrient inputs that may hinder their abundance of prey, and improve the connectivity between aquatic and terrestrial habitats more efficiently than our original predictions.
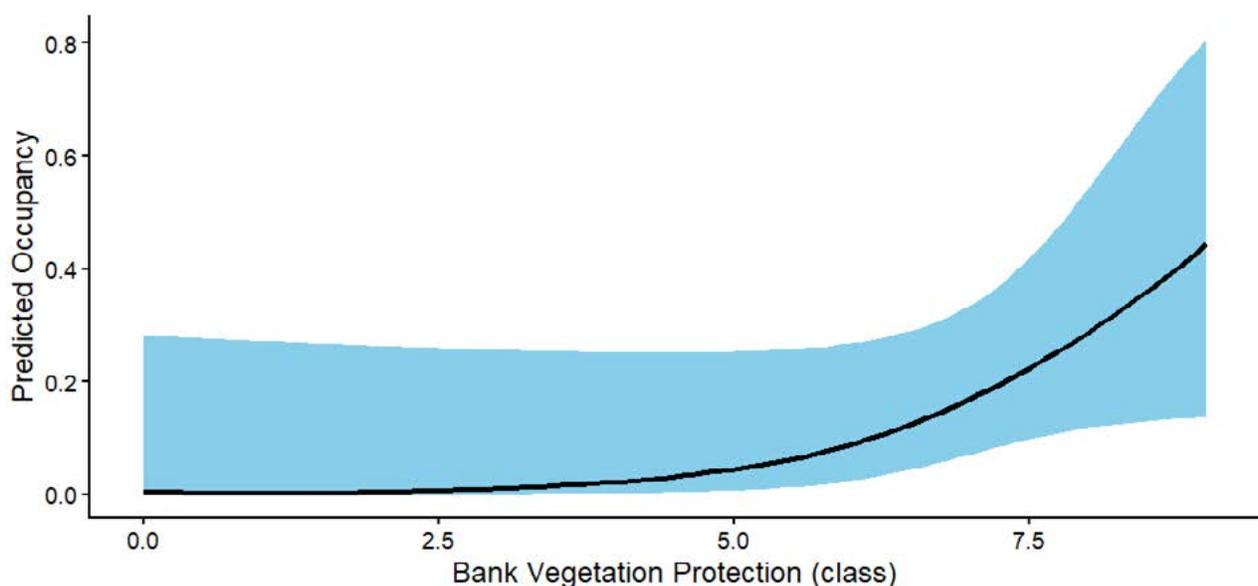
Figure 27 Bank vegetation protection is an important variable in predicting otter occupancy.

Avian Acoustics

Utility of passive acoustic monitoring (PAM) to assess long-term patterns of songbird community composition within northeastern forests

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Dave Lutz, School of Arts & Sciences, Colby Sawyer College, New London, NH

Laurel Symes, K. Lisa Yang Center for Conservation Bioacoustics, Cornell Lab of Ornithology, Cornell University, Ithaca, NY

Sharon Martinson, K. Lisa Yang Center for Conservation Bioacoustics, Cornell Lab of Ornithology, Cornell University, Ithaca, NY

Hannah ter Hofstede, Integrative Biology, University of Windsor, Windsor, Ontario

Abstract

Forests provide critical breeding habitat for a large diversity of resident and migratory birds, whose community structure is closely linked to forest age and composition. Given the variety of stressors affecting northeastern forests and projected patterns of its composition into the future, long-term monitoring is critical to understand bird population and community responses so that conservation and management actions can appropriately integrate compositional and cross-scale effects of future disturbances on bird communities. In this study, we evaluated the use of passive acoustic monitoring for its ability to improve long-term songbird monitoring of forests with unique historical management histories. Acoustic recording units (ARUs) were placed at 104 sites distributed across 3 national park units (ME, VT) and one experimental forest (NH) to evaluate the performance of PAM. We assessed performance by comparing species richness estimates of songbirds generated by (a) traditional 10-minute point counts, (b) processing many sound files with BirdNET (a machine learning algorithm), and (c) manually listening to a subset of the sound files by expert birders. Our results suggest that PAM coupled with birdNET is an incredibly powerful approach for monitoring songbirds to better understand seasonal patterns of habitat use and provide robust estimates of species richness in northeastern forests. We found that analyzing sound files collected across an entire breeding season with BirdNET greatly enhanced species richness estimates compared to the other methods. However, BirdNET performed poorly at identifying a few species, especially those with low-frequency vocalizations. The results of this work encourage the continued use and integration of PAM into songbird monitoring programs to better understand how forest dynamics affect songbird diversity.
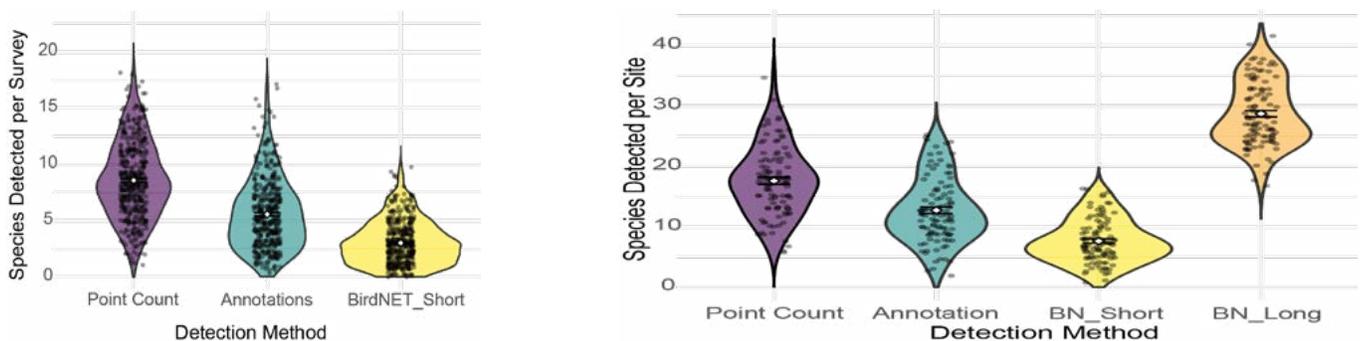
Figure 28 Point count surveys exhibited the highest species detection per survey, however, when BirdNET was used for a longer sampling period, more species were detected at the site level.

Evaluating Machine Learning Threshold Stability in Large-Scale Passive Acoustic Monitoring

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Abstract

Bioacoustics, the study of the natural world through sound, can be a powerful way to learn about the presence, relative abundance, interactions, habitat use, and general ecology of soniferous organisms. While traditional bioacoustic methods involve active listening in real-time to detect animals, advances in technology increasingly allow for sounds to be recorded and analyzed through post-hoc analysis. Passive acoustic monitoring (PAM) involves gathering audio data from programmed autonomous recording units (ARUs). Often, arrays of many ARUs are deployed across broad geographic areas and for long durations (weeks to seasons to years), which provides a rich data source for further insight into the ecology of these animals. However, this also presents challenges, as the sheer volume of data collected would be impossible to analyze by ear. Artificial intelligence (AI), specifically machine learning (ML), partially automates much of the process that turns audio recordings into usable data.

We present an overview of the pipeline for analyzing passive acoustic monitoring data using machine learning, with particular focus on the considerations and caveats for generalizing analyses across space and time. Machine learning approaches often rely on empirically established thresholds to determine which potential detections to retain or discard. Being able to generalize thresholds across space and time would facilitate rapid analysis of large datasets, but with potential costs to accuracy and the possibility that inaccuracies are not uniformly distributed across space or time. Some types of statistical analyses will be more sensitive to these errors and assumptions. As conservation efforts increasingly integrate multiyear datasets that span large geographic areas, it is unknown whether thresholds remain stable or need to be tested and recalibrated. Using audio data from across New England, we test the stability of these thresholds across a range of species and provide general guidance for their use in the analysis of acoustic data.
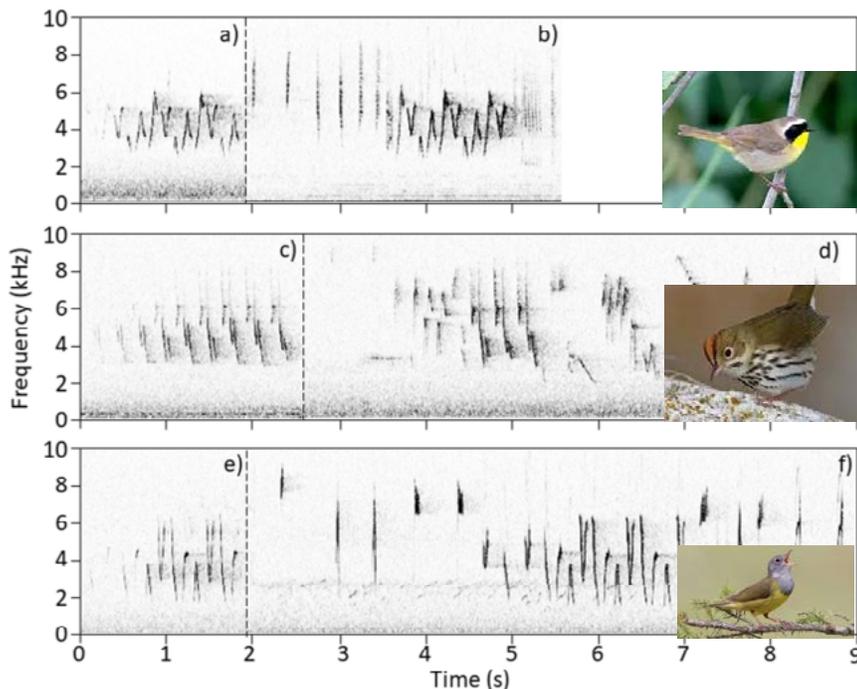
Figure 29 Song variance across sites or years can lead to threshold instability.

Can we predict abundance from acoustic data?

Vijay Ramesh, K. Lisa Yang Center for Conservation Bioacoustics, Cornell Lab of Ornithology

Pooja Panwar, Ecology, Evolution, Environment and Society, Dartmouth College

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Laurel Symes, K. Lisa Yang Center for Conservation Bioacoustics, Cornell Lab of Ornithology

Abstract

Inferring species abundance is critical for biodiversity monitoring. Survey techniques such as systematic point counts and mist netting provide detailed estimates of species densities. However, such techniques can involve significant human effort over long periods of time to arrive at the numbers of individuals. In remote geographies where extensive human surveys are not possible, passive acoustic monitoring (PAM) has emerged as an important survey technique to detect species across space and time. However, acoustic information so far has largely informed species presence without informing how many individuals of a species occur at a survey location. Using synchronously collected data for 45 bird species using point-counts (PC) and autonomous recording units (ARU) across 104 locations in the Northeastern United States, we asked (1) can we predict species densities from acoustic data alone? and (2) are there functional traits that may explain predictive associations between PC and ARU data? At the community level, species that were seen more often were also heard more often, as estimated from ARU data and abundance from PC data. Species-specific regressions revealed a positive slope for less than half of the species examined. However, for only a few species (n=4/45), we identified a statistically significant predictive relationship between ARU and PC data (Adj-R2 > 0.4). Further, species functional traits did not explain the above relationship. Our study revealed that acoustic data cannot be solely relied on to estimate densities for certain species. We suggest follow-up approaches to determine whether it is possible to predict species with strong PC-ARU associations.
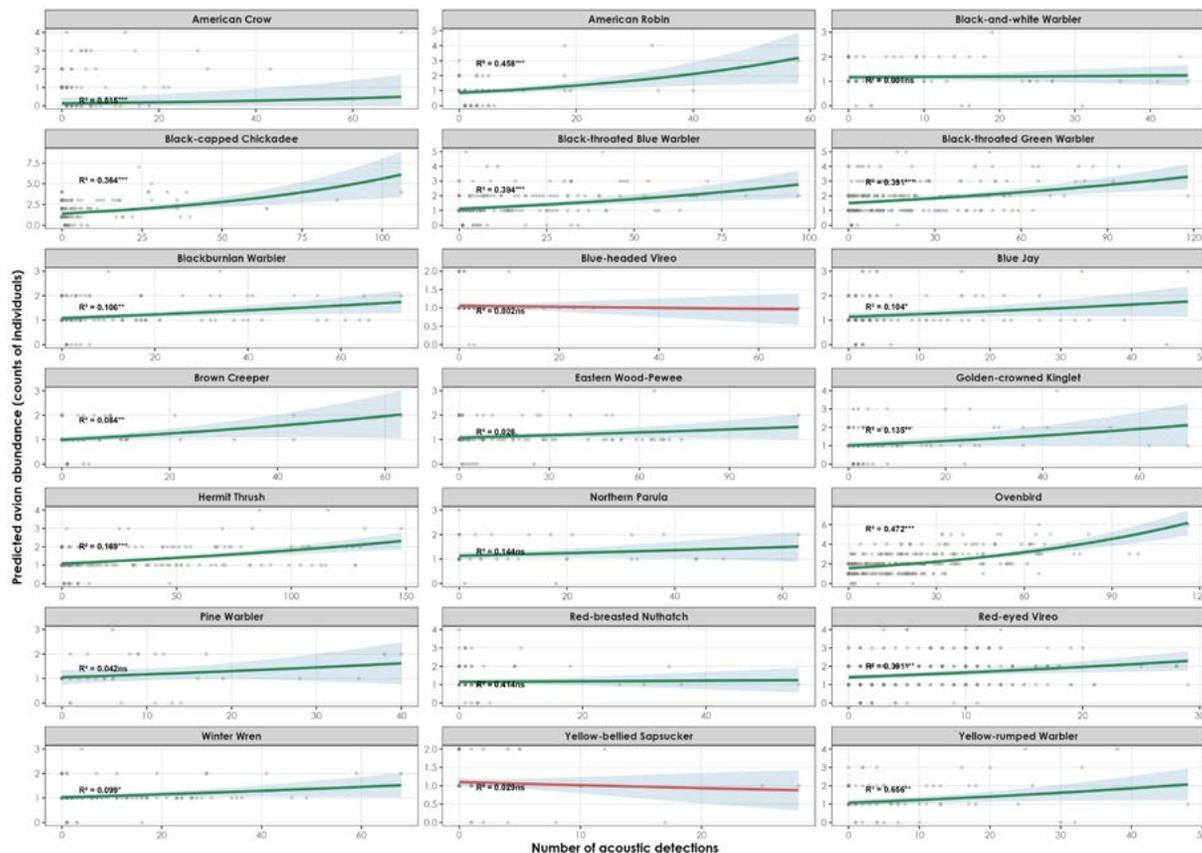
Figure 30
Several species showed a positive and statistically significant association between predicted counts and acoustic detections.

Evaluating machine learning's potential for assessing forest-dependent and migratory bird species presence in the Colombian Amazon

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Wilmer Andres Ramirez Riano, Asociacion de observadores de aves del Guaviare

Dhruv Varun Cohen, Cornell University

Camilo Loiaza, Wildlife Conservation Society, Bogota, Colombia

Diego F. Rocha, Wildlife Conservation Society, Bogota, Colombia

Maria Elisa Mendiwelso Moreno, Universidad de los Andes, Bogota, Colombia

Ismael Dussan Huaca, Universidad Nacional Abierta y a Distancia, Florencia, Colombia

Silvia J. Alvarez, Wildlife Conservation Society, Bogota, Colombia

Steven J. Morreale, Department of Natural Resources and the Environment, Cornell University, Ithaca, NY, United States of America

Shorna B. Allred, University of North Carolina at Chapel Hill

Abstract

Passive acoustic monitoring offers growing potential for collecting large-scale, contemporaneous biodiversity data across landscapes. Combining these acoustic recording methods with automated species detection presents further opportunities for rapidly assessing biodiversity and ecosystem health. Such efforts rely on large amounts of acoustic training data, which is limited in less extensively surveyed regions of the world, such as the Colombian Amazon. To address this challenge, we collected four seasons of acoustic data from 63 forest and farmland sites in the Colombian Departments of Guaviare and Caqueta. Using BirdNET Analyzer, we validated detection confidence thresholds for over 150 bird species, including migratory songbirds from North America and forest-dependent residents, for both SwiftOne and Audiomoth recorder types. We then used additional data to train a BirdNET custom classifier on underperforming species and validated its results. We find that passive acoustic monitoring, combined with BirdNET's machine learning analysis of the data, successfully identifies nearly 30% of our chosen species for both recorder types. Improvement with a custom classifier can raise this figure to nearly 40%. The results can be used to evaluate meaningful differences between bird species community composition across different landscape units, with clear implications for applied forest conservation research in regions with limited training data and which constitute migratory birds' wintering grounds.
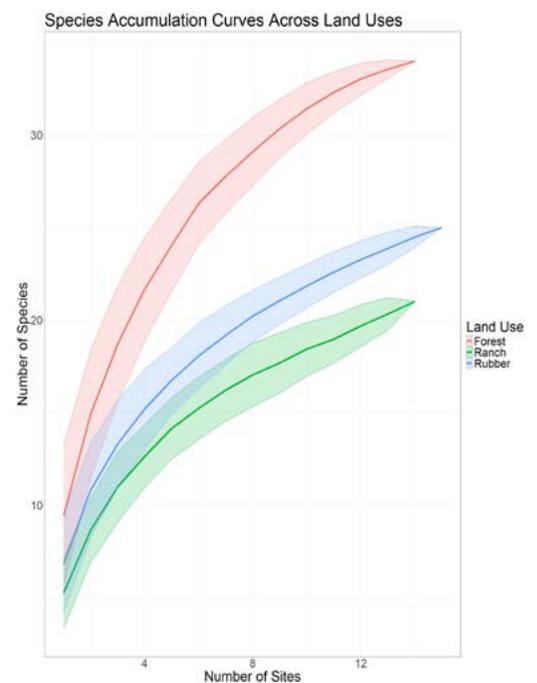
Figure 31 Number of species documented varies across land use type.

Highlights from long-term research and Monitoring on Watersheds of Mt. Mansfield

Warmer winters drive snowpack declines and runoff increases in a headwater region of the northeastern United States

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Andrew Schroth Schroth, Department of Geography and Geosciences, University of Vermont, Burlington, Vermont, USA

James Shanley, U.S. Geological Survey, New England Water Science Center, Montpelier, Vermont, USA

Beverley Wemple, Department of Geography and Geosciences, University of Vermont, Burlington, Vermont, USA

Abstract

In montane, snow-affected regions of the United States, a warming climate threatens the timing and amount of future water delivery. It is expected that winter precipitation falling as snow will continue decreasing and the frequency of winter snowmelt events will continue increasing, with unknown impacts on partitioning of water between evapotranspiration and runoff, water quality, flooding, and drought. The northeastern United States represents a humid climate with relatively uniform precipitation seasonality and a transient snowpack. Limited research about changing winter conditions and water availability has been conducted in the region, in part due to scarce observations. Leveraging decades of continuous meteorological, hydrological, and snowpack monitoring in the Mount Mansfield region of Vermont, we relate long-term snowpack characteristics to seasonal and annual runoff within the headwater Ranch Brook watershed (9.6 km2). In the last 57 years, average winter temperatures have increased by 2.6 oC, snow season length has decreased by nearly three weeks, average seasonal snow water equivalent has decreased by 13%, and winter season rain-on-snow (ROS) event frequency has increased from 1 to 3.5 per year. In response, average winter season runoff has increased, which strongly related to increased annual runoff ratios (R2 = 0.70). To evaluate a potential physical mechanism driving such relationship, we separated the 22-year runoff record into water years with more and less winter season runoff. We determined that years with more winter runoff corresponded to increased winter temperatures, , 15% smaller snowpack, two times more ROS events, increased water partitioning to runoff in winter months, 31% larger annual runoff ratio, and increased summer rainfall variance. A steady decline in the regional snowpack and related impacts on downstream water resources may have implications for ecosystems and agricultural, industrial, and domestic water supply.
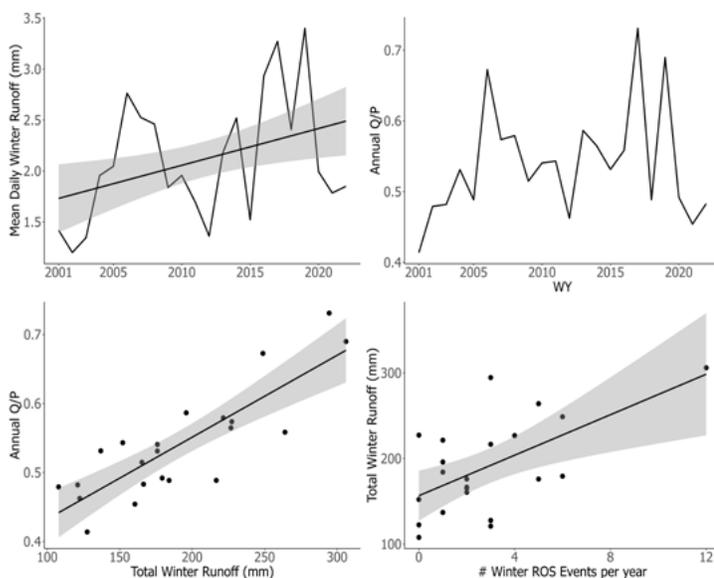
Figure 32 Increases in winter runoff, related to rain-on-snow events, are driving increased annual runoff ratios.

The Summit-to-Shore Snow Monitoring Network in Vermont

Arne Bomblies, University of Vermont

Beverley Wemple, University of Vermont

Jamie Shanley, USGS

Anna Grunes, University of Vermont

Jacob LaDue, University of Vermont

Abstract

We present the Summit-to-Shore Environmental Observation Network, a network of 22 weather- and snow monitoring stations which is designed to monitor snowpack characteristics and meteorological variables at high temporal resolution. Stations are located along a transect that spans central Vermont from South Burlington to Danville, with a particularly high station density in Mount Mansfield's Ranch Brook watershed. Various elevations, slopes, aspects and forest cover types are monitored in order to capture drivers of snow variability. Ground-based observations are supplemented by UAS-based lidar snow depths, and resulting snow data are used as the basis for physics-based and machine learning approaches to snow modeling. Wet snow environments such as in Vermont are understudied, difficult to model, and in need of further research, for which the current and future data are valuable. Practical applications of monitoring include flood risk analysis from rain-on-snow events and climate change impacts on snowpack.
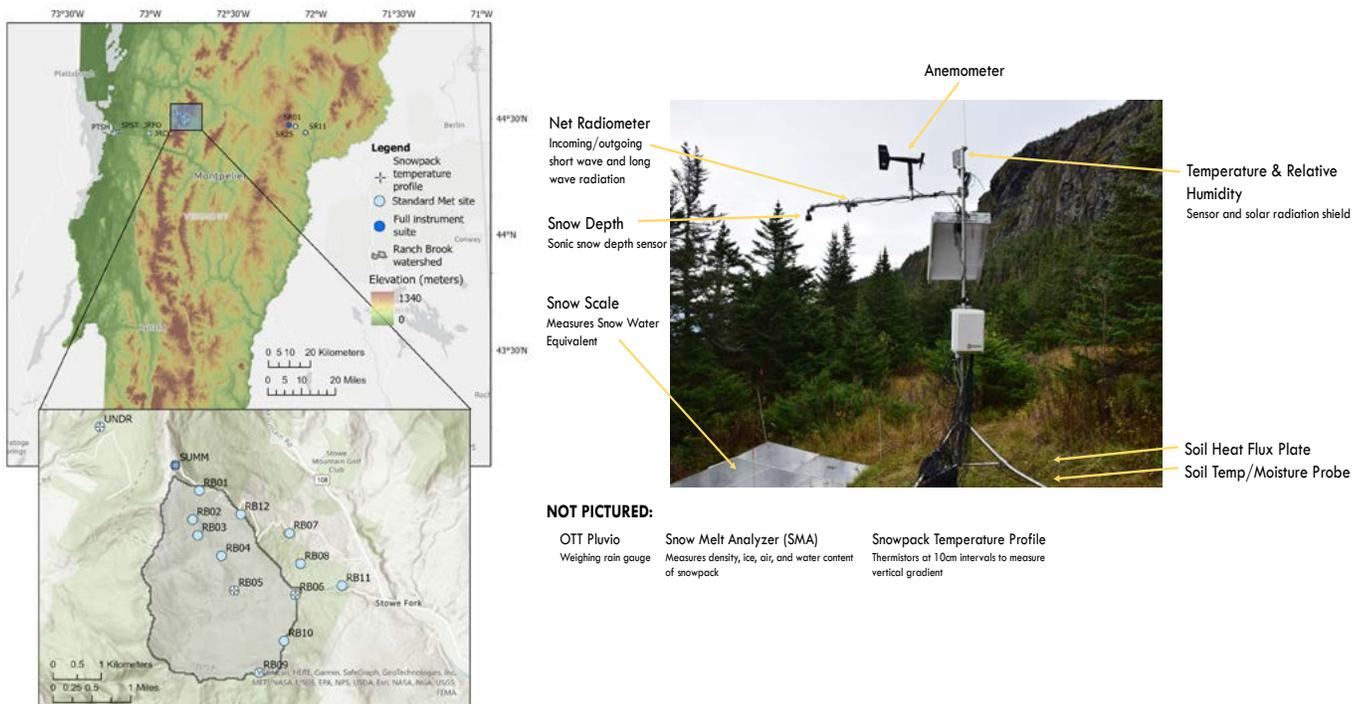
Figure 33 Monitorin stations are located along a transect spanning central Vermont. Each station has numerous sensors to capture a variety of metrics including snow depth, emperature and relative humidity, soil heat flux, and others.

Determining Links Between LiDAR-Derived Canopy Metrics and Daily Changes in Snow Depth around Vermont, US

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Beverley Wemple, Department of Geography and Geosciences, University of Vermont

Anna Grunes, Department of Civil and Environmental Engineering, University of Vermont

Arne Bomblies, Department of Civil and Environmental Engineering, University of Vermont

Abstract

Snowpack dynamics are understudied in the Northeastern US and few studies have documented the role of vegetation on snowpack dynamics in this setting. In the Green Mountains of Vermont, mixed and deciduous forest canopy have undocumented effects on snow accumulation and ablation. This study addresses this gap by assessing the role of forest canopy attributes on snow accumulation and melt over three winter seasons from fall 2022 - spring 2025 . Airborne LiDAR scanning (ALS) and aerial imagery data were analyzed to compute a suite of forest canopy structure metrics around stations from the University of Vermont's Summit to Shore Environmental Observation Network which collects snow and meteorological observations along an elevational transect from the shores of Lake Champlain to the state's highest summit. These forest canopy structure metrics fall into five categories describing canopy: (1) density, (2) height, (3) arrangement, (4) openness and (5) variability. The Random Forest machine learning algorithm was leveraged for its utility in modeling complex, non-linear relationships between numerous features. Random forest models were trained on different combinations of temporal meteorological and static forest canopy metrics with the goal of predicting snow depth. Results show that forest canopy metrics lead to higher accuracy random forest models compared to those with solely meteorological features. Importance and SHAP values were examined to deduce specific mechanisms of the forest canopy metrics on snow accumulation and ablation. This work shows how machine learning can be applied to forest hydrology and provides new insights into the interactions of weather and forest canopies on snowpacks of the Northeastern US.
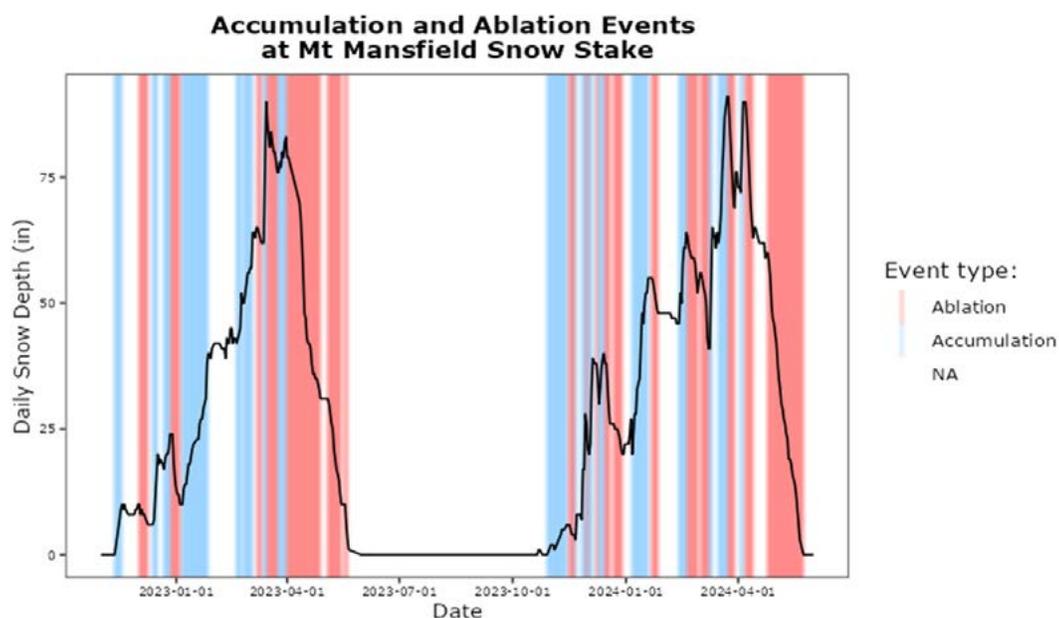
Figure 34 Snow accumulation and ablation events at the Mt. Mansfield snow stake.

Insights from 25 Years of Biological Monitoring in the Ranch Brook and West Branch Little River Watersheds: A Comparative Study of Benthic Macroinvertebrates

Meaghan Hickey, Vermont Department of Environmental Conservation

Meaghan Hickey, Vermont Department of Environmental Conservation

Aaron Moore, Vermont Agency of Agriculture

Abstract

Brook and West Branch Little River, two similarly sized high-elevation watersheds in the Mount Mansfield region. Ranch Brook, a minimally disturbed reference site, and the more developed West Branch Little River site provide an insightful comparison for assessing the effects of environmental change on stream biological communities, particularly in response to stressors such as drought, flooding, and rising temperatures. Monitoring efforts include annual benthic macroinvertebrate surveys, ambient chemistry, habitat, and stream flow data collection, as well as continuous water temperature measurements at Ranch Brook. These datasets provide a comprehensive understanding of the stream condition at both sites including biological community and disturbance tolerance metric calculation, ecosystem health assessments, examination of trends over time, and comparative analysis of the biological responses at both sites to temperature and flow regime changes. Differences in macroinvertebrate resilience and recovery between the sites highlight the role of land use and restoration in shaping aquatic responses. Furthermore, the Ranch Brook monitoring site has been used in several additional special studies as a reference dataset including in an investigation into the recovery of nearby Cotton Brook from a landslide, a flood recovery study following the July 2023 and 2024 flood events, and the EPA's Regional Monitoring Network, a collection of long-term data for region-level analyses and trend detection, particularly in relation to climate and temperature changes. Twenty-five years of monitoring at these paired watersheds underscores the importance of long-term data in providing critical insights into the drivers of stream ecosystem resilience and supporting efforts to protect the biological health of Vermont's rivers and streams in a changing climate.
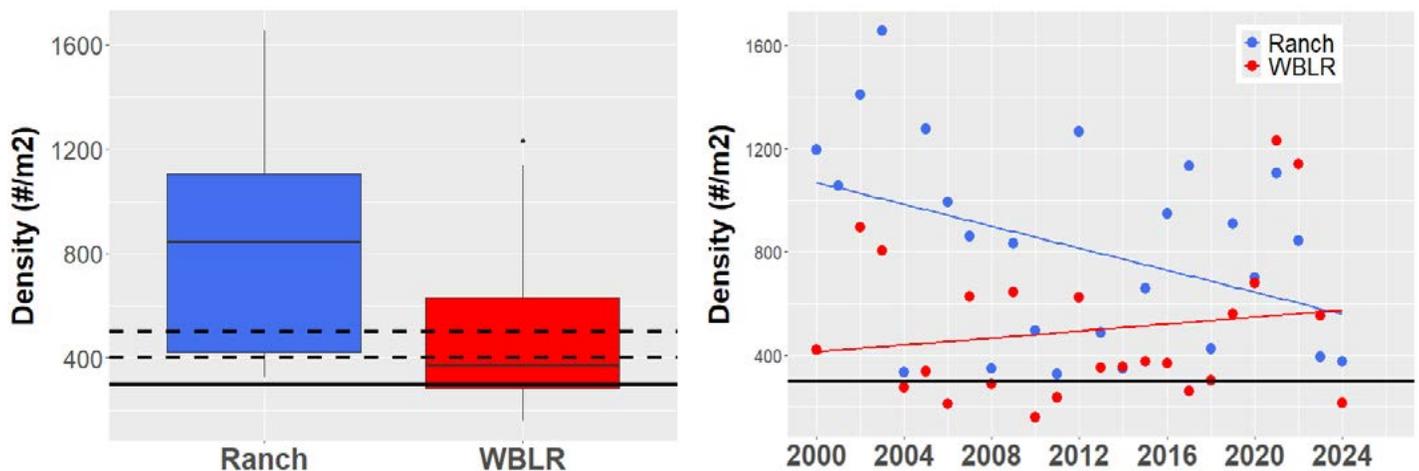
Figure 35 Macroinvertebrate density at WBLR is consistently lower than in Ranch Brook. The decreasing trend in density over time at Ranch is driven by low densityin recent flood years. Density appears to be improving over time at WBLR, bu not significantly.

Forests and Community

A citizen science early-detection system: Managing forests in Maine with help from iNaturalist and eBird users

Kyle Lima, Schoodic Institute

Christopher Nadeau, Schoodic Institute

Nicholas Fisichelli, Schoodic Institute

Abstract

Climate change, development, and invasive species are rapidly changing forested ecosystems in the seven-state FEMC region and beyond. Detecting these changes early is critical to implementing cost-effective management and effectively limiting the impact of disturbances. However, many forest disturbances go undetected for too long because current monitoring protocols are labor intensive, focus on small monitoring plots which often miss invasive species, and often require specialized skillsets. This often results in larger, more sustained, and costly management strategies to prevent spread and further impacts. An early-detection system that can be applied over large spatial scales is needed to help protect forests and improve management of invasive species. We've attempted to fill this monitoring gap by engaging and inspiring the large, and rapidly growing, number of citizen scientists already interacting with protected areas. In partnership with Maine Coast Heritage Trust (MCHT) who manages over 170,000 acres of land in over 150 preserves in coastal Maine, we have developed an automated early-detection system that communicates observations of species of management priority to stewards that are reported in or near the 150+ preserves. We supplemented the general influx of citizen science data submitted to major citizen science platforms with organized bioblitzes at MCHT properties that also serve to train and encourage a dedicated base of volunteer monitors. This early-detection system is fully automated thus requiring no maintenance from managers or stewards, and is transferable to any protected area or at any scale.
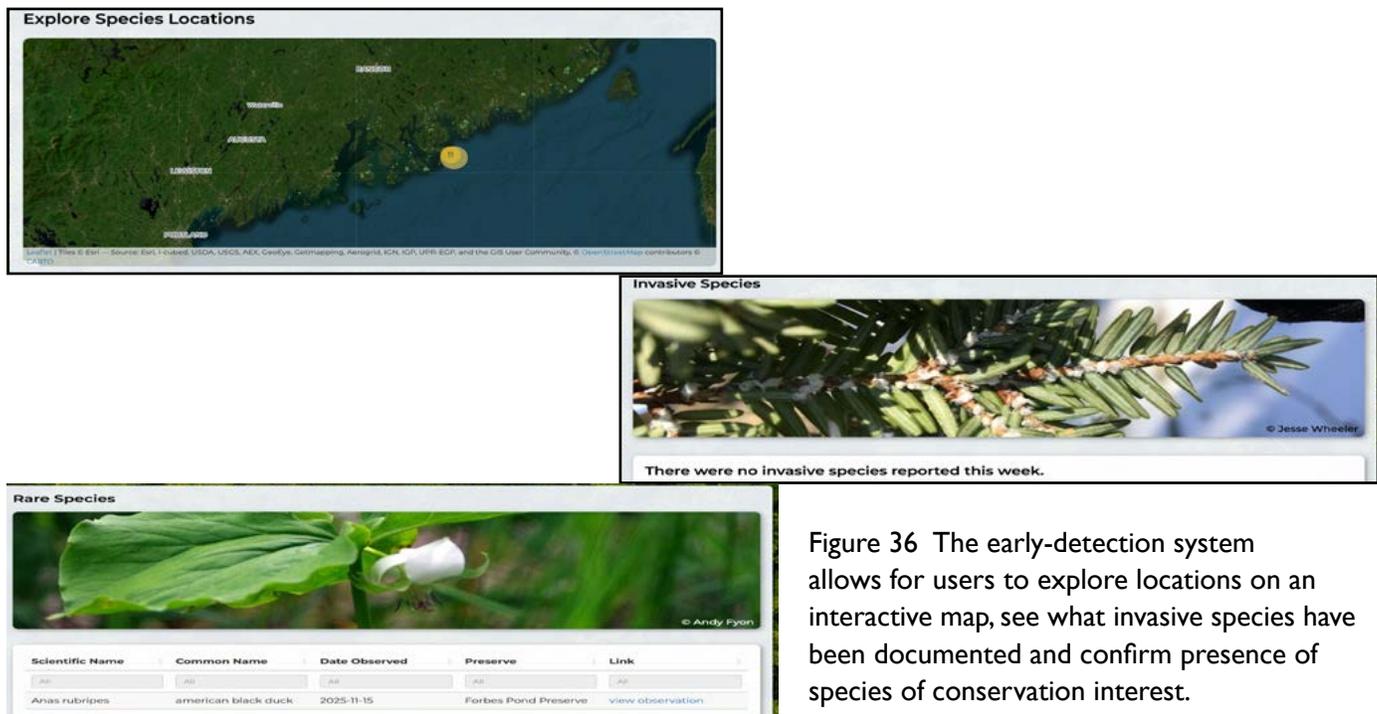
Figure 36 The early-detection system allows for users to explore locations on an interactive map, see what invasive species have been documented and confirm presence of species of conservation interest.

Forests Are Part of our Story: Enhancing Forest Resilience throughout Northeastern National Parks

Rachel Swanwick, Forest Stewards Guild

Abstract

Forests are iconic to the National Park experience, including the cultural and historic sites predominant in the Northeast region of the National Park Service. These forests are threatened by a complex array of stressors (e.g., invasive plants, pests, pathogens, herbivory) that impact the landscape, cultural values, and park visitor experience. To address this growing challenge, the Resilient Forest Initiative (RFI) fosters partnership between the National Park Service, Forest Stewards Guild, and local businesses to conduct restoration that will enhance the ecological integrity and resilience of these forests. The RFI aims to contribute to ecosystem structure and function and fulfill social values now and into the future. Stewardship approaches include removing invasive plants, planting native trees, and protecting native regeneration and plantings from herbivory. Thus far, the RFI has been working across 20 National Parks, restored 642 acres, planted 5,300 trees, and employed 22 youth. The impacts of this initiative are expected to grow in the coming years and demonstrate the value of ensuring forests remain a central part of the National Park experience in the Northeast and beyond.
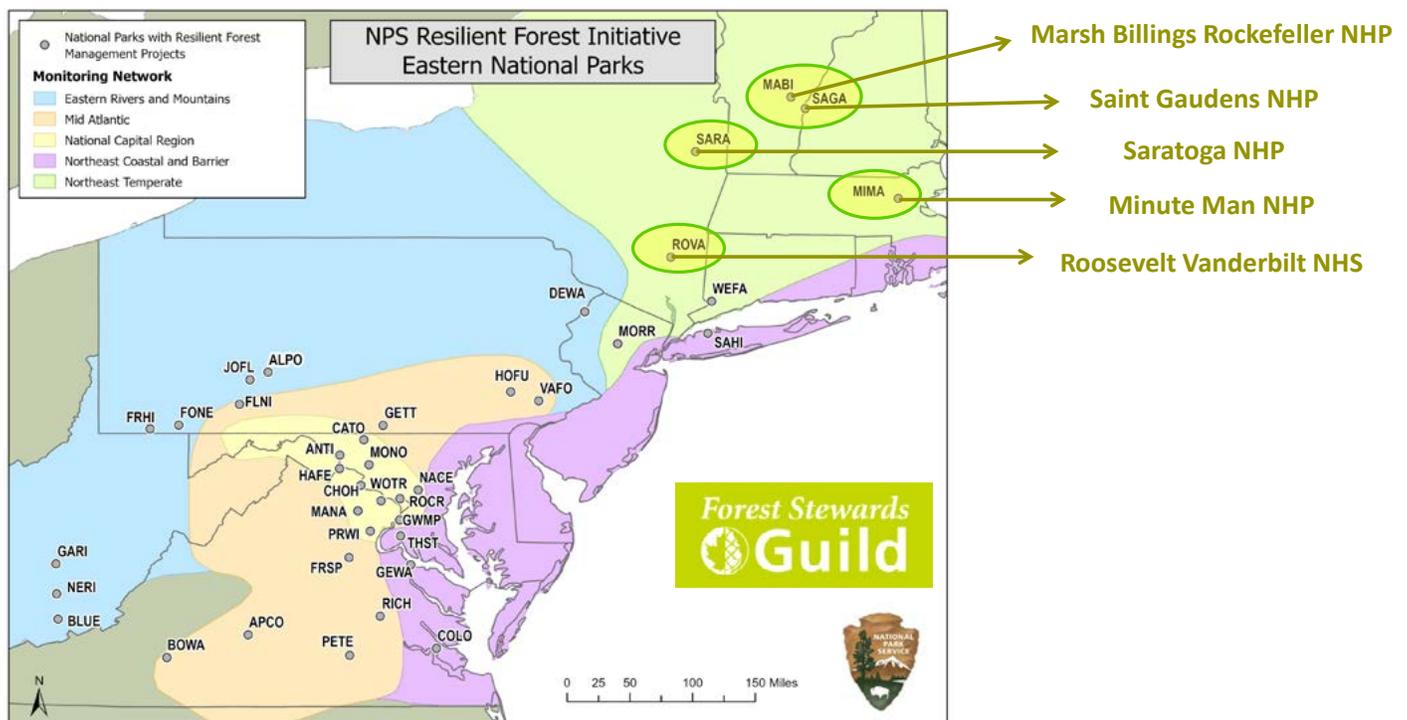
Figure 37 As part of the Resilient Forests Initiative, ~270 acres are in restoration at the five National Historical Parks and Sites in the Northeastern region. Actions at these sites include introduced plant control, scheduled for 2025 - 2027 and planting scheduled for 2028-20209.

Spotlight on Black Ash Communities in Vermont: Outreach, treatment, and seed collection on State Land

Joanne Garton, VT Forests, Parks & Recreation

Liam Farley, VT Forests, Parks & Recreation

Josh Halman, VT Forests, Parks & Recreation

Noah Hoffman, VT Forests, Parks & Recreation

Danielle Owczarski, VT Fish & Wildlife

Abstract

The unique ecosystems that support black ash (Fraxinus nigra) trees are changing rapidly as emerald ash borer spreads throughout Vermont and the northeast. Facing functional extirpation from the landscape, black ash trees require specific care and management to preserve their legacy on the land in swamps and seepage forests. In human-centered communities, black ash trees are the root of connection to history, crafts, and culture through selected tree harvest, pounding events, and weaving with splints.

Vermont Forests, Parks & Recreation and Vermont Fish & Wildlife are carefully selecting and monitoring black ash stands on state-owned land as part of a four-pronged forest health project involving: 1) mapping, identification, and outreach about black ash stands on public and some private lands, 2) selection of 14 black ash preservation patches on state-owned land for treatment with systemic insecticides, 3) monitoring for seed collection from female black ash trees, and 4) harvest of black ash for public black ash pounding workshops led by Abenaki basket makers and educators. By partnering with The Intervale Seed Collection Program, Northwoods Stewardship Center seed collection field crews, and by hosting a forestry student intern from the University of Vermont, VT FPR and F&W are staying connected to emerging research and methodology surrounding black ash stewardship and benefiting from on-the-ground observation and monitoring throughout diverse ecoregions statewide. The natural community types that benefit from this work include the Red-Maple Black Ash Seepage Swamp, Calcareous Red Maple-Tamarack Swamp (rare), Red Maple-Northern White Cedar Swamp (rare), and Maple-Green Ash Swamp (rare) among others.

In 2025, FPR staff treated black ash trees at three locations in State Parks and Wildlife Management Areas. In 2026, treatment of up to 11 other sites will lay the groundwork for future regeneration of black ash, potential for seed saving, and potential for monitoring locations when trees are retreated every three to four years. Stay connected to opportunities on state-owned land to continue collaboration of black ash stewardship and research, and consider how your audiences can contribute to the ongoing learning and discussion.

Vermont Counties w/ Black Ash Treatment in 2025

Caledonia
Franklin
Lamoille
Rutland
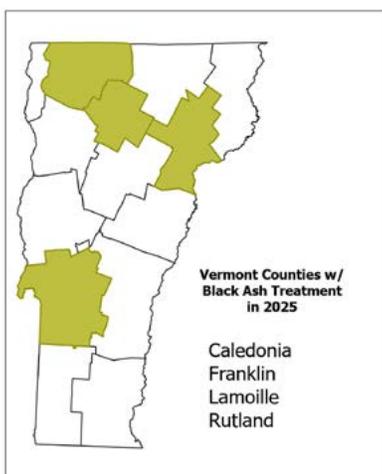
Figure 38 Six sites in four Vermont counties with black ash received insecticed treatment in 2025, treating 10-20 trees per site. Sites will be visited in future years to collect seeds for research and breeding.

Advancing Workforce Development in Forestry through a Multi-Pronged Educational Approach

Paulina Murray, Maine Timber Research and Environmental Education (TREE) Foundation

Logan Johnson, Maine TREE Foundation

Abstract

Maine's forestry industry supports thousands of jobs and communities across the state, yet faces a rapidly changing workforce. For example, 37% of the 2020 workforce will have reached or surpassed retirement age by 2031. Maine Timber Research and Environmental Education Foundation (Maine TREE) takes a multi-pronged approach to facilitating green jobs exposure and empowerment for Maine's students at multiple educational levels- elementary, high school, undergraduate, and graduate. Through job fairs, direct classroom engagement, and bringing students to the field, Maine TREE, and its collaborators promote and advance opportunities in workforce development for the students who will manage Maine's forests in the future. This presentation will explore Maine TREE's workforce development approach, highlight Holt Research Forest as a case study for forest-based research careers and long-term ecological monitoring, and discuss how immersive, stage-appropriate learning experiences can foster exploration and understanding of Maine's forests across age groups and educational stages. We will also share the successes and challenges in creating a collaborative and inclusive environment that promotes career interest and professional skill development in forestry.

Figure 39 Maine TREE engages with many communities to provide training and opportunities for workforce development.
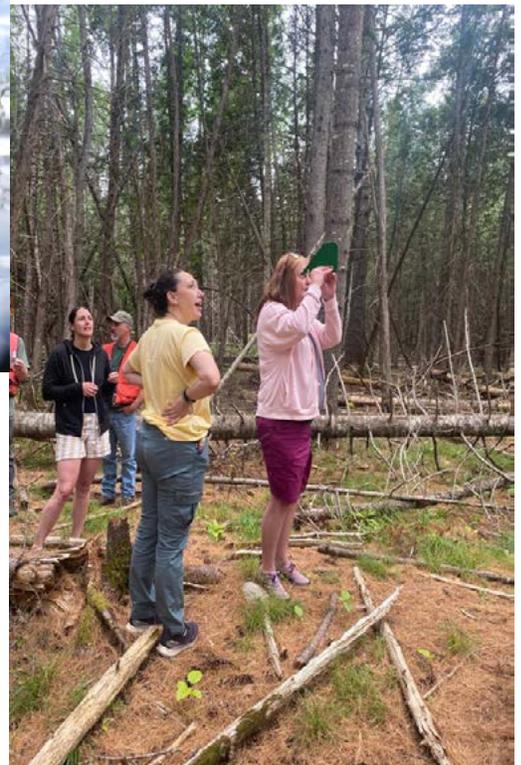
Fire in Northeastern Ecosystems

A Post-Smoke Critique: "Asbestos Forest" Management Paradigms in the Northeastern USA

Andrew Vander Yacht, SUNY ESF

Abstract

In the summer of 2023, unprecedented amounts of smoke from Canadian wildfires descended upon the northeastern United States. As a result, millions of people in this fire-infrequent region were exposed to extremely hazardous air quality and grew more aware of wildland fire issues they had previously been largely insulated from. Before this event fades from memory, and before forecasted increases in fire activity reach the region and others like it across the globe, an opportunity exists to broadly reconsider fire management within currently fire- infrequent regions. We review related science and conclude that climate-change driven increases in fire activity are predicted for many fire-infrequent regions where fire-sensitive structures and species compositions have been recently promoted by strong adherence to passive "asbestos forest" management paradigms (i.e., approaches over-minimizing fire's historical influence). Without intervention, shifts towards drought- and fire-sensitive trees will continue ahead of forecasted increases in fire activity - risking future degradation of regional forests and associated ecosystem services. However, prescribed fire and mechanical surrogates - and research refining effective application - could enhance fire resilience by restoring disturbance-dependent biodiversity. Unfortunately, positive feedback between asbestos paradigms and ecological change in the absence of fire continue to limit the use of such tools and related research. The 2023 smoke event in the northeastern U.S. provides an opportunity to galvanize global stakeholder support for researching and applying disturbance-integrated land management. These perspectives will be key to enhancing forest resiliency across similar regions where fire activity is currently rare but predicted to increase in the future.
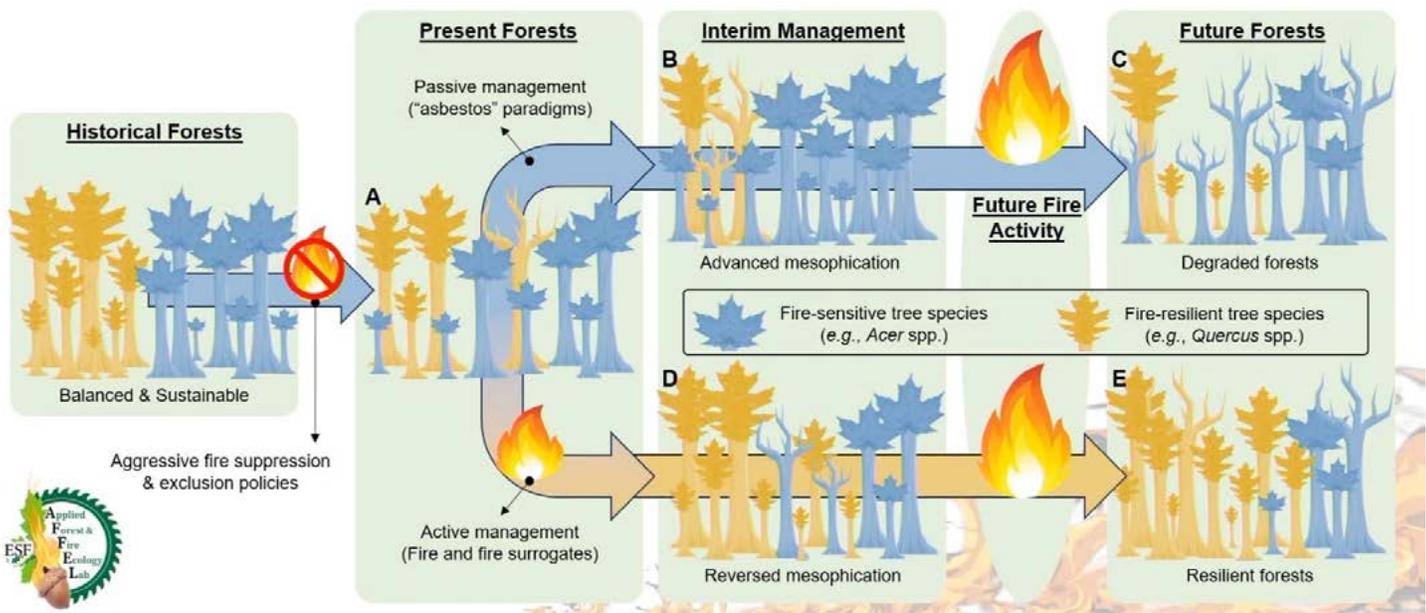
Figure 40 Potential outcomes under different management scenarios for northeastern forests. Passive management will likely lead to advanced mesophication and greater risk of uncontrolled fire, whereas active management will reverse mesophication and increase forest resiliency.

Restoring Ecosystem Health with Fire in a Rare Inland Pine barrens

Neil A. Gifford, Albany Pine Bush Preserve Commission

Abstract

Fire is the heartbeat of the pyrogenic ecosystems, but attempting to restore ecosystem dynamics and endangered wildlife habitat by simply applying what we know of post-colonial disturbance regimes can be logistically challenging and ecologically ineffective. This is especially true for those of us managing systems, like inland pitch pine-scrub oak barrens (PPSOB), for which there are not any fully "functional" reference communities left to guide our work. The Albany Pine Bush Preserve (APBP) contains one of the best remaining examples of an inland PPSOB and habitat for 114 rare (S1-S3) wildlife including >70 of NY State's 366 wildlife species of greatest conservation need and the federally endangered Karner blue (Plebejus samuelis). Since 1991 managers have employed strategies (mechanical, chemical, pyric) to restore fire's fundamental role in this landscape. Limited ecological success and extreme fire behavior presented significant early challenges and resulted in a paradigm shift in our understanding of PPSOB ecosystem dynamics. It also revealed important clues about restoration and maintenance fire regimes. Applying a dual front approach while simultaneously tracking rare wildlife populations has helped define and monitor ecosystem health. It has also resulted in increased distribution and abundance of rare wildlife - including the complete recovery of the local Karner population and the return of the eastern whip-poor-will- while dramatically reducing wildfire risk and improving Rx fire logistics in a congested and complicated wildland urban interface at the NYS Capital.
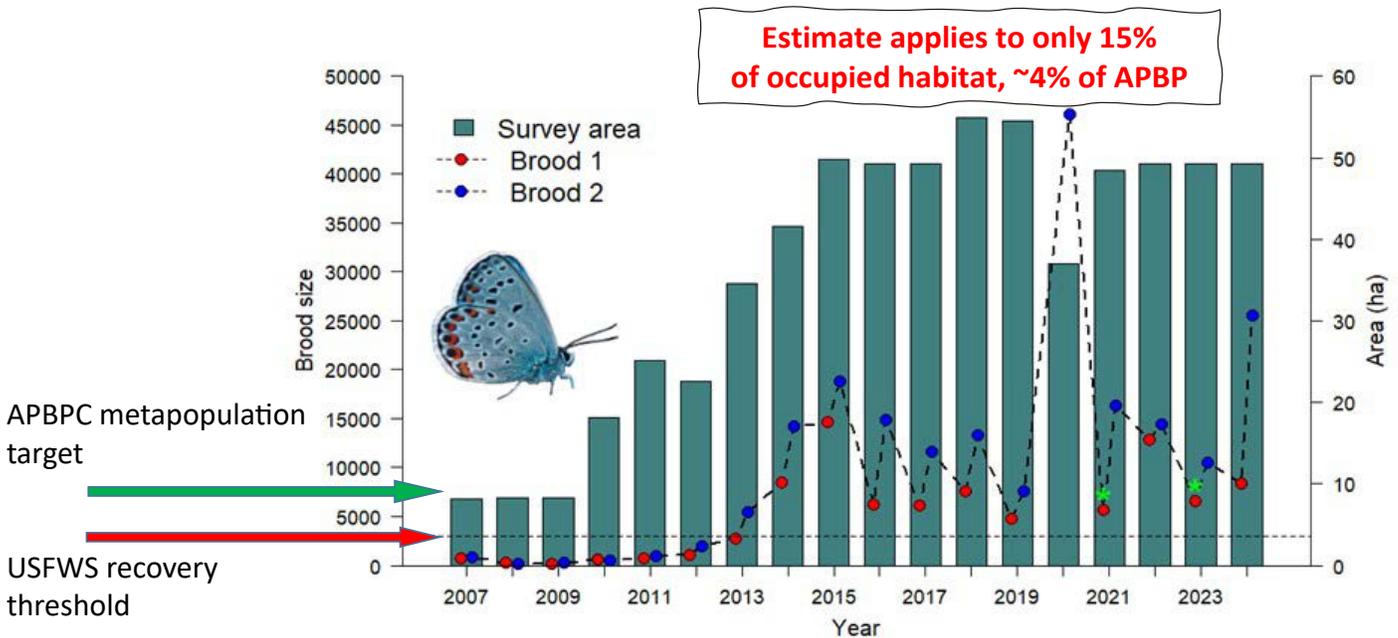
Figure 41 The Karner blue butterfly population has been locally recovered at the Albany Pine Bush Preserve.

Keeping the Pine in the Pine Barrens on Long Island

Kathy Schwager, Brookhaven National Laboratory

Abstract

Atlantic coastal pine barrens are a globally rare, fire-dependent ecosystem that occurs in only three areas across the Atlantic Coastal Plain of the eastern US. The Long Island Central Pine Barrens (CPB) is one such example. These communities are known to be characterized by an open canopy of pitch pine (Pinus rigida) with an understory of scrub oak (Quercus ilicifolia), and a variety of heath species and grasses. A century of fire suppression, intensive development, and the complete absence of forest management has resulted in a destabilized and stressed system that is gradually succeeding into closed canopy mixed oak (Quercus spp.) forest. This is further facilitated by the arrival of southern pine beetle (Dendroctonus frontalis) that has killed millions of pitch pines throughout the CPB region. The need for active management through prescribed fire and mechanical treatments has never been more urgent. Implementing management on the scale necessary and balancing a variety of objectives that include fuels mitigation in addition to ecosystem restoration has proved challenging, particularly because we do not have a reference ecosystem to use as a benchmark. Monitoring of vegetation and wildlife--formally and informally, qualitatively and quantitatively--helps to inform and refine management strategies in the face of stressors brought upon by the introduction of invasive species and a changing climate.

Figure 42 Pre- and post-prescribed burn photo points to use in Composite Burn Index evaluation. Clockwise from upper left, pre-burn, immediate post-burn, three months post-burn, and one year post-burn.

MassWildlife Fire-Managed Grasslands: Restoring Grasslands Big and Small

Alex Entrup, MassWildlife

Abstract

MassWildlife has been using fire to restore warm season grasslands for over 20 years, with sites ranging from less than one acre to over 400 acres. Different scales provide different benefits for a wide variety of species. Several types of grasslands occur in Massachusetts, including sandplain, maritime, river valley, and wetland grasslands. Each of these have various histories of periodic fire. While not a natural community, old fields and forest openings are also grasslands for which there is opportunity to convert to native grasses. Converting these plots of lands provides benefit for many birds and pollinators, including bees and beetls, turkey, grasshopper sparrows, and bobolinks. Several considerations must be taken into account when selecting sites for restoration, including size, soil type, location, and management feasbility. Also of importance is the ability to safely conduct a prescribed fire and the ability to manage smoke. Several steps are used in the process of completing the conversion, which will be outlined in the talk, along with challenges that may arise. Lessons learned from past and current projects will be presented.

Figure 43 The exact details of a grassland conversion vary based on site characteristics, but the basic steps of the process incorporate site preparation prior to planting the desired seed.

Northern Forest Center: Help Develop a Messaging Guide for Communicating Forest Stewardship

Workshop

Kendra Collins and Julie Renaud Evans, Northern Forest Center

Communicating about forest stewardship and the many values of responsible forest management is a common challenge across the region. A generally disconnected public combined with increased interest in the role forests can play in mitigating climate change has added an additional layer to communicating about a complex subject. The Northern Forest Center has been working to identify key messages about forests and forest management to be potentially shared across a range of platforms and used by many. Using these key messages, we have developed a messaging guide that brings this information forward in several formats for a wide range of uses.

This workshop presented participants with a series of messages that were developed by the Northern Forest Center to engage with audiences using a variety of framing approaches. Participants provided feedback and editing about the messages to improve their effectiveness. The Northern Forest Center intends to take the suggestions into consideration as they finalize the messaging guide.

Figure 44 Participants listen to messages and provide feedback to the Northern Forest Center.

POSTER SESSION

A poster session was held in-person during the event. Posters are included here that were made available.

1. ## What's in a song? An analysis of avian vocalization patterns in a northeastern forest

Joseph Hagerty, Department of Biological Sciences, Dartmouth College;

Matthew P. Ayres, Department of Biological Sciences, Dartmouth College;

Wyatt J. Cummings, Department of Biological Sciences, Dartmouth College;

Laurel Symes, K. Lisa Yang Center for Conservation Bioacoustics, Cornell Lab of Ornithology, Cornell University;

Aaron S. Weed, U.S. Department of the Interior, National Park Service, Northeast Temperate Network;

Hannah ter Hofstede, Department of Integrative Biology, University of Windsor, Canada;

Pooja Panwar, Department of Biological Sciences, Dartmouth College;

Sharon Martinson, K. Lisa Yang Center for Conservation Bioacoustics, Cornell Lab of Ornithology, Cornell University

2. ## Forest management strategies to rehabilitate a coastal red spruce forest in Maine

Reg Clarke, School of Forest Resources, University of Maine

Keith Kanoti, School of Forest Resources, University of Maine

Rose Gellman, Smokey House Center, Danby, VT

Nicole Rogers, Maine Forest Service

Jay Wason, School of Forest Resources, University of Maine

3. ## Analyzing habitat factors associated with amphibian diversity in riparian floodplains of the Lewis Creek watershed

Lydia Emry, University of Vermont (no poster image available)

4. ## Assessing eco-geomorphic habitat factors associated with amphibian diversity in riparian floodplains of the Lewis Creek watershed

Margreta Grady, University of Vermont, Rubenstein School of Environment and Natural Resources

Lilo Schultz, University of Vermont, College of Arts and Sciences, Department of Biology

Elizabeth Doran, University of Vermont, College of Engineering and Mathematical Sciences, Department of Civil & Environmental Engineering

Lydia Emry, University of Vermont, Rubenstein School of Environment and Natural Resources

Brittany Mosher, University of Vermont, Rubenstein School of Environment and Natural Resources

James Murdoch, University of Vermont, Rubenstein School of Environment and Natural Resources

Kristen Underwood, University of Vermont, College of Engineering and Mathematical Sciences, Department of Civil & Environmental Engineering

Rebecca Diehl, University of Vermont, College of Arts and Sciences, Department of Geography and Geosciences

Rose Watts, College of Engineering and Mathematical Sciences, Department of Civil & Environmental Engineering

Kenneth Johnston, University of Vermont, College of Arts and Sciences, Department of Geography and Geosciences

5. **Help Us Find Additional Survivor Elms!**

Christopher F. Hansen, University of Vermont, Rubenstein School of Environment and Natural Resources

John R. Butnor, 2USDA Forest Service, Northern Research Station, Burlington VT

Anthony W. D'Amato, University of Vermont, Rubenstein School of Environment and Natural Resources

Cornelia Wilson, USDA Forest Service, Northern Research Station, Delaware OH

Kathleen S. Knight, USDA Forest Service, Northern Research Station, Delaware OH

6. **Utilizing Bioacoustics to Study the Elusive Habits of Bats in North-temperate Forests**

Jessica Jones, Department of Biological Sciences, Dartmouth College

Pooja Panwar, Department of Biological Sciences, Dartmouth College

Hannah terHofstede, Department of Integrative Biology, University of Windsor, Canada

Matthew Ayres, Department of Biological Sciences, Dartmouth College

7. **Optimizing Vegetation Indices for Enhanced Management of Parks and Protected Areas: A Case Study from Acadia National Park**

Min Kook Kim, Stockton University (no poster image available)

8. **Vermont Mesonet - A Statewide, Meteorological Monitoring Network**

Samantha Koehler, Water Resources Institute, University of Vermont

Joshua Benes, Water Resources Institute, University of Vermont

9. **Gully-washing Storms & Overland Flow: How to Slow, Spread, and Sink Stormwater in Vermont's Forests**

Alexandra Murphy, Vermont Family Forests

10. **For the Love of Snow: Snow Monitoring with Community Science**

Madelyn Wood, Appalachian Mountain Club

Georgia Murray, Appalachian Mountain Club

Braedon Lineman, Appalachian Mountain Club

Amy Villamagna, Plymouth State University

Jordon Tourville, Appalachian Mountain Club

Sarah Nelson, Appalachian Mountain Club

11. **Snow refugia: Managing temperate forest canopies to maintain winter conditions**

Sarah J. Nelson, Appalachian Mountain Club

Melissa A. Pastore, Northern Research Station, USDA Forest Service

Elizabeth A. Burakowski, Earth Systems Research Center, University of New Hampshire

Alexandra R. Contosta, Earth Systems Research Center, University of New Hampshire

Anthony W. D'Amato, Rubenstein School of Environment and Natural Resources, University of Vermont

Sarah Garlick, The Nature Conservancy

Edward Lindsey, Old Town High School, Old Town, ME

David A. Lutz, Department of Environmental Studies, Dartmouth College, Hanover, NH; Environmental Science Program, Colby-Sawyer College

Toni Lyn Morelli, U.S Geological Survey, Northeast Climate Adaptation Science Center

Alexej P. K. Sirén, Earth Systems Research Center, University of New Hampshire

Grace A. Smith, Rubenstein School of Environment and Natural Resources, University of Vermont

Aaron Weiskittel, 10Center for Research on Sustainable Forests, University of Maine

12. Turning Objectives into Action: Adaptive Planting on Vermont Lands

Danielle Owczarski, Vermont Department of Fish and Wildlife

Al Freeman, Vermont Department of Forests, Parks & Recreation

Grace Glynn, Vermont Department of Fish and Wildlife

13. Spatio-Temporal Patterns of Bird Communities Using Regional Passive Acoustic Monitoring

Pooja Panwar, Department of Biological Sciences, Dartmouth College

Aaron S. Weed, U.S. Department of the Interior, National Park Service, Northeast Temperate Network

Matthew P. Ayres, Department of Biological Sciences, Dartmouth College

David A. Lutz, School of Arts & Sciences, Colby-Sawyer College

Hannah terHofstede, Department of Integrative Biology, University of Windsor, Canada

Laurel Symes, K. Lisa Yang Center for Conservation Bioacoustics, Cornell Lab of Ornithology, Cornell University

14. The Appalachian Trail as a Mega-transect: Using iNaturalist to Study Plant Phenology

Aiesha Parmar, Appalachian Mountain Club

Madelyn Wood, Appalachian Mountain Club

Morgan Southgate, Appalachian Mountain Club

Jordon Tourville, Appalachian Mountain Club

Georgia Murray, Appalachian Mountain Club

Sarah Nelson, Appalachian Mountain Club

15. Tracking Forest Soil Health: 25 Years of Soil Monitoring by the U.S. Forest Inventory and Analysis Program

Melissa A. Pastore, Northern Research Station, USDA Forest Service

Ashley Lang, Northern Research Station, USDA Forest Service

John Shaw, Rocky Mountain Research Station, USDA ForestService

Sean Cahoon, Pacific Northwest Research Station, USDA Forest Service

Hayley Peter-Contesse, Dept. of Natural Resources and Environmental Management, University of Hawai'i at Mānoa

Suzanne Owen, Pacific Northwest Research Station, USDA Forest Service

Randall Morin, Northern Research Station, USDA Forest Service

Jonathan Knott, Northern Research Station, USDA Forest Service

Grant Domke, Northern Research Station, USDA Forest Service

Belinda Esham, Southern Research Station, USDA Forest Service

Erin Berryman, Rocky Mountain Research Station, USDA Forest Service

16. A Snapshot of FEMC's Regional Forest Health Monitoring Network: A Temporal Analysis 2022 - 2024

Benjamin Porter, University of Vermont, RSENR; FEMC

Soren Donisvitch, University of Vermont, RSENR; FEMC

Matthew Rios, University of Vermont, RSENR; FEMC

Alison Adams, University of Vermont, RSENR; FEMC

Elissa Schuett, University of Vermont, RSENR; FEMC

Nancy Voorhis, University of Vermont, RSENR; FEMC

Alexana Wolf, University of Vermont, RSENR; FEMC

17. Across the Northern Forest: Wood Products Businesses Share Their Forest Story

Amy Robinson, Northern Forest Center (no poster image available)

18. Finding lingering ash for resistance breeding: MaMA 2025 program update

Jonathan Rosenthal, Ecological Research Institute

Radka Wildova, Ecological Research Institute

19. Power in the Patchwork? Enhancing Biodiversity and Resiliency by Using Summertime Patch-cutting to Create Uneven-Aged Northern Forests.

Audrey Tamasy, SUNY College of Environmental Science and Forestry

Stacy McNulty Ph.D., SUNY College of Environmental Science and Forestry

Andrew Vander Yacht Ph.D., SUNY College of Environmental Science and Forestry

20. The Maine Woods Initiative: Protecting 130,000 Acres of Land in the 100-Mile Wilderness

Jordon Tourville, Appalachian Mountain Club

Hannah Clipp, Appalachian Mountain Club

Braedon Lineman, Appalachian Mountain Club

Georgia Murray, Appalachian Mountain Club

Madelyn Wood, Appalachian Mountain Club

Sarah Nelson, Appalachian Mountain Club

21. A collaborative regional approach to forest insect monitoring and management

Val Watson, Schoodic Institute

Emma Lanning, Schoodic Institute, National Park Service

Kyle Lima, Schoodic Institute

Jesse Wheeler, National Park Service

22. Implications of cold air pooling on dynamic soil properties and carbon storage

Grace Wang, UVM, Rubenstein School of Environment and Natural Resources

Shealagh Brown, UVM, Rubenstein School of Environment and Natural Resources

(no poster image available)

23. Prioritizing Sites to Search for Lingering Hemlock

Radka Wildova, Ecological Research Institute

Jonathan Rosenthal, Ecological Research Institute

What's in a song?
An analysis of avian vocalization bouts in a northeastern forest

Joseph Hagerty[1], Matthew P. Ayres[1], Wyatt J. Cummings[1], Laurel Symes[2], Aaron S. Weed[3], Hannah ter Hofstede[4], Pooja Panwar[1], Sharon Martinson[2]

[1] Department of Biological Sciences, Dartmouth College, Hanover, NH, USA
[2] K. Lisa Yang Center for Conservation Bioacoustics, Cornell Lab of Ornithology, Cornell University, NY, USA
[3] U.S. Department of the Interior, National Park Service, Northeast Temperate Network, USA
[4] Department of Integrative Biology, University of Windsor, Canada

Background

Within the morning chorus of north-temperate birds, there are a variety of songs and vocalizations used to attract mates or defend territory. But how are these crucial signals conveyed through song?

Vocalization pattens have been studied in katydids and crickets have been studied with respect to patterns of vocalization onset, vocalization duration, and vocalization duty cycles:

- **Phonotaxis** as sounds continue in a pattern, organisms are drawn to the source of that sound (Hedwig et al. 2017)

- **Zipf's Law of Brevity-** the more frequent a vocalization, the shorter that vocalization tends to be (Symes et al. 2021)

- **Tradeoffs exist-** longer and more complex vocalizations tend to be less frequent than shorter, simpler ones (Symes et al. 2021)

Songbirds vary in length of their songs and frequency of bouts:

- **Songbird cadence,** or the regular onset and offset of songs, can be important to **signaling a single individual source** (Beletsky 1989)

- The silent periods are **inter-song intervals** (ISI), or more generally, **inter-vocalization intervals (IVI)**

- **Song frequency** can be important to individual discrimination and signal reception (Nagel et al. 2012)

- Both **bird vocalizations and human speech** rhythmicity is influenced by two genes Neurexin I and Coenzyme Q8A (Sebastianelli et al. 2024)

- **Acoustic adaptation hypothesis-** birdsong can be adaptively adjusted to the surrounding environment to enhance communication (Sebastianelli et al. 2024)

Methods

Do birds have rhythm?
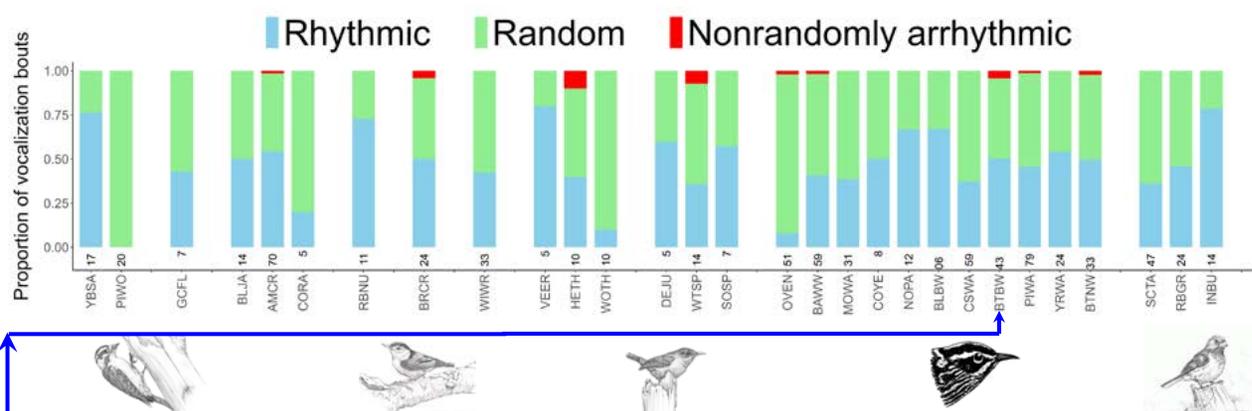
Fig. 2. Most species frequently displayed rhythmic vocalizations within 10-minute bouts. Pileated woodpeckers, common ravens, hermit thrush and ovenbirds notably less rhythmic. See Fig. 1 for bout-by-bout analyses for one species. Values above x-axis indicate number of 10-minute bouts.

How long between songs?
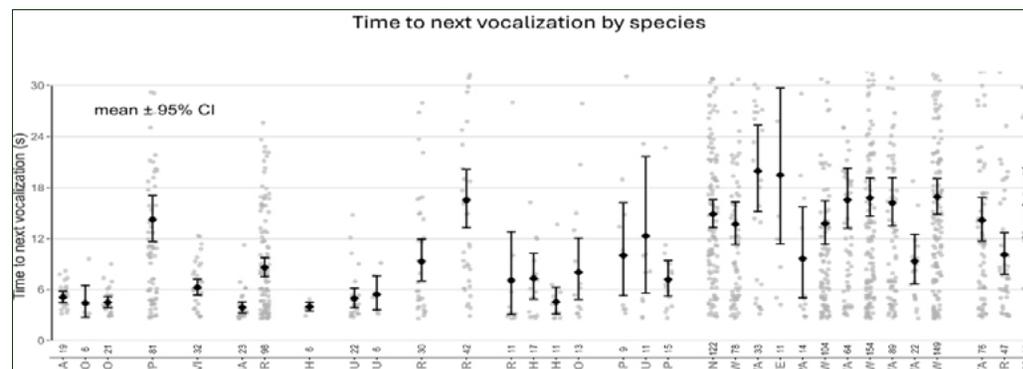
Forest Management Strategies to Rehabilitate a Coastal Red Spruce Forest in Maine

Reg Clarke[1], Keith Kanoti[1], Rose Gellman[2], Nicole Rogers[3], Jay Wason[1]

1 School of Forest Resources, University of Maine, Orono, ME; 2 Smokey House Center, Danby, VT; 3 Maine Forest Service, Augusta, ME

Introduction

Background:
- Major portions of Maine's historically iconic coastal red spruce (*Picea rubens*) forests are in a degraded state [1]
- A lack of awareness and funding to support sustainable management practices has limited active rehabilitation [2]
- This project uses a 28-acre woodlot in coastal Maine with the goal to increase awareness of management options for spruce rehabilitation

Objectives:
- To demonstrate forest management strategies that can increase red spruce composition as well as diversify forest structure and age

Figure 1. A photo of the property in coastal Maine.

Methods

Property Information:
- Historically likely a large proportion of red spruce
- Likely heavily logged upon settlement
- White pine (weevil), red maple (stump sprouts), balsam fir (balsam woolly adelgid)

Inventory:
- Inventoried in October 2025
- 16 plots across 4 stands
- Sampled overstory trees, saplings, seedlings
- Data shown is limited to the two largest stands (20 acres total, 70% of property)

Current Conditions
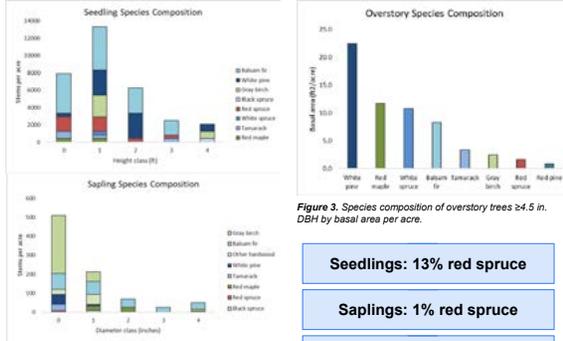
Figure 2. Species composition of seedlings ≤4.5 ft tall by stems per acre (top) and saplings >4.5 ft tall and <4.5 in. DBH (bottom).

Figure 3. Species composition of overstory trees ≥4.5 in. DBH by basal area per acre.

Seedlings: 13% red spruce

Saplings: 1% red spruce

Overstory: 3% red spruce

Possible Future Conditions

Current Forest Condition
- White pine
- White spruce
- Balsam fir
- Red spruce
- Red maple
- Intolerant hardwood

Passive Management

Year 1: Regeneration dominated by balsam fir, intolerant hardwoods in gaps.

Year 2: Balsam fir stressed by woolly adelgid as it matures, crown mortality continues.

Year 50: Intolerant hardwoods die out. Woolly adelgid kills mature balsam fir. Advance regeneration of fir succeeds.

Active Management

Year 1: Balsam fir removed in cleaning treatment, red maple clumps reduced to one stem.

Year 2: Enrichment planting of red spruce where species isn't present, white spruce in open gaps.

Year 50: Red spruce forest with white pine and white spruce components. Advance regeneration of red spruce, white pine in gaps.

Pros and Cons

	Passive Management	Active Management
Pros	- Low to no cost - Preserves "natural" processes - Avoids soil disturbance	- Promotes historical structure and composition - Improves forest health and timber value - Mimics natural processes - Supports forest resilience
Cons	- Forest health concerns - Low timber value threatens forestland retention - Preservation of "natural" processes ignores historical impacts to forest	- Initial cost without immediate return - Short-term aesthetic impact - Requires expertise

Implications

- Cleaning treatments and enrichment planting may effectively improve forest health and promote advance regeneration of red spruce
- Despite initial cost without return, active management may improve timber value
- An increase in timber value supports light-touch management to achieve rehabilitation objectives
- Future management mimicking normal wind disturbances may allow established red spruce regeneration to succeed in gaps [3]
- Overall, **long-term benefits of active management may outweigh initial costs**

Acknowledgements

References

1. Thompson, J. et al. 2013. Four Centuries of Change in Northeastern Forests. PLoS ONE 8, 9.
2. Gellman, R. et al. 2025. Coastal Spruce Forests: A Guide to Ecological Management. University of Maine, School of Forest Resources.
3. Seirup, C. 2024. Sixty Years of Change in Picea rubens (red spruce) Forests of Coastal Maine, U.S.A. *Electronic Theses and Dissertations*, 3928.

Assessing eco-geomorphic habitat factors associated with amphibian diversity in riparian floodplains of the Lewis Creek watershed

Margreta Grady[1], Lilo Schultz[2], Elizabeth Doran[3], Lydia Emry[1], Brittany Mosher[1], James Murdoch[1], Kristen Underwood[3], Rebecca Diehl[4], Rose Watts[3], and Kenneth Johnston[4]

1: University of Vermont, Rubenstein School of Environment and Natural Resources
2: University of Vermont, College of Arts and Sciences, Department of Biology
3: University of Vermont, College of Engineering and Mathematical Sciences, Department of Civil & Environmental Engineering
4: University of Vermont, College of Arts and Sciences, Department of Geography and Geosciences

Abstract

Functioning floodplains provide valuable habitat for a diverse array of wildlife, yet they are susceptible to threats such as altered hydrology, species invasions, and land use change. Prioritizing floodplain restoration and conservation projects for enhanced habitat objectives requires a thorough understanding of how wildlife use these habitats and respond to environmental changes. In this study, **we use amphibian diversity to evaluate the habitat quality of 30 forested, agricultural, and emergent wetland floodplain sites in the Lewis Creek watershed, Vermont State, USA**. Spatial analysis of site land cover composition was conducted for amphibian home ranges (23m) and dispersal ranges (300m) to account for differences in mobility among amphibian species. Using primary component analysis, we determined that our amphibian sites had three dominant land cover types: forest (deciduous and coniferous), wetland (forested, shrub/scrub, and emergent), and agriculture (hay and pasture). **We hypothesized that amphibian species richness and alpha diversity would be higher at sites with dominant wetland and forest cover. Additionally, we hypothesized that amphibian diversity would be lower at sites with dominant agricultural land cover.** Statistical analyses using Kruskal-Wallis and one-way ANOVA tests **disproved our hypotheses**—amphibian species richness and alpha diversity were not significantly higher in wetland, forest, or agricultural dominated land covers. We conclude that **agriculture-dominated landscapes can be suitable habitat for amphibians, especially in heavily restored floodplains** such as the Lewis Creek watershed, likely due to the presence of heterogenous, low-management fields for foraging. With the results from our analyses, we hope to demonstrate the importance of floodplain health for amphibian conservation and **better inform prioritization of floodplain restoration in the Lake Champlain Basin.**

Introduction

- Healthy **floodplain ecosystems provide ecosystem services** including wildlife habitat, nutrient cycling, flood risk reduction, pollution buffering, community livelihoods, and recreation.
- **Amphibian conservation research is urgently needed** to address global population declines resulting from land use change, climate change, and disease.
- Amphibians have complex life histories involving both terrestrial and aquatic systems. Thus, **amphibian diversity is an important indicator of floodplain ecosystem connectivity and health.**
- Understanding amphibian diversity patterns of the Lewis Creek watershed will help **evaluate the success of past floodplain restoration efforts and inform the prioritization of future projects.**
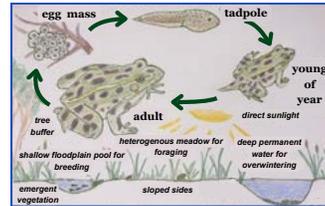
Figure I: Northern leopard frog (*Lithobates pipiens*) life cycle and associated habitat requirements

Results
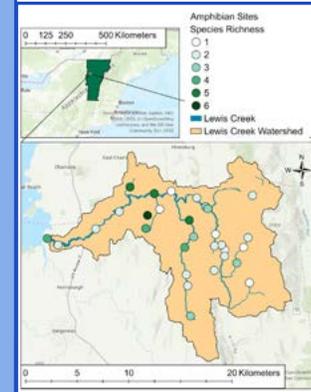
Figure II: Locations and amphibian species richness of 30 surveyed sites within the Lewis Creek watershed, VT
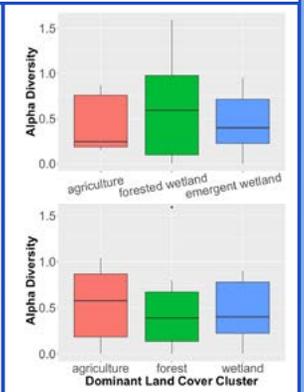
Figure III: Amphibian alpha diversity by dominant land cover in home range (top) versus dispersal range (bottom)

Table I: Kruskal-Wallis and one-way ANOVA tests determined **no significant relationships** between **dominant site land cover class** and **amphibian species richness/alpha diversity**

	N	df	Kruskal-Wallis H	ANOVA F	p
23m land cover (species richness)	30	2	1.836	-	0.399
300m land cover (species richness)	30	2	1.354	-	0.508
23m land cover (alpha diversity)	30	2	-	0.563	0.576
300m land cover (alpha diversity)	30	2	-	0.096	0.909

Methods

60 study sites generated along Lewis Creek and tributaries

Landowner permissions

30 sites with floodplain pools selected

3 mins **10-20 mins** 1 sweep/10m
average of 40m searched

Acoustic, visual, and dip net surveys

Spatial analysis of site land cover composition using two buffer sizes: **23m diameter** for home range, **300m diameter** for dispersal range

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Identified amphibians to species aided by USGS Frog Call Quiz, USGS field guide to amphibian larvae and eggs, and iNaturalist

Site species richness and alpha diversity calculated using Shannon-Weiner index

Principal component analysis and K means clustering = 3 dominant land cover classes: **agriculture, forest, wetland**

Kruskal-Wallis and one-way ANOVA tests

Discussion

- Results indicate that in the restored Lewis Creek watershed, **dominant land cover class is not a significant predictor of amphibian diversity**—wetlands associated with forest, emergent vegetation, and agriculture are all suitable habitat
- To manage for diverse amphibian communities, riparian landowners should **avoid developing wet areas**, plant **riparian buffers** to maintain water quality, and choose **heterogenous vegetation patches** over lawns to support amphibian foraging.
- Future analyses include an amphibian occupancy model with other site covariates: geomorphology, distance to road, vegetation community type, invasive species presence, and lateral and riverine connectivity.
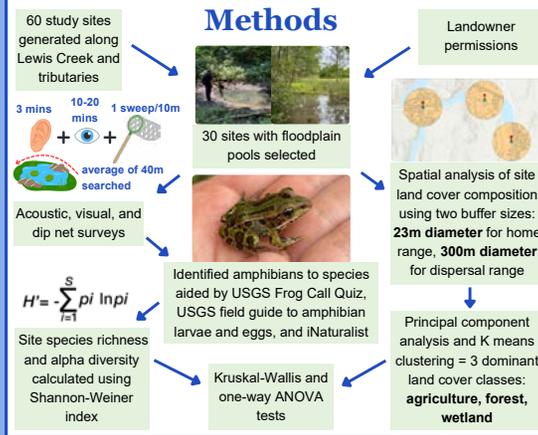
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Michalsky, S., & Peat Hamm, H. (2018, April). Guide to managing for optimal habitat attributes: Northern leopard frog. Saskatchewan Prairie Conservation Action Plan.

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Acknowledgements

Help Us Find Survivor American Elms!

Christopher F. Hansen[1], John R. Butnor[2], Anthony W. D'Amato[1], Cornelia Wilson[3], Kathleen S. Knight[3]

[1]University of Vermont, Rubenstein School of Environment and Natural Resources,
[2]USDA Forest Service, Northern Research Station, Burlington VT, [3]USDA Forest Service, Northern Research Station, Delaware OH

Background

The American elm (*Ulmus americana L.*) was a foundational floodplain species that provided substantial ecological benefits before its significant decline due to Dutch elm disease (DED). First introduced in the 1920's, DED functionally removed mature American elm from the floodplain forests of New England. However, mature "survivor" trees still exist on the landscape that may exhibit disease tolerance. Breeding programs, led by the USDA Northern Research Station and partnering with The Nature Conservancy and the University of Vermont, aim to develop locally adapted and genetically diverse seed orchards for future restoration efforts.

Outreach and Survivor Tree Criteria

- A tree in good health of at least 22 inches in diameter at breast height

- Located in an area where dead and/or dying American elms are within about one mile

- Identified tree has not been treated with fungicides to prevent DED

Many survivor elms have been found throughout New England. Additional trees are needed to increase the diversity of source material for successful future restoration efforts.

We are asking for the help of state foresters and other forestry professionals, park employees, and the interested public to identify large American elm trees surviving on their landscapes.

Please report survivor elms via the Survivor Elm Survey Tool on the USDA Forest Service website or email **chansen@uvm.edu**

https://research.fs.usda.gov/nrs/products/dataandtools/survivor-elm-survey

Resistance Plantings

Existing resistance trial plantings in Benson (~6000 trees) and Lemington (~1000 trees), VT are being assessed to better understand performance and climate adaptation among specific crosses and genotypes. Trees at these plantings are scheduled to be inoculated in spring 2026.

Growth – diameter and height assessed annually for performance differences.

Phenology – spring bud break and flower bud development as well as fall leaf senescence to assess growing season length and susceptibility to cold damage.

Cold Tolerance – differential thermal analysis and relative electrolyte leakage methodologies to assess local adaptation to source climate.

Stomatal Conductance and Chlorophyll Fluorescence – measured using a LiCor-600 fluorometer porometer to assess differences in photosynthetic capacity and leaf performance.

Identify Survivor Elms And Collect Scion → **Graft Scion Onto Rootstock** → **Clonal Propagation Via Softwood Cuttings** → **Resistance Plantings And DED Inoculations** → **Most Resistance Sources To Be Planted In Seed Orchard**
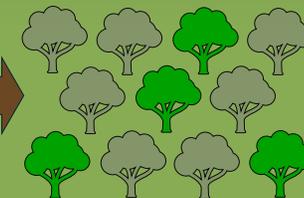
Utilizing Bioacoustics to Study the Elusive Habits of Bats in North-Temperate Forests

Jessica Jones*, Pooja Panwar, Hannah ter Hofstede, Matthew Ayres

DARTMOUTH Guarini School of Graduate and Advanced Studies · NATIONAL PARK SERVICE · LTER NETWORK · HUBBARD BROOK RESEARCH FOUNDATION

Hoary Bat
(*Lasiurus cinereus*)

Eastern Red Bat
(*Lasiurus borealis*)

Big Brown Bat
(*Eptesicus fuscus*)

Little Brown Bat
(*Myotis lucifugus*)

Northern Long-eared Bat
(*Myotis septentrionalis*)

Tri-colored Bat
(*Perimyotis subflavus*)

Introduction

Bat research and conservation have become a focus of attention in New England as our insectivorous bats face many challenges (human impacts, disease, climate change).

This project aims to monitor the seasonality and relative abundance of bats at forested ponds with passive acoustic recorders, providing a novel long-term dataset for analysis of echolocation and communication signals to answer new questions regarding bat behavior and ecology.

Methods

Beginning 2015, I deployed a high frequency acoustic recorder on Mirror Lake. Every night, 6pm-6am, from early May to mid-November. The detector would record 20 sec recordings containing bat sounds.
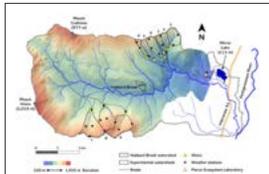
Figure 1 (right). Map of Hubbard Brook Experimental Forest (HBEF)

Acoustic Data & Analysis

Bat echolocation calls were species identified using SonoBat & quantified on a nightly scale.
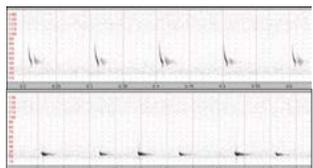
Figure 2 (left). Echolocation calls for Little Brown bat (above) and Hoary bat (below).

Main findings on bat activity over a forested pond in NH White Mtns:

1. All **8 bat species** were detected
2. Activity levels **varied interannually** but showed **predictable seasonal (intra-annual) patterns**.
3. Some species use the pond more at distinctly different times of the year.

Key Terms
- **Phenology:** the study of the annual timing of biological events.
- **Migratory bats:** are species that go south in the fall to overwinter and return to NE in the spring.
- **Hibernating bats:** are species that go dormant in hibernacula during the winter.
- **Niche partitioning** refers to the process by which different species in the same habitat divide resources (food, time, space).

Example of a slowed-down recording of the echolocation calls produced by a bat catching an insect in flight

Search calls · Approach calls · "Feeding Buzz"

Results

Mean Residuals with 95% Confidence Intervals by Year
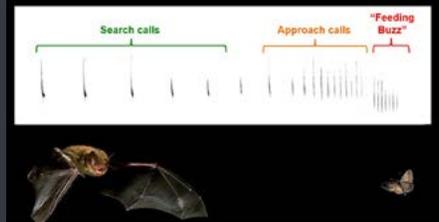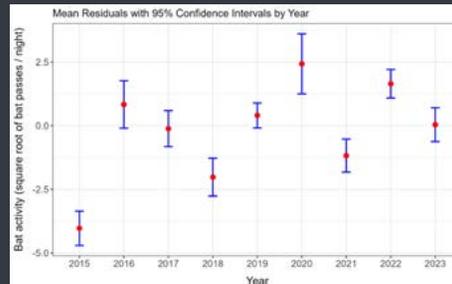
Figure 3 (above). Residuals derived from nightly means in comparison to the model line in **Figure 4 (below)**. Big Brown bat phenology.

Recruitment · Emigration

Mid recruitment 21 July (± 2 d) · Mid emigration 22 Aug (± 7 d)
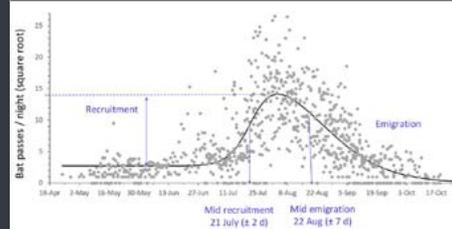
Table 1. Leaderboard for number of files with confirmed species ID in 2015-2023 acoustic dataset from Mirror Lake in HBEF.

Rank	Species CODE	Common Name	Total Rec (#)
1	EPFU	Big Brown bat	60683
2	MYLU	Little Brown bat	22992
3	LANO	Silver-haired bat	15964
4	LACI	Hoary bat	11554
5	LABO	Eastern Red bat	3068
6	PESU	Tri-colored bat	948
7	MYLE	Small-footed bat	384
8	MYSE	Northern long-eared bat	145

Mean Nightly Activity Levels (2015-2023) for Little Brown and Big Brown Bats at Mirror Lake
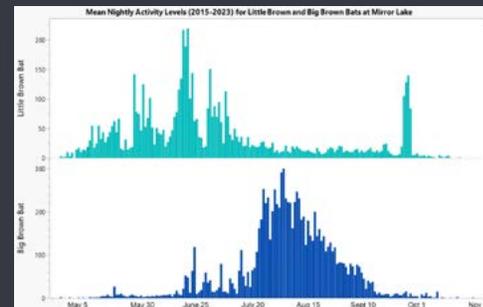
Future Directions

- Determining the potential drivers to the differential temporal patterns found across bat species at the pond:
  - Movement ecology
  - Roosting ecology
  - Foraging ecology

- Does seasonality of species vary across ponds?
- What does bat seasonality look like at other habitats? Forests? Farms?

- Integration of insect (prey) data
- How can we better understand the strategies used by bats to forage optimally in heterogenic landscapes across changing seasons with dynamic resource waves?

References
Brooks (2011), Fenton (1997), Ford et al (2011), Jones et al (2009), Loeb et al (2015)

Jones et al. (2025) Calling activity of Bats in the White Mountain National Forest: Manifest of ###,### high frequency acoustic recordings from various habitats in and nearby Hubbard Brook Forest: 2015 – 2023. In prep.

Photos originated from the following: BCI, NABat, USFWS

Vermont Mesonet - A Statewide, Meteorological Monitoring Network

Samantha Koehler[1]
Joshua Benes[1]
[1]Water Resources Institute, Univerisyt of Vermont, Burlington, Vermont

Intro:

- Vermont ranks 7th place nationally in federal disaster declarations due to recent extreme weather and ranks 4th place in disaster declarations from 2011-2024 (*Vermont Atlas of Disaster*, 2024).
- Complex terrain in Vermont limits National Weather Service radar coverage east of the Green Mountains (fig 1).
- Need for statewide, high resolution, real-time meteorological data is increasing.
- UVM's Leahy Institute granted seed funding for 2 prototype stations, kickstarting the Vermont Mesonet.
- The Vermont Mesonet will fill the gaps in meteorological monitoring for the state.
- The network will consist of 20 – 22 stations; a minimum of one per county.

Figure 1. National Weather Service radar coverage gaps

Data will serve…

- **Emergency services:** Assist in warnings and decision making
- **Education:** Create hands-on curriculums and learning opportunities for K-12 and undergraduate students
- **Agriculture:** Provide data for agricultural planning
- **Transportation:** Inform decisions during hazardous road conditions
- **Recreation & Tourism:** Provide real-time weather data for hiking and winter sports
- **Utilities & Energy:** Provide data that will help predict energy demands, manage power grids, and pinpoint outages for extreme events

Figure 3. Proposed Weather Station Design
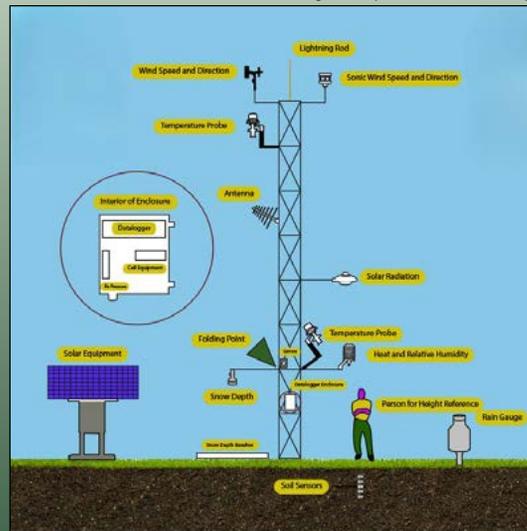
Methods:

- A site suitability analysis was conducted, following the World Meteorological Organization (WMO) requirements while balancing the needs of shareholders.
- Waterbury and Lyndon were the first two towns chosen based on the needs and recommendations of the National Weather Service, Vermont Dam Safety, and Vermont Agency of Transportation.
- Instrumentation is selected based on WMO suggestions and neighboring observation networks to create Northeast synergies.
- Each weather station will contain a 10m high tower with soil sensors measuring as deep as 0.5m. Orientation of each station will remain consistent through the whole network (fig. 2 & 3).
- Most data will be sampled at a 3-5 second interval with data packages sent every 5 minutes through cellular communication.
- Data will be transmitted directly to the National Weather Service and the Meteorological Assimilation Data Ingest System (MADIS) while undergoing internal QA/QC.
- Mesonet data will be supplemented by the Summit to Shore network to provide measurements along elevational grades and forested land types.
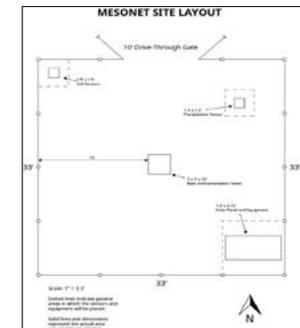
Figure 2. Station Layout for each location

Gully-washing Storms & Overland Flow

How to Slow, Spread, & Sink Stormwater in Vermont's Forests

Restoring Spongy Catchments

In 1609, when Samuel de Champlain sailed up the lake that now bears his name, Vermont's forests were spongy catchments. When hard rains fell, the forests absorbed them. Though we can't say for sure that overland flow never happened in pre-settlement forests, it's safe to call it a rarity.

Settlers soon turned these spongy catchments into ditched watersheds, and they remain so today. Culverts and roadside ditches speed water downhill, adding volume and velocity to nearby streams. These freighted waterways roar toward the valleys, scouring their banks as they go. Here in western Vermont, these sediment-laden waters pour into Lake Champlain, adding to the phosphorus load in this aquatic community.

Extensive flood damage along lower Ireland Road in Starksboro. Reducing the volume and velocity of storm flow starts in headwater forests. Most soil erosion and stormwater runoff from forests comes from access roads.

Overland flow on an old logging skid trail following a one-inch rainfall. Though the deeply incised path is unused and revegetated, it continues to concentrate storm flow, contributing to the "flashiness" of streams and rivers downstream.

Lines of Grace—Stability & Beauty

As the contour lines on the map of Little Hogback Community Forest (below) show, this land is mighty hilly. Many of the original trails climbed straight uphill. Since 2006, Vermont Family Forests has worked with the landowners to close steep roads and reroute them to gentler grades, creating what we call "Lines of Grace"—beautiful, functional, stable access paths. The long-term hydrological benefits of slowing, spreading, and sinking storm flow outweigh the short-term site disturbance of rerouting forest paths, especially given the increasingly intense storms caused by climate change.
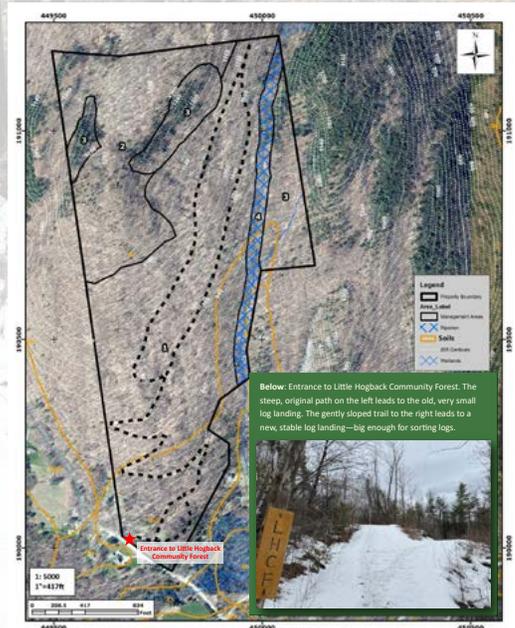
Below: Entrance to Little Hogback Community Forest. The steep, original path on the left leads to the old, very small log landing. The gently sloped trail to the right leads to a new, stable log landing—big enough for sorting logs.

12 Practices for Drought & Flood Resilience

1. Retain healthy forest cover.
2. Monitor forest health.
3. Limit access paths to 5% of forest area.
4. Aim for 7% average grade.
5. Build paths under dry summer conditions.
6. Install erosion control structures per Vermont's *Acceptable Management Practices* manual.
7. Use broad-based dips. Avoid culverts and ditches.
8. Out-slope trails to shed water into forest.
9. Avoid building paths in steep areas (>35%) or near surface water.
10. Log under frozen winter conditions.
11. Use forwarders, not skidders.
12. Directionally fell low-value trees across slopes.

Vermont Family Forests Executive Director David Brynn (right) watches as Chris Cram excavates a broad-based dip on a forest access road.

Bill Torrey uses a forwarder to collect logs in the forest. Forwarders are much lighter on access paths than skidders, which drag logs.

Broad-based Dips Rock!

Broad-based dips are a great choice for controlling erosion on forest paths. They need little maintenance, and they direct water into the forest, where it can soak in. Culverts are expensive to buy and install and must kept clear of debris. Teamed with ditches, they funnel runoff out of the forest and into waterways. If they clog during a storm, culverts can cause road washout, sending sediment into streams and necessitating costly repairs.

Distance Between Broad-based Dips on Forest Paths	
Grade (% Slope)	Distance (feet)
1	300
2	250
4	170
5	135
6	120
8	100
10	80

CLEAN WATER — The Premier Forest Product

Created by Vermont Family Forests in 2007, **Little Hogback Community Forest** (LHCF) is an experiment in community-based forest ownership. Within LHCF, 16 shareholders jointly own a 115-acre forest parcel in Monkton. A conservation easement held by the Vermont Land Trust ensures that it will not be subdivided or developed. The remaining rights—to carry out conservation practices, harvest firewood and timber, tap maples, hike, and such—belong to the shareholders. Half the shares are reserved and subsidized for Addison County residents whose family income is below the county median. LHCF is an example of how VFF works to cultivate mutually beneficial relationship with the land and with each other, here in our home place.

For the Love of Snow: Snow Monitoring with Community Science

Madelyn Wood[1], Georgia Murray[1], Braedon Lineman[1], Amy Villamagna[2], Jordon Tourville[1], Sarah Nelson[1]

1 | Appalachian Mountain Club   2 | Plymouth State University

Introduction

The Appalachian Mountain Club has been recording snow depth at Joe Dodge Lodge since the 1930s, and more recently at 3 mountain huts, however spatial distribution of snow in the complex terrain of the White Mountains is generally unmonitored. In 2022, AMC and partner organizations joined efforts with Community Snow Observations (CSO) to engage winter recreationists in crowdsourcing mountain snow depth measurements, filling in gaps where traditional measurements are scarce. More complete information improves the understanding of snow depth variability in mountainous terrain, allowing for more precise estimates of avalanches, floods, agriculture impacts, and ecosystem science.

These efforts demonstrate the effectiveness of different outreach strategies & illuminates gaps in current modeling practices.

Methods

Engagement:

AMC, Partners, and CSO ambassadors in the Northeast have been promoting the CSO program to expand participation in this region through:
- Outreach tabling at winter recreation-focused events and AMC facilities
- Informational webinars
- Teacher trainings
- Hosting hands-on workshops
- Self-guided walks with provided ruler and instructions
- Youth-oriented story-based guides
- Print materials distributed that walk volunteers through how to take snow depth measurements and point towards more resources
- Focused "snow-blitzes" events, recruiting for a weekend or day of intensive sampling

Data Collection and Analysis:

CSO snow depth measurements are reported using the Snow Scope app and a ruler or avalanche probe by volunteers. The field observations come with geolocation information and are displayed and accessible for download on the CSO website https://communitysnowobs.org. We downloaded 2457 observations made in the Northeast region from 2017-2025. Raster values for elevation were extracted from USGS 3DEP 1m DEM Mosaic in ArcPro. The predicted snow depth from CSO's model[1], available through a public Google Cloud storage bucket, was extracted on the same date and location as the observations where possible. Of the 2457 observations, only 576 observations were within the time and geographic frame of the model domain established over the White Mountains. From this group of observations, microtopography was derived for 404 observations from a 1m dem using the Geomorphon tool in ESRI ArcPro. Micro-topography was split into 10 distinct features, and then grouped into 4 larger categories – concave, convex, sloped and flat – as some features did not have enough data to be significant.

Concave	Pit, Valley, Hollow	n = 79
Convex	Ridge, Peak	n = 24
Sloped	Footslope, Shoulder, Slope, Spur	n = 295
Flat	Flat	n = 6

[1] For more info on model data sources: https://www.mountainsnow.org

Citizen science observations are key in improving predictive models for snow depth

Observation Growth By Winter Season
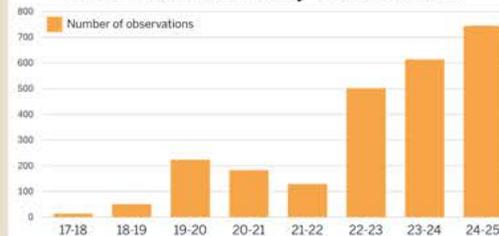
Fig 1: Number of observations submitted to the Snow Scope app within a winter season within the northeastern region, defined as Oct-Apr.

Snow Depth Difference Across Elevation
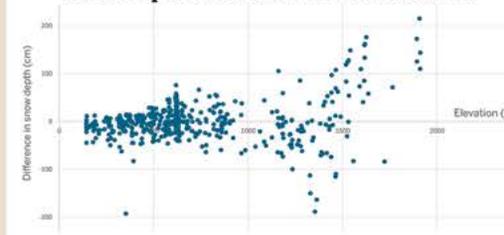
Fig 2: Difference between Snow Scope observations and modeled snow depth at that location and date across elevation (m) within the NH model domain. Positive average values represent an overestimation by the model, and negatives an underestimation.

Difference in Modeled vs Measured Snow Depth
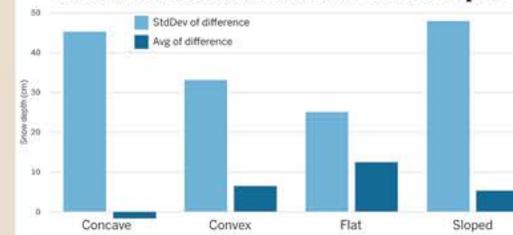
Fig 3: Within grouped landforms, in cm, the standard deviation and average of the difference between Snow Scope observations and modeled snow depth at that location and date within the NH model domain. Positive average values represent an overestimation by the model, and negatives an underestimation.

Join Community Snow Observations

1. Download the **Snow Scope** app for iOS or Android
2. Measure snow depth to the nearest centimeter, 3 or 4 times in a small radius, in undisturbed snow
3. Record the average of your measurements with the "Snowpack Height" feature in the **Snow Scope** app

Scan to download the free Snow Scope app

Visit communitysnowobs.org to learn more

Results

Engagement:

Between November 2022 and March 2025, **AMC conducted 30 outreach events, reaching over 1020 winter recreationists.** This effort, combined with the passive distribution of print materials and efforts from partners, has led to an increase in observations season after season since AMC became involved. Just over 75% of all observations are from November 2022 onward, aligning with the timing of AMC and partners promotion of the program.

Data Collection and Analysis:

The average difference of observed vs modeled snow depth is 25cm, with the largest difference being a 215cm overestimation from the model at the summit of Mount Washington. The model underestimated snow depth in concave landforms by 2cm on average, while overestimating all other groups of landforms by 5-12cm on average. **All landform categories had high variability in model accuracy, with standard deviation positively correlated with the number of observations in the model, varying from 25-48cm.**

Discussion

Engagement:

Focusing on the strength rather than the size of the volunteer network may see a higher return on investment for outreach efforts.

Over 50% of observations come from just 14 people, 5.5% of all participants, and over 90% of observations come from just under 50% of observers. Additionally, **PSU's successful weekend Snow Blitz** in March of 2025, seeing 75 observations over 3 days, provides a framework for future outreach events.

Data Collection and Analysis:

The high level of variation between modeled and actual snow depth shows the gaps in current snow modeling in the Northeast.
Our results show that convex landforms are prone to overestimation, consistent with the effect wind plays in the locations of snow accumulation in mountainous terrains. The limited number of both snow monitoring and wind measuring sites in these regions amplifies the need for citizen science to take in situ measurements to improve models, similar to Crumley et al. 2021. **Further, this work informs the Northeast Snow Survey feasibility study,** a project that aims to monitor snowpack, and other variables, across elevational gradients to better understand the impacts of climate change on regional snowfall and snowpack.

Contact

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Snow refugia: Managing temperate forest canopies to maintain winter conditions

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* Lead co-authors, snelson@outdoors.org, Melissa.Pastore@usda.gov

Introduction

Climate change is reducing snowpack across temperate regions with negative consequences for human and natural systems.[1] Because forest canopies create microclimates that preserve snowpack, managing forests to support **snow refugia – areas that remain relatively buffered from contemporary climate change over time that sustain snow quality, quantity, and/or timing appropriate to the landscape** – could reduce climate change impacts on snow cover, sustaining the benefits of snow.

- Most studies in N. America focus on closed-conifer forests vs. open areas and snow interactions; there are knowledge gaps for deciduous and mixed forests with dormant season leaf loss.

- We propose that there is an optimal, intermediate zone along a gradient of dormant season canopy cover (**DSCC; proportion of the ground area covered by the canopy during the dormant season**) where peak snowpack depth and the potential for snow refugia will be greatest because the canopy-mediated effects of snowpack sheltering (which can preserve snowpack) outweigh those of snowfall interception (which can limit snowpack). *Figure 1, Figure 2*

- As an initial test of our hypothesis, we leveraged snowpack measurements in the northeastern US spanning the DSCC gradient (*low/<25% DSCC, medium/25-50% DSCC, high/>50% DSCC*). *Figure 3*

Approach – Case Studies

12 sites: Acadia National Park, ME
2 sites: Old Town, ME
30 sites: White Mountains, NH

DSCC:

low

medium

high
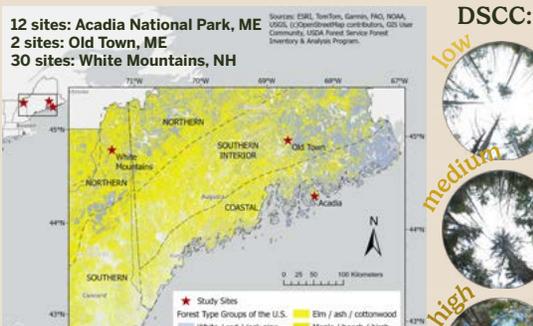
Conceptual Model
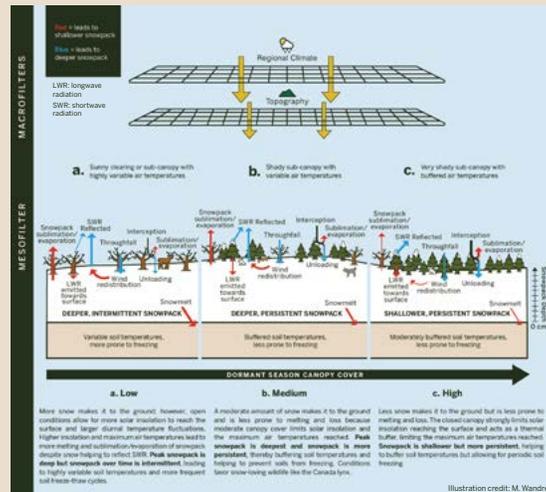
Figure 1. Conceptual diagram of the mechanisms driving differences in snowpack along a continuous gradient of DSCC.

Macrofilters such as regional climate and topographical characteristics (e.g., elevation, slope, aspect) determine base conditions, which are modified by the interrelated vegetation mesofilter characteristics that determine canopy cover (e.g., forest type/composition, canopy density, leaf area, spatial arrangement, gap distributions/sizes).
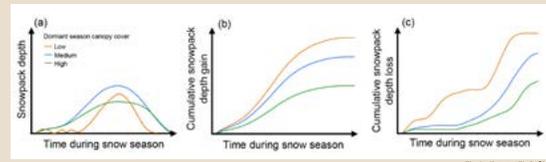
Figure 2. (a) Hypotheses of how differences in DSCC affect sub-canopy snowpack depth and snow cover duration during the snow season. At a given point in time, snowpack depth is the difference between (b) cumulative snowpack depth gain (i.e., snow that reaches the surface) and (c) cumulative snowpack depth loss (i.e., losses from sub-canopy snowpack).

Findings – Case Studies

a. Old Town, Maine:
Snowpack depth in medium DSCC mixed and high DSCC coniferous forest stands over five consecutive winters.
- 15 cm deeper snowpack in medium than high DSCC stands on average
- Similar snow cover duration, but up to >1 month later date of maximum snow depth in medium DSCC than high DSCC stands

b. Acadia National Park, Maine:
Snowpack depth as mean (+/- SE) for 12 sites during winter 2004-2005.
- Sites with medium DSCC had the greatest snowpack depth after the early season accumulation as hypothesized in Fig. 2a
- Low DSCC snow depth was greater than high DSCC after early season but leveled out and began declining February

c. White Mountains, NH:
Mean (+/- SE) snowpack depth (cm) predictions by DSCC for each survey from snowpack data collected at 30 sites during the winter of 2011-2012.
- Early through mid-winter: Deepest snowpack at open sites vs. shallowest at high DSCC sites
- Peak snowpack through late winter: Deepest snowpack at medium DSCC sites

Figure 3. Snowpack depth over time in forests spanning DSCC gradient.

Take-home Messages

Medium DSCC forests (typically, mature mixed coniferous-deciduous) exhibited the deepest peak snowpacks, likely due to reduced snowfall interception compared to high DSCC forests and reduced snowpack loss compared to low DSCC forests.

This is consistent with our conceptual model, which suggests that there is an optimal, intermediate zone along a gradient of DSCC that enables snow accumulation while protecting against loss, a balance long recognized but rarely tested across forest types or DSCC gradients.[2-4]

Many snow accumulation or snowpack studies focus on the contrast between coniferous and open sites, but our results indicate a need for enhanced focus on mixed canopy sites that could serve as snow refugia.

Measuring snowpack depth and timing across a wider range of DSCC

Turning Objectives into Action: Adaptive Planting on Vermont Lands

Danielle Owczarski – State Lands Ecologist, Al Freeman – Climate Forester, Grace Glynn – State Botanist

Vermont Department of Fish and Wildlife & Vermont Department of Forests, Parks and Recreation

WHY DO WE NEED PLANTING GUIDELINES?

Vegetation management and habitat restoration on Vermont's more than 360,000 acres of public land requires more than ecological intent—it demands a shared, science-based approach that bridges research, management, and on-the-ground realities.

We recognize the importance of balancing ecological goals with challenges such as planting stock availability, site limitations, limited staff resources, and increasing climate change impacts and novel stressors.

To meet these challenges, the Vermont Agency of Natural Resources (ANR) developed the *Planting Guidelines for ANR State Lands* (2025) — to help ANR state land managers navigate decision-making for planting projects on state lands. The guidelines also provide transparency to the public about ANR's expectations for protecting and enhancing biodiversity and ecological resilience.

The guidelines advance six primary objectives for Vermont state lands:

- Protect and enhance native biodiversity and ecosystem function.
- Protect genetics of locally adapted plant species and populations.
- Avoid introduction of non-native invasive plants, pests, and pathogens.
- Provide guidance on adaptation plantings to address novel stressors such as climate change, pests, and pathogens.
- Provide a framework/tool for project development and review.
- Raise awareness and educate ANR staff on best practices for successful planting projects.

Beyond these objectives, the guidelines create a common foundation for learning and refinement, encouraging feedback from state land managers to strengthen future iterations and identify emerging needs.

What the guidelines are not:

- ❌ They are not regulatory or permitting documents.
- ❌ They are not comprehensive planting manuals.
- ❌ They do not apply to all land types and do not cover every restoration or adaptation scenario.
- ❌ They are not intended for rare, threatened, or endangered species recovery.
- ❌ They are not prescriptive blueprints and are not static.

PROCESS AND DEVELOPMENT OF THE GUIDELINES

Development of the guidelines was led by ANR's Departments of Fish & Wildlife and Forests, Parks & Recreation in collaboration with land managers, foresters, biologists, ecologists, and watershed planners. The process included:

- Reviewing existing forest adaptation and restoration frameworks used in Vermont and the Northeast.
- Identifying management objectives and recurring project types across ANR lands.
- Developing a decision framework ("keys") linking objectives, site factors, and planting recommendations.
- Incorporating feedback from field staff at multiple points in the development process.
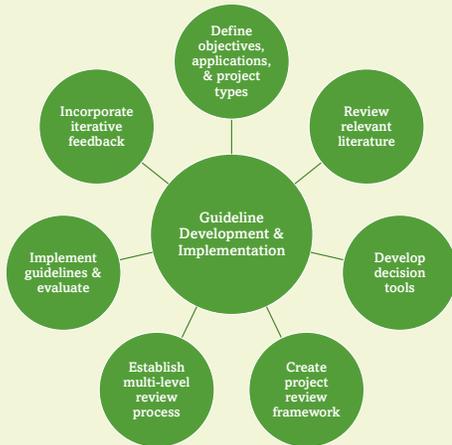
This process produced a document that provides both statewide direction and site-specific guidance. Using an iterative approach and practitioner feedback from projects in developed landscapes, riparian buffers, and post-harvest regeneration, we aim to evaluate whether the guidelines improve consistency, communication, and ecological alignment across departments and project types.

The guidelines are available online and can also serve as a resource for those implementing planting projects on private lands.

PROJECT TOOLS

The guidelines produced a suite of adaptive decision tools, including:

General Guidelines: Overarching principles for planting on ANR lands, offering broad guidance on planning, species selection, and adaptive management to support consistent, science-based restoration across diverse project types.

Project-Specific Keys: Stepwise questions that lead users from broad objectives (e.g., floodplain restoration) to specific planting recommendations based on site factors.
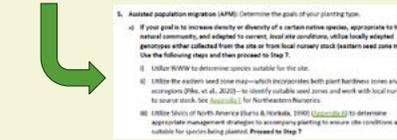
Species Selection Tables: Regionally appropriate, climate-resilient species lists organized by ecoregion and habitat.

Genetic Guidance: Emphasis on planting common species and sourcing from local or regionally adapted genotypes to prevent maladaptive plantings.

Assisted Migration Guidance: Recommendations on how to strategically select and plant species or genotypes that are expected to be better suited to future environmental conditions.

THE FUTURE OF THE GUIDELINES: ITERATIVE PLANNING

These guidelines are designed to be dynamic, with timely periodic reviews to incorporate the latest scientific advancements.

To account for the uncertainty around adaptability to novel stressors, these guidelines empower Agency staff to manage state lands as complex adaptive systems, to maintain and enhance structural and compositional diversity and redundancy across multiple temporal and spatial scales, and support multiple ecosystem services, including carbon sequestration and storage, cultural and aesthetic values, water filtration, natural community assemblages, and more.

The adaptive planting approach bridges science and implementation by converting complex ecological goals into structured, repeatable actions. The keys encourage staff to consider both current and future stressors, integrating climate adaptation directly into on-the-ground decisions.

Challenges remain, including seed source limitations, evolving pest pressures, and ensuring consistent use across departments.

Future work will include the following:

- Expanding species lists for all planting types
- Refining guidance on assisted migration monitoring
- Integrating emerging research into the guidelines
- Updating project-type keys to improve usability

By linking ecological theory with practical decision-making, the guidelines strengthen Vermont's capacity to enhance and restore resilient, biodiverse habitats that can thrive under changing conditions.

ACKNOWLEDGEMENTS

Spatio-Temporal Patterns of Bird Communities Using Regional Passive Acoustic Monitoring

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Introduction

- Passive Acoustic Monitoring (PAM) has emerged as scalable solution for long-term Biodiversity Monitoring Program (Gibb et al. 2018, Sugai et al. 2019).
- Deep learning classifiers enable efficient processing of large acoustic datasets (Kahl et al. 2021).
- Evaluating the performance of these methods is critical for data-driven decision making.

Questions
1. How well does birdNET perform to detect species at a regional spatial scale?
2. How robust are precision-based thresholds across different spatial extents and validation methods?
3. Can we detect spatial and temporal occupancy patterns of birds using this approach?

Methods

Collection → Processing → Validation

A. 104 recording locations in the northeastern US

B. Collected 72,000 hrs of recordings across 2022 and 2023

C. Processed recording through BirdNET to obtain species-level detections

D. Validated 1200 segments per species to get confidence score threshold for 90% precision (Wood and Kahl 2024)
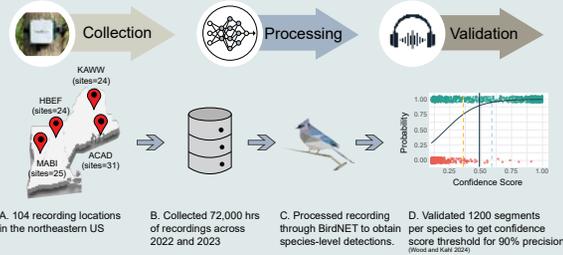
Results

How many species detected with high precision?

125 Species

Species Detection
- Good (90% Precision)
- Poor – Common Species
- Poor – Uncommon Species
- Poor – Rare Species (<10 True Detections)

79 species detected with 90% precision.

High resolution data on space use & phenology

How many segments should you validate?

Are BirdNET threshold same across space?
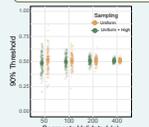
Figure. Left panel represents variation in confidence score threshold for 90% precision for Black-throated Blue Warbler for different number of segments validated when segments are drawn uniformly across confidence score range (0 - 1; yellow) and drawn uniformly with 20% extra segments in high confidence interval (0.8-1; green). Right panel shows variation in confidence score threshold for 90% precision across four sites.

Spatial Occupancy Across Season
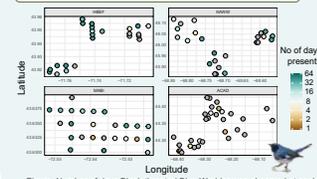
Figure. Number of days Black-throated Blue Warbler was observed at each recording location (circles). Grey circles represent unoccupied site.

Vocal Activity across Season (Phenology)

Tennessee Warbler
Yellow-bellied Sapsucker
Eastern Wood Pewee
Black-throated Blue Warbler
Hermit Thrush

1 May   15 May   1 Jun   15 Jun   1 Jul   15 Jul   31 Jul
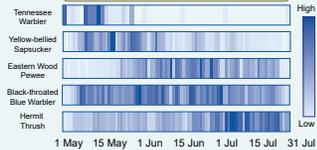
Discussion

Confidence score thresholds for 90% precision vary across species. Using a blanket threshold may overestimate presence of many species.

Some species are poorly detected due to similar-sounding species or background noise (e.g., wind). Improving model accuracy with **strongly annotated training data** would be beneficial.

Validating at least **200 segments per species** and including some high-confidence detections helps reduce uncertainty in threshold estimation.

The 90% precision threshold vary spatially. In areas where a species is relatively uncommon, false positives can inflate presence estimates. Adding conditions such as high precision detections on at least two separate days can make occupancy data more robust.

Conclusions

Deep Learning Classifier (BirdNET) can detect most species with high precision within the eastern temperate forest bird community in North America.

However, careful filtering of true detections from false detections is critical to maintain integrity of longterm monitoring data.

Passive Acoustic Monitoring offers high-resolution spatial and temporal data on presence of soniferous species, to assess changing species distribution, vocal activity behavior, and phenology.

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The Appalachian Trail as a Mega-Transect:
Using iNaturalist to Study Plant Phenology

Aiesha Parmar, Madelyn Wood, Morgan Southgate, Jordon Tourville, Georgia Murray, Sarah Nelson

Introduction

- The **Appalachian Trail (A.T.) corridor** spans 2,190 miles, 14 states, 12° latitude, and nearly 2,000 m elevation → ideal **"mega-transect"** for monitoring phenological change
- **Phenology** = timing of seasonal biological events, such as leaf-out, flowering, and fruiting in plants
- **Climate change** drives shifts in phenological timing → cascading effects on species interactions, migration, and resilience
- **Plants** may be experiencing shifts in first bloom due to climate change → can serve as **bioindicators**, assessing condition of environment and identifying shifts over time
- Traditional long-term monitoring is limited by logistics, esp. in mountains → **citizen science via iNaturalist** overcomes spatial and temporal gaps

Study Objectives:
1. Community science-based study of spring wildflower phenology across A.T. Corridor
2. Outreach to facilitate community science and communicate research results
3. Integrate results to track wildflower climate sensitivity across spatial scales, identify bioindicators for climate change, and present to conservation partners to aid management decisions

> **Citizen science via iNaturalist is a powerful tool for large-scale, long-term phenology monitoring.**

Methods

- **Platform:** iNaturalist project *Flowers and Fauna along the Appalachian Trail Corridor* (est. 2018).
- **Target Species (8):** *Arisaema triphyllum, Clintonia borealis, Erythronium americanum, Maianthemum canadense, Sanguinaria canadensis, Trillium erectum, Trillium undulatum, Viburnum lantanoides.*
- **Outreach:** trainings, pocket guides, activity booklets, in-person tabling
- **Data Curation:** observations must be (1) research-grade (≥ 2 IDs), (2) geo and date tagged, (3) within A.T. corridor, and (4) positional accuracy ≤250 m.
- **Analysis:**
  - Flowering phenophase timing vs. elevation, latitude, and longitude
    - Tested against Hopkins' Bioclimatic Law
    - Flowering curves generated to compare species and regions

Figure 1. Heatmap showing distribution of research-grade plant observations up to Sept. 2025 in the Flowers and Fauna along the Appalachian Trail Corridor iNaturalist project. Callouts show photos from individual observations of 3 of our target species: painted trillium (left), trout lily (middle), Hobblebush (right). Credit respectively to observers Curt's Hansen, Trix Neinberger, and Jason Hill.

Figure 2. Flowering curve showing number of observations by month for 8 target species until July 2024, separated by latitude. Peak flowering is shifted ~25 days later when comparing the Northern (42-46 N latitude) to the Mid-Atlantic (38-42 N latitude) and Southern (34-38 N latitude) regions

Peak Flowering by Latitudinal Divisions
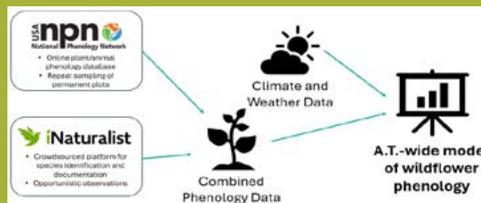
Figure 3. Future directions of this work will involve integrating iNaturalist with National Phenology Network and coarse-level climate data to model wildflower phenology at a macroclimatic level

Results

- **Participation** (as of Sept. 2025):
  - 67,000+ total observations since 2018
  - 10,000+ unique observers
  - 999 project members
- **Outreach:** 2024 outreach reached 1,068 people (+214% vs. 2023).
  - Distribution: Tabling (966), Presentations (76), Webinars (26)
- **Phenology Patterns:**
  - Shifts in phenology aligned with directions predicted by Hopkins' Bioclimatic Law, though magnitudes differed
  - Tourville et al. 2024 results show spring phenology advances with warming for understory forbs (−6 days °C⁻¹) and canopy trees (−3 days °C⁻¹), with the strongest sensitivity in the mid-Atlantic (−10 days °C⁻¹) and an expanded spring phenological window in the northern region (−2.7 days °C⁻¹)
- **Regional Differences:**
  - Elevational relationships were strongest in Northern and Southern A.T., while Mid-Atlantic results were more variable
  - Flowering peak occurred ~25 days later in the North vs. South/Mid-Atlantic (Figure 2)
- **Biases:**
  - 52% of observations in flowering phase (showy flowers attract observers).
  - Stronger representation in the White Mountains (NH), Green Mountains (VT), and Blue Ridge (VA/NC); data gaps in PA and southern VA.

Discussion & What's Next

The project demonstrates that woodland flowering species can serve as **reliable bioindicators of climate change**, with flowering times shifting predictably along elevational and latitudinal gradients. Regional variability may be attributed to limited elevational gradients and sampling gaps in the Mid-Atlantic, highlighting both ecological complexity and the importance of filling data gaps through **targeted outreach and curation**.

In 2025, the project focus will be on curating the potentially tens of thousands of suitable observations into the project, focusing on expanding representation of spring wildflowers in terms of both functional and phylogenetic diversity. In addition, by sustaining participation in the project and integrating iNaturalist records with National Phenology Network data, we hope to create a **robust, multi-source monitoring framework**. This combined approach will enable stronger detection of climate-driven phenological shifts, while **engaging thousands of community scientists** in biodiversity conservation across one of North America's most **iconic landscapes**.

Acknowledgements

Tracking forest soil health: 25 years of soil monitoring by the U.S. Forest Inventory and Analysis program

Melissa A. Pastore[1], Ashley Lang[1], John Shaw[2], Sean Cahoon[3], Hayley Peter-Contesse[4], Suzanne Owen[3], Randall Morin[1], Jonathan Knott[1], Grant Domke[1], Belinda Esham[5], Erin Berryman[2]

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Program History

FIA program began
With the McSweeney-McNary Act of 1928, USDA was tasked with conducting a national forest inventory to track the nation's timber and forest products supply.

Beginnings of soil indicator in EMAP
Concern about declines in forest health grew. EPA Science Advisory Board initiated the Environmental Monitoring and Assessment Program.

Soil indicator pilot testing via FHM
NVS and EMAP-Forest programs combined to create the Forest Health Monitoring Program. Early efforts focused on air pollution, but scope quickly expanded to include criteria and indicators from the Montreal Process.

FIA soil monitoring began
FHM & FIA plot networks merged. Phase 3 began. Soil Indicator fully implemented within FIA forest health indicators program in NFI.

Overview and Design

The FIA National Forest Inventory (NFI) is based on a grid of 2,428-ha hexagons covering the U.S., with one permanent plot in each hexagon, creating an equal-probability sample of the nation's forested lands. The soil monitoring component uses a national set of core protocols to monitor a suite of chemical and physical properties while allowing regional flexibility in soil sampling intensity to accommodate budgets and priorities. For example, the Northern Research Station (NRS) samples alternating 1/16 subsets of NFI plots (totaling 1/8 overall), while other stations vary from full-coverage approaches to limited regional sampling.

Chemical Properties
- % C, % N
- pH
- Extractable P
- Effective cation exchange capacity
- Exchangeable Na, K, Mg, Ca, Al, Mn, Fe, Ni, Cu, Zn, Cd, Pb, S

Physical Properties
- Litter & forest floor thickness
- Bulk density
- Coarse fraction %
- Soil weights (field, air-dry, oven-dry)
- Water content %
- Soil texture
- Depth to restriction
- Bare soil %
- Soil compaction % and type

- Forest floor (i.e., combined litter and duff) samples collected adjacent to subplots 2, 3, and 4
- Mineral soil (0-10 and 10-20 cm) samples collected adjacent to subplot 2
- First sample collected at soil sampling site 1, with subsequent samples in following years taken from alternating positions on opposite sides of the initial sampling point

Diverse Applications: Case Study Examples

Pairing aboveground and belowground data to assess forest health

Figure 1: Sugar maple dieback and soil Ca:Al ratios

- NY, PA, WV, and OH experienced strong deposition of sulfur dioxide and nitrogen oxides during the early 2000s, which has since improved[2].
- Soil Ca:Al increased from the early 2000s period (2000-2005) to the later period (2012-2021) by 7x at a depth of 0-10 cm and by 6x at a depth of 10-20 cm (Fig. 1a), while the proportion of sugar maple crowns with high (>15%) crown dieback declined by 67% (Fig. 1b)[1].
- Increases in soil Ca:Al were due to both declines in Al and increases in Ca over time. Specifically, the average annual rate of change in soil exchangeable Al was -4.9 mg kg^{-1} y^{-1} at 0-10 cm and -3.8 mg kg^{-1} y^{-1} at 10-20 cm. For soil exchangeable Ca, the average annual rate of change was +18.9 mg kg^{-1} y^{-1} at 0-10 cm and +11.4 mg kg^{-1} y^{-1} at 10-20 cm[1].

Exploring temporal soil dynamics using direct field measurements

Figure 2: Changes in soil organic carbon over time and across forest types

- In plots across the U.S. with soil data available from two measurement times, soil organic carbon (SOC) increased by 1.9 ± 0.3 Mg ha^{-1} per year on average[1].
- Mean annual SOC gains were 4x greater in deciduous dominated plots compared to coniferous dominated plots (Fig. 2), possibly because coniferous forests may be more prone to fire and pest outbreaks[1].

Interested in carbon? Check these papers out…

New frameworks for estimating soil carbon stocks across the U.S. were developed with NFI and International Soil Carbon Network data[3,4,5]. These new methods resulted in a 44% decrease (-2 Pg) in estimates of forest floor carbon stocks[3] and a 65% increase (+11 Pg) in estimates of mineral soil organic carbon stocks (to a depth of 100 cm)[4] on U.S. forestlands. New calculation methods may further refine these estimates[6].

Data Availability and Status

About 10,000 forested NFI plots have been sampled for soil analyses nationwide (Fig. 3), representing about 7% of NFI base plots containing forestland. The number of plots with 2+ soil visits is rapidly growing in the NRS and RMRS regions, but soil remeasurements are scarce in the SRS and contiguous PNWRS regions, where soils are not currently being sampled (Table 1).

Figure 3. NFI plots that have been visited for soil sampling. Plot locations are fuzzed.

Number of soil visits
- 1
- 2
- 3

	NRS	RMRS	SRS	PNWRS-Contiguous	PNWRS-Coastal Alaska	PNWRS-Interior Alaska	PNWRS-Hawai'i
Visits	2000-2005, 2012-2024	2000-2024	2003-2006, 2009-2010	2001, 2003-2008	2008-2010	2014, 2016-2024	2011-2012, 2019-2022
Lab	2000-2005, 2012-2021	2000-2010, 2012-2023	2003-2006	2001, 2003-2006, 2008	2008-2010	2014, 2016-2020	2011, 2019-2022
Field-General	2000-2005, 2012-2006	2000-2023	2003-2006, 2009-2010	2001, 2003-2008	2008-2010	2014, 2016-2020	2011-2012, 2019-2022
Field-Erosion	2000-2005, 2012-2023	2000-2023	2003-2006, 2009-2010	2001, 2003-2008	2008-2010	NA	NA

Table 1. Summary of measurement years with plot visits for soil sampling and lab or field data availability.

Potential Future Advances

- Full national implementation of soil sampling
- Increase soil sampling intensity of NFI plots
- Increase number of mineral soil cores extracted per plot to a minimum of 3 cores
- Increase depth of mineral soil core sampling to a minimum of 30 cm
- Separately analyze litter and duff layers
- Use advanced soil texture analyses
- Characterize soil microbial communities
- We'd love to hear your ideas!

Acknowledgments

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Melissa.Pastore@usda.gov

A Snapshot of FEMC's Regional Forest Health Monitoring Network. A Temporal Analysis 2022-2024

Benjamin Porter[1,2]; Soren Donisvitch[1,2]; Matthew Rios,[1,2]; Alison Adams[1,2]; Elissa Schuett[1,2]; Nancy Voorhis[1,2]; Alexana Wolf[1,2]

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Through long-term forest health monitoring in seven (7) northeastern states, the Forest Health Monitoring (FHM) program has begun to observe minor trends in declining health across northeastern forests. Overall, forests remain relatively healthy, however, due to specific damages and diseases, certain species should be continued to be closely monitored and managed, such as American beech, white oak, black cherry, and white ash.

Introduction

The FHM program of the FEMC has previously conducted long-term monitoring assessments of forest health throughout Vermont since 1990. Expansion in 2022 allowed FEMC to established 194 total plots throughout Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont (Fig. 4). These new sites were primarily co-located at established long-term forest health monitoring plot locations (FIA and CFI), representing the major forest types and geographies on public lands. 2024 marked the third year of monitoring on all plots within our regional 7-state network – allowing for some initial time series analysis.

During the 2024 field season, the FEMC FHM crews assessed seedling regeneration, sapling survivorship, and overstory health. Forest health metrics included tree heights, tree diameter at breast height (DBH), vigor, dieback, transparency, defoliation, and discoloration of the forest canopy. Lastly, crews documented special damages for each tree, along with invasive species presence and the degree of browse pressure observed within each plot.

2024 represented the third year of sampling of our complete regional network, allowing us to begin to assess region-wide temporal trends. It is important to note that emerging trends described here are based on only three years of sampling and may not represent true trends across these forests over longer time periods; as we collect more data in future years, observed trends will become less uncertain.

Plot Layout
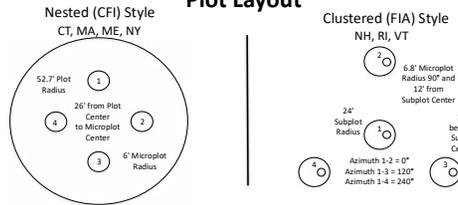
Figure 1. Our nested (CFI-style) (left) and clustered (FIA-style) (right) FHM plots are shown. Our FHM program adopted these to accommodate plot layouts from each state's historical FHM efforts. The nested plots contain an overstory plot (large circle) and four regeneration microplots (small circles at cardinal directions), while the clustered plots contain four subplots and four regeneration microplots, based upon the USFS FIA style plot network.

Results

- Based on 2024 crown health assessments, we determined white oak (Quercus alba), American beech (Fagus Americana), and black cherry (Prunus serotina) as species of concern in 2024.
- Forest health declined slightly from 2022–2024, with increasing crown transparency, fine-twig dieback, and reduced vigor across multiple species, suggesting growing regional stress.
- Oak species show rising dieback likely linked to drought and oak wilt. State-wide declines in Rhode Island and Maine display the highest moderate-to-severe vigor ratios, possibly due to recent droughts, but possibly influenced by sample sizes.
- Black cherry and northern white cedar are two species with higher transparency values, possibly from drought sensitivity or pest pressures, while most conifers remain stable in vigor. While black cherry is not known as a specific host for certain pests or pathogens, it is sensitive to drought and fungal infections, which have become increasingly common with recent swings in precipitation events across the region.
- American beech, balsam fir, and white ash have the highest mortality, driven by BBD and BLD, climatic stress on fir, and EAB.
- Basal area trends show a small rise in dead-tree proportion and fewer "healthy" trees; large species like white ash have an outsized impact on forest structure (BA) when they die, while smaller, more abundant species like balsam fir dominate mortality trends by tree count.
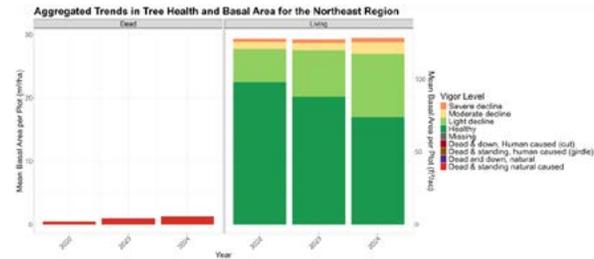
Figure 2. Region-wide mean basal area per plot in hectares (m²/ha, left axis) and acres (ft²/ac, right axis) for living and dead trees across different tree vigor classes. Data are grouped by tree status, with living classes shown on the right and dead classes on the left. An overall average trend towards less vigorous trees is evident.
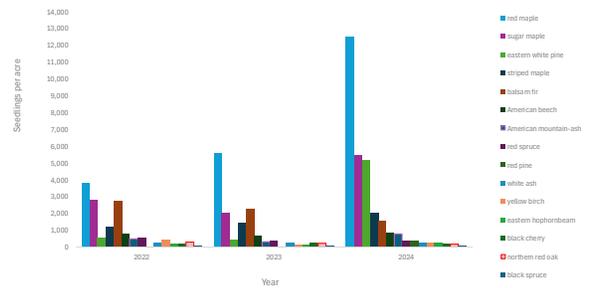
Figure 3. A temporal analysis of the mean seedling density (counts per acre) for each species between 2022 and 2024. Plots consistently visited since 2022 (189 plots) were used in the analysis. Masting by select species could be the cause of large seedling discrepancies.

FHM Program Plots in 2025
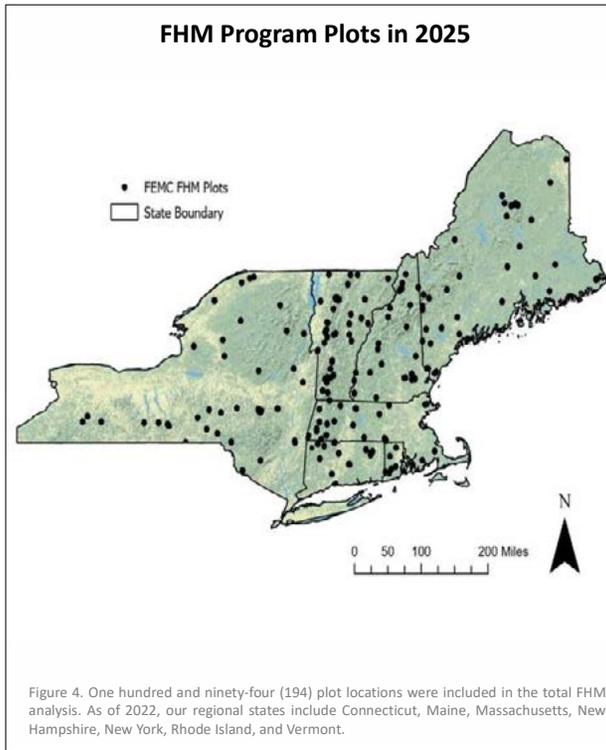
Figure 4. One hundred and ninety-four (194) plot locations were included in the total FHM analysis. As of 2022, our regional states include Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.
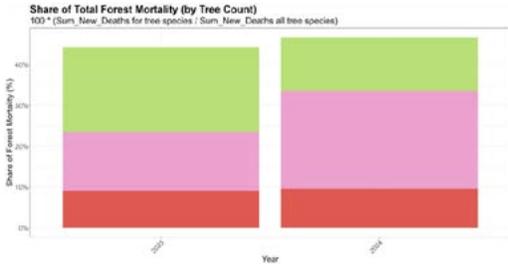
Figure 5. Share of total forest mortality trends by total count across the Northeast region for the top three species with the highest number of newly dead trees, relative to all newly reported tree deaths across all species comprising greater than 1% of regional total basal area.
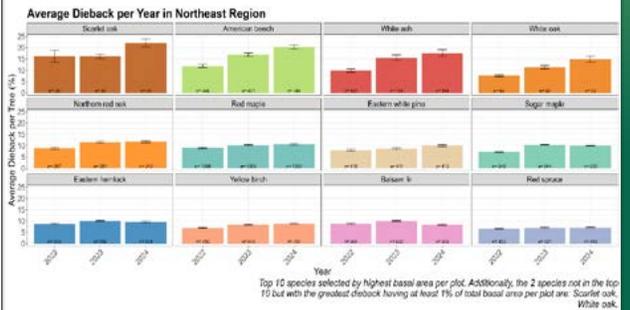
Figure 6. Regional average fine twig dieback trends by species and year for the top ten species by basal area, plus two that are less representative by basal area but nonetheless showed high dieback (scarlet oak and white oak). Species are ordered based on dieback rates in 2024.

Finding lingering ash for resistance breeding: MaMA 2025 program update

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What is MaMA?

Monitoring and Managing Ash (MaMA) is a program of the Ecological Research Institute (ERI) that enables detection of strictly defined lingering ash, and collection of material from them for resistance breeding.
Lingering ash are chemically untreated, native, naturally occurring trees that had ≥ 4" DBH at the time of peak EAB infestation and retained healthy crowns for ≥ 2 years after ≥ 95% of the mature ash in the area were killed by EAB. The **USFS EAB Resistance Breeding Project** has shown (for green and white ash) that material collected from such trees can be used in selective breeding programs to yield highly EAB-resistant native ash.

MaMA is being implemented throughout **New York** and **New England** thanks to support provided by the **Tree Species in Peril initiative** led by the USFS and The Nature Conservancy.

MaMA's ability to detect lingering ash relies on: **1) large-scale data collection to identify where and when to search for lingering ash**; and **2) integrating lingering ash detection into ash management** (as management practices such as large-scale proactive cutting can prevent finding such trees). Finding lingering ash depends on searching soon after the mortality threshold has been met and the trees have maintained their health long enough to demonstrate they are truly lingering ash (waiting too long after this can make detection impossible).

Lingering ash search timing

MaMA's **action maps** enable searching for lingering ash at the right places at the right times, by showing: 1) areas known or projected to be ready to search for lingering ash; and 2) areas needing more data and which MaMA project to use to collect it. The maps are first created using EAB detection data along with standard mortality trajectories and spread rates and are updated annually using mortality data collected by MaMA projects.

The map below is based on data collected through 2024; we are in the process of generating a new map incorporating data from 2025. This will likely show that in addition to areas of NY, CT, and MA, some locations in VT, NH and possibly ME will be ready to be searched, especially for lingering black ash, which tends to decline most quickly.
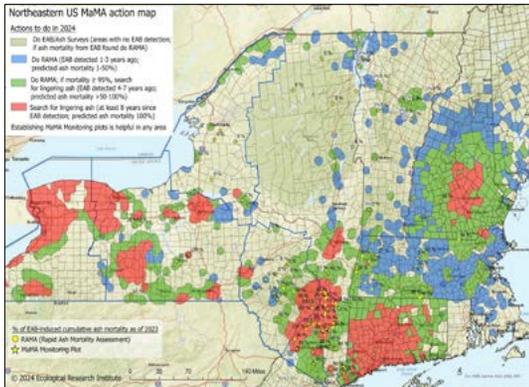
To access MaMA action maps, go to www.monitoringash.org/mama-action-maps.

MaMA's four data collection projects

photo by T. Bittner

MaMA has achieved detection of lingering ash of all three widespread NE ash species (white, green, black) and collection of material from them for a resistance breeding program at Cornell University.

These projects comprise **MaMA Monitoring Plots Network** (40 trees monitored until they die from EAB); **MaMA Rapid Ash Mortality Assessments (MAMA RAMAs**, a less precise but less time-consuming alternative to plots); **MaMA Lingering Ash Search** (reporting lingering ash found opportunistically or through systematic searches**;** and **MaMA Ash/EAB Surveys** (reporting EAB evidence from areas where it hadn't yet been reported). For full descriptions of each, see www.MonitoringAsh.org.

All of MaMA's activities rely on numerous partnerships with agencies, NGOs, researchers, professional land managers and community scientists.

2025 updates

1) Collaboration with indigenous initiatives, aimed largely at black ash conservation.

Lingering green ash

ERI hosted a team from Ash Protection Collaboration Across Waponahkk (APCAW) at Hudson Valley MaMA sites to examine diverse outcomes in ash stands long invaded by EAB.

Collaborative training of professionals and community scientists in Maine by ERI, APCAW and the Gulf of Maine Research Institute (GMRI) that integrated lingering ash detection into other approaches to ash and cultural conservation.

This beautiful 20.5" DBH female lingering black ash found during APWAC visit in the Hudson Valley !!! In the fall we found 8.5" DBH male lingering black ash nearby.

ERI was invited to give a presentation at the Gathering on the Future of Black Ash and Basketry at the Odanak Abenaki community in Quebec.

Mohawk fancy black ash and sweet grass basket.

2) Our other efforts to increase lingering black ash detection have included working with **NY Natural Heritage** to identify sites with historic black ash occurrences, which can provide a model for other states. We are also prioritizing initiatives with other institutions in NY and northern New England responsible for black ash management. Aside from black ash, we are also prioritizing green ash, because we need more data on this species, which is considerably less common than white ash in the New York-New England region.

3) Data collected, lingering ash detected

- First data reported from Maine; expansion in all other states in the region.
- New plots added to MaMA Monitoring Plots Network in CT, ME, NH, NY and VT.
- New RAMAs done in CT, MA, ME, NH, NY and VT.
- Mortality data from other initiatives shared that can help populate action maps.
- 82 new lingering ash found and validated (white ash 54, green ash 8, white/green ash 13, black ash 7), bringing totals to 245 overall (**white ash 190, green ash 22, white/green ash 16, black ash 17**); other possible lingering ash were reported, awaiting validation
- Exciting new collaboration with FEMC. FEMC field crews performed 39 RAMAs in NH, NY, MA, VT (and set up a plot in NH)

ERI trained FEMC field crew leaders in MaMA data collection projects.

4) Data reporting and management collaborations

- MaMA Ash/EAB Surveys and MaMA Lingering Ash Search are now also supported on **TreeSnap** in addition to its original platform, **Anecdata** (smartphone app and Anecdata.org)

- ERI worked with APCAW and GMRI to harmonize their **Protecting Ash for the Future** initiative data collection with MaMA data forms.

5) Lingering ash material collection

- MaMA has already collected scion from **72** lingering ash (**53 white, 9 green, 10 black ash**) for EAB resistance breeding at Cornell University.

- ERI collected seed from a lingering black ash; will attempt to collect more from it and also from a lingering green ash.

Lingering black ash

Scion (left) and seed (right) collection from lingering trees

6) Ash propagation collaboration

- New Hampshire's state nursery supplied white ash seedlings to our new propagation partner, Land Stewards, in NY; these will be ready to receive lingering scion collected from NY, CT this winter.
- This will complement the breeding already being done at Cornell, where trees from grafted lingering scion of all three species collected in 2024 were planted out in October.

Acknowledgements

Power in the Patchwork?

Enhancing Biodiversity and Resilience by Using Summertime Patch Cutting to Create Uneven-Aged Northern Forests

Audrey Tamasy[1], Stacy McNulty *Ph.D.*[1], Andrew Vander Yacht *Ph.D.*[1]

[1]SUNY College of Environmental Science and Forestry

Introduction

- Northern hardwood forests face **increasing stressors**: herbivory, disease, and climate change[1].
- Managing forests for compositional and structural diversity may **increase forest resiliency**.[2]
- Traditional uneven-age silviculture can be difficult to apply and often abused (*i.e.*, high-grading), and **questions remain regarding the effectiveness of shelterwood and no-action approaches**.[2]
- Systematic patch clear-cutting every 25 years was initiated in 2002 (2nd entry planned summer 2026) at ESF's Huntington Wildlife Forest to create **diverse, uneven-aged (6 ages) stands**.
- Effects on **tree regeneration, birds, and beech-leaf disease** will be monitored.

Driving Questions

- How does summertime patch clear-cutting affect tree regeneration dynamics in Northern Hardwood stands relative to traditional shelterwoods or no-action?
- How will this mosaic of forest age classes, and effects on structural heterogeneity within stands, affect the diversity and abundance of songbirds and ruffed grouse?
- Could summertime patch clear-cutting mitigate effects of Beech Leaf Disease (BLD)?

Will managing forests for greater diversity lead to greater resilience?

Arial image of Bureau Brother's tract post harvest 2002.

Hypotheses: Patch-cuts will...

1. Increase density and diversity of desirable tree regeneration, and herbaceous plant cover and density, by increasing structural diversity and spatially distributing ungulate browsing. Such responses will also be greater after summer than winter cuts due to less beech resprouting.
2. Increase the diversity and relative abundance of songbirds and ruffed grouse by creating a patchy and well-distributed mosaic of habitat properties.
3. Decrease prevalence and/or severity of BLD by distributing aggregates of disease prone trees among younger, more vigorous trees.

Acknowledgements

Bureau Bros. Management Area Timber Sale

Newcomb

Each patch is 0.4ac

	165 ft	330 ft	
110 feet	Clear Cut 2026	1. Clear Cut 2002	2. Clear Cut 2026
220 feet		3. Clear Cut 2050	4. Clear Cut 2075
		5. Clear Cut 2100	6. Clear Cut 2125
	Clear Cut 2026		Clear Cut 2026

(330 ft)

Methods

Study Area: Huntington Wildlife Forest, Newcomb NY

Bureau Brother's Turn: 100-acre patch-clear-cutting (uneven-aged management). 1st entry in 2002.

Treatments: Patch-cut, shelterwood, and no action comparing effects on forest regen, wildlife, and disease.

Seasonality: 2002 cuts were in the winter, and 2026 cuts will be in the summer, enabling comparisons of effects on regeneration and interfering beech resprouting.

Wildlife: Ruffed grouse and species-specific songbird response quantified via passive ARU and active point-counts (5 locations for each per stand cores) in late spring (2026 pre-cut, 2027 post-cut).

Vegetation: Assessed using a nested plot structure sampling groundcover, seedling and sapling densities by species, canopy cover, and overstory basal area (30 plots per treatment, pre- and post- harvest).

Beech Leaf Disease (BLD): Monitored via beech bud sampling and visual assessment across treatment types.

Preliminary Results from 2002 winter harvest

Herbivory data was recorded five times from the first entry of patch clear-cuts in 2002 until 2025. Herbivory exclosures and control plots were established within patch-cuts and areas of thinned mature forest.

- Patch clear-cuts showed **greater density of hardwood regeneration** by year 2025.
- Exclosed plots generally had greater amounts of regeneration showing that **herbivores are impacting regen**.
- Patch clear-cuts may be **dispersing regeneration** enough to reduce herbivory impact.

Traditional Silviculture / Patch Clear-Cutting

Regeneration — A / B
Wildlife — C / D
Disease — E / F

Figure 1. Comparison of the effect of herbivory exclosures on white ash, yellow birch, American beech, and sugar maple density in patch-cuts verses thinned mature forest on the Bureau Brother's Turn.

Cut Control / Cut Exclosure / Thinned Control / Thinned Exclosure

2001 → 2002 → 2003

Potential Impact

This project is in partnership with NGOs **New York Audubon Society** and the **Ruffed Grouse Society** and federal partners at **U.S. Forest Service** which allows for findings to be shared with stakeholders across the Northeast through community outreach and educational programs. This project's ecosystem approach of disseminating wildlife data with forest management information will help forest owners and managers "connect the dots" between forest management and forest health.

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Maine Woods Field Station: Building Research Capacity to Conserve the Wildlands of the Northeast

Jordon Tourville , Hannah Clipp, Braedon Lineman, Georgia Murray, Madelyn Wood, and Sarah Nelson | Appalachian Mountain Club

Introduction

- The northeastern US is experiencing large shifts in climate, with warming winters, increased frequency of extreme precipitation events, and severe droughts [1-2].
- Since 2003, as part of its Maine Woods Initiative (MWI), AMC has conserved 130,000 acres of land in the 100-Mile Wilderness, which lies in the heart of Maine's north woods, a region that features some of the largest areas of undeveloped forests, lakes, and ponds in the United States, as well as an area of exceptionally high habitat connectivity and resilience to climate change [3].
- Significant components of MWI include: 1) restoring degraded forestland; 2) restoring watersheds to their more natural states; and 3) climate change research.
- Given the urgent need for an understanding of the effects of climate change in the Northeast coupled with the abundance of scientists conducting climate-related research in the region, the need to disseminate information about MWI as a resource is incredibly timely.

Pictures Above: The 130,000 protected acres within MWI contains both ample aquatic ecosystems, such as lakes, streams, and wetlands (left), and upland systems, such as northern hardwood and spruce-fir forests (right).

Key Gaps and Barriers

- There is no recognized field station in Maine's 3.5-million-acre North Woods, and it remains a largely under-studied landscape, newly open to science and ecological forest management since major transitions in large land ownership [4].
- Many scientists working in the region are largely unaware of AMC's ownership or of the natural resources and research infrastructure (research plots, sensors, forest treatments, existing data) that AMC and partners have recently developed.

Overarching Goal

- **We plan to create a permanent research station in AMC's MWI.** We aim to expand research opportunities to more scientists and make MWI available for additional research projects with the ultimate purpose of conserving and restoring wildland ecosystems in northern Maine and nationwide.

The Maine Woods Initiative

Map Left: MWI boundary and adjacent conservation lands. Future land acquisitions may further expand these boundaries.

Map Right: Habitat types within MWI boundaries based on Nature Conservancy (TNC) analysis and modeling (Northeast Habitat Map; https://www.maps.tnc.org/nehabitatmap/)

Forest and Aquatic Resources

Figure Top-Left: Percent cover of major habitat types within MWI portioned between upland and wetland (labels represent total acreage).

Table Left: List of state and federally listed species potentially found within MWI.

Figure Bottom-Left: Increase in carbon stocks within core sections of active ecologically managed forests over the past two decades.

Mammals	Birds	Fish
Species	Species	Species
Rock vole	Eastern bluebird	Lake trout
Long-tailed shrew	Horned lark	Brook trout
Canada lynx	Merlin	Landlocked Atlantic salmon
	Red-shouldered hawk	
	Cooper's hawk	
	Bald eagle	
	Northern goshawk	
	Red-breasted merganser	
	American black duck	
	Bicknell's thrush	
	Fox sparrow	
	Rusty blackbird	
	Great blue heron	
	Black tern	
	Peregrine falcon	
	Sedge wren	

Invertebrates	Herps	Plants
Species	Species	Species
Tidewater mucket	Northern spring salamander	Mountain sweet-cicely
Brook floater		
Roaring brook mayfly		

Current Research and Opportunities

Over the past 30 years...

- 22 funded projects in MWI led by AMC, academic, agency, and NGO partners (see map on right; breakdown by topic on bottom-right).

Some examples...

- Climate research installations
- 30-year bird study
- Maine DEP's Biomonitoring
- Dragonfly Mercury Project
- Lake Stewards of Maine
- Citizen science projects such as iNaturalist
- 10-year study to support Atlantic salmon passage
- AMC's research on wildlife occupancy related to large wood additions

Take-Aways

- AMC's burgeoning research at MWI builds on the decades of research and long-term monitoring that AMC pursues across the region. Many scientists have already traveled to MWI to conduct research on its more than 50 lakes and ponds, over 130 stream restoration sites, rare bird habitat, and 130,000 acres of forest, including ecoreserve and forest restoration sites. We have hosted undergraduate research field courses at our New Hampshire facilities, a model ripe for expansion to MWI.
- MWI offers opportunities for research in silviculture, wildlands, plant ecology, freshwaters, biodiversity, climate, and social science related to natural resources. It is located in proximity to other ecologically significant lands, including Baxter State Park, the Appalachian Trail, Gulf Hagas National Natural Landmark, Debsconeag Lakes Wilderness Area, Nahmakanta ecological reserve, and Katahdin Woods and Waters National Monument, making MWI an ideal launch point for research.

The time is ripe to develop a network of researchers to participate in the creation of a MWI Research Field Station.

Next steps

- Complete an initial prospectus on the potential and feasibility of a MWI field research station.
- Compile all MWI-relevant data into a single searchable and public-facing database with associated metadata.
- Advertise the research potential of MWI and form additional partnerships with academic, NGO, and governmental organizations.
- Examine and address the infrastructure and other logistical needs that would help to better serve researchers.

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For more about MWI, scan here:

A collaborative regional approach to forest insect monitoring and management

Val Watson[1], Emma Lanning[1,2], Kyle Lima[1], Jesse Wheeler[2]

[1]Schoodic Institute, [2]National Park Service

Project Overview

Hemlock woolly adelgid (HWA) and emerald ash borer (EAB) are growing problems in the north woods and often need to be addressed by many neighboring landholders simultaneously. However, resources for comprehensive planning and inter-group coordination are often lacking. The goals of this project are:

1. Create concise literature reviews of the biology, ecology, and management of forest insects newly arrived to Mount Desert Island to contextualize management actions

2. Build framework of protocols and data sheets for detection, monitoring, and management that is transferable across landholders

3. Facilitate communication among land managers on the island

4. Compile a management plan for Acadia National Park that could be used by neighboring land managers

Regional Context

While much of Mount Desert Island is a part of Acadia National Park, several other conservation organizations also own one or more properties on the island, often sharing boundary lines. As a result, both problematic forest insects their biocontrol predators may migrate between properties, making management coordination especially important.


Map of Mount Desert Island, via National Park Service (Acadia National Park in green)

Products

This project produced several tools for insect detection, monitoring, and management:

Literature Reviews

We reviewed the available literature on HWA and EAB biology, ecology, and management. We then compiled concise reviews written for a general audience to contextualize management options for administrators, managers, and funders.
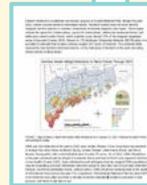
Protocols and Data sheets

Survey protocols and data sheets created in collaboration with park biologists provide a standard structure for forest stand delineation, prioritization of stands, insect monitoring, and assessment of management actions

Management Plans

Management plans written for Acadia National Park offer a template for neighboring land managers and communicate planned actions

Process

1. Review existing literature on HWA and EAB to compile a comprehensive review, then refine for local relevance and digestibility

2. Coordinate meeting with land managers on the island to identify characteristics of stands that are a high priority for protection. Also meet with Wabanaki foresters to identify management priorities

3. Use the priorities identified to create protocols and data sheets to evaluate stand characteristics for future prioritization of sites for management action. Field test the protocols alongside park biologists to refine

4. Compile all into a comprehensive management plan for Acadia and beyond, improve with iterative feedback

Schoodic Institute is located in Acadia National Park at Schoodic Point, homeland of the Wabanaki, People of the Dawn

We recognize and respect Wabanaki relations past and present with Schoodic Point and the surrounding waters. We support the Penobscot, Passamaquoddy, Maliseet, and Mi'kmaq Nations as they continue to practice and renew their cultural traditions and identities in Acadia and beyond. Honoring Wabanaki sovereignty benefits all who live here, today and in the future.

Historically, Schoodic Point was home to Wabanaki families who harvested fish, clams, sea birds, and mammals in both the distant and recent past. Today, Schoodic Point remains an important place for Wabanaki families, and a place for cultural events, community gatherings, and meetings between Wabanaki governments and the National Park Service.

As a nonprofit partner of the National Park Service, we have a unique role to play in supporting the government-to-government relationship of Wabanaki Nations and the U.S. Department of Interior. Our role includes supporting Wabanaki scientists conducting research in Acadia on behalf of their communities. We have much to learn from them, and from holders of traditional ecological knowledge, about the environmental changes and human responses that are the focus of our research and education programs.

Identifying sites to use for hemlock health monitoring or lingering tree searches

Dr. Radka Wildova and Jonathan Rosenthal, Ecological Research institute

Benefits/purposes of lingering hemlock searches

1) Obtain material to test for heritable resistance/tolerance to HWA and EHS.
2) If heritable resistance/tolerance found, use for breeding.

Criteria:
Lingering hemlock searches: sites where dead/dying trees ≥ 80%.

Lingering hemlock (left) at site in Mohonk Preserve (right) where 90% of hemlock trees are dead or dying. Both EHS and HWA are at the site and on the lingering tree; photos by R. Wildova.

Benefits/purposes of monitoring plots

1) Enable detection of when decline/mortality threshold reached.
2) Can assess factors influencing decline/mortality rates, thus better identification of where/when to search; also help fine-tune management responses.

Criteria:
Monitoring plots: sites where dead/dying trees < 80%.
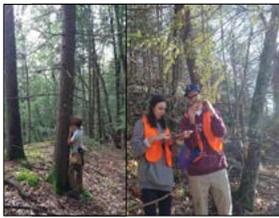
Monitoring hemlock health at sites in Mohonk Preserve; photos by R. Wildova.

Factors related to hemlock mortality in stands infested by HWA/EHS*

Hemlock stress factors
Related to hemlock water budget, risk of drying:
- High summer temperatures, high winter temperatures
- Latitude and altitude (lower latitudes stressful due to temperature)
- Steepness of slope (steeper more stressful)
- Aspect (highest mortality on W, S – facing slopes; lowest mortality on N-facing slopes)
- Substrate's water availability (based on soil type, etc.)
- Summer drought (higher mortality with less precipitation)
- Ridgetops particularly stressful

Other stressors:
- Impacts of other pests (e.g., spongy moth)
- Light availability (higher mortality with lower light availability)

HWA favorability
- Warmer summer: positive effect on HWA
- Warmer winter: positive effect on HWA
- Cold due to altitude, latitude can have some negative effect on HWA

Tree characteristics
- Tree DBH (some studies have found higher mortality in larger trees)
- Total hemlock basal area (higher mortality in denser hemlock stands)
- Nitrogen content of foliage (higher mortality in stands with higher N in leaves)

Case study of site-to-site variation in hemlock mortality: Mohonk Preserve, NY

ERI established 20 monitoring plots in 2015. Previous researchers had recorded arrival of HWA and EHS at these sites, ranging from 20 to 30 years ago.
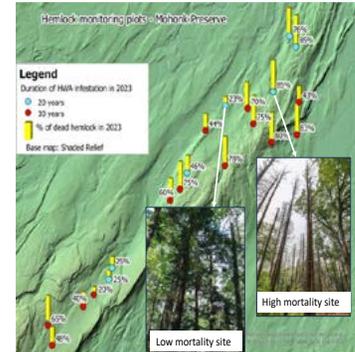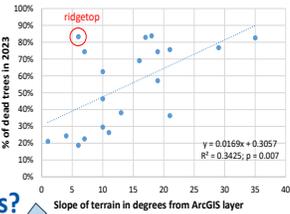Great variation in decline and mortality rates even among nearby sites due to:
➢ invasion duration and
➢ environmental variables
Mortality ranges from 20% to 85% in stands with same infestation histories.

We analyzed multiple possible factors to find which one(s) contributed most to hemlock mortality at the preserve.

Hemlock monitoring plots - Mohonk Preserve

High mortality site
Low mortality site

Terrain's slope correlation w/ hemlock mortality

$y = 0.0169x + 0.3057$
$R^2 = 0.3425; p = 0.007$

X-axis: Slope of terrain in degrees from ArcGIS layer
Y-axis: % of dead trees in 2023

The main factor contributing to differences in hemlock mortality at the Mohonk Preserve is the **terrain's slope**.

Site with 20-degree slope; mortality in 2023 was 83% (92% dead + dying trees). HWA was first recorded in 2002 at this site.

Where to search for lingering hemlock vs. do monitoring plots?

HWA DISTRIBUTION AND REGIONAL HEMLOCK MORTALITY PATTERNS
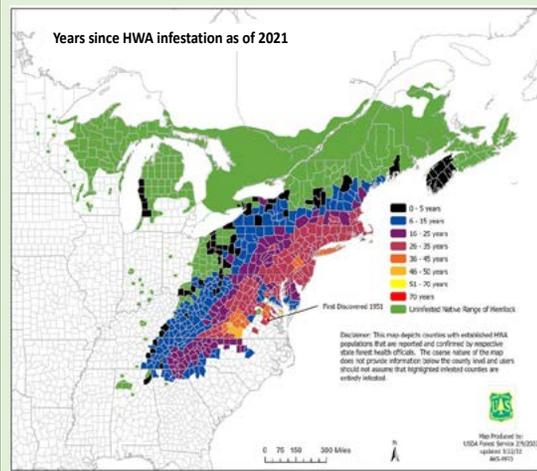
This county-level map shows similar HWA infestation durations across broad areas. However, uniform mortalities across them cannot be assumed, as studies, such as those in table below, have shown great variation in mortality time courses. (*Note*: Hemlock mortality in absence of HWA and EHS is close to 0%.**)

Years since HWA infestation as of 2021

Legend:
- 0 - 5 years
- 6 - 15 years
- 16 - 25 years
- 26 - 35 years
- 36 - 45 years
- 46 - 50 years
- 51 - 70 years
- 70 years
- Uninfested Native Range of Hemlock

First Discovered 1951

Disclaimer: This map depicts counties with established HWA infestations that are reported and confirmed by respective state forest health officials. The coarse nature of the map does not provide information below the county level and users should not assume that highlighted infested counties are entirely infested.

Map Produced by: USDA Forest Service 2/6/2023 updated 3/22/22 WS-FHP

Examples of hemlock mortality at sites in different regions

Study site(s)	Time since infestation onset	Average mortality across sites included in each study	Resource
NC	8 yrs	84%	Ford et al. 2012
NJ	8 yrs	10%	Eschtruth et al. 2006
PA	8 yrs	20%	Eschtruth et al. 2006
CT	6 yrs	59% range 14-97%	Orwig & Foster 1998
NY	20 yrs	50% range 23-85%	Wildova & Rosenthal unpubl. data
VA	20 yrs	46% range 0-100%#	McAvoy et al. 2025

SITE-TO-SITE MORTALITY VARIATION

Considerable mortality variation has been found even among nearby sites with the same infestation histories. This is likely largely due to environmental stressors, but might also reflect population-level genetic differences.

Type of sites where hemlock dies fastest after HWA or HWA/EHS arrival
- ❖ Steep slopes, especially facing S or W
- ❖ Ridgetops
- ❖ Limited soil water access (e.g. rocky field)
- ❖ Warmer sites
- ❖ Stands with large hemlocks and high hemlock density
- ❖ Accelerated decline where combination of stressors and/or unfavorable weather events and/or other forest pests occur

GUIDANCE FOR WHERE TO SEARCH FOR LINGERING HEMLOCK VS. DO MONITORING PLOTS

- Even at a local scale (e.g., within a large preserve or state park), some sites can be ready for lingering tree searches while others are suitable for monitoring
- For long-invaded areas, probably best to start by doing lingering tree searches in the most stressful locations (and vulnerable trees, i.e., large, high-density) to not miss out on any lingering trees before they succumb; can then move on to progressively less stressful sites if no lingering trees found. Also, some long-invaded sites might have low enough mortality to be suitable for monitoring plots. Note: If you find a stand of relatively healthy hemlock in a long-invaded site with stressful conditions, this might comprise closely related trees all having heritable resistance/tolerance, so make sure to report them (as a lingering tree cluster).
- For shorter-invaded areas, some sites might be so stressful as to already have sufficient mortality/decline to reveal lingering trees, if they haven't yet reached it, such sites should be prioritized for monitoring, as mortality/decline rates likely to be most rapid there (and can overtake the rates at longer invaded but less stressful sites).
- Try to get a good sense of site's dead and dying percentage before further data collection for either protocol for greatest efficiency. Use the Rapid Hemlock Mortality Assessment tool on the **TreeSnap** app.
- If initial plot set-up reveals ≥ 80% dead/dying trees, you can then repurpose the data to immediately report lingering trees. Similarly, if a lingering tree search shows <80% dead/dying trees, you can then repurpose the data for initial plot set-up.

TreeSnap

*Studies that showed effect of environmental factors or tree characteristics: Orwig & Foster 1998, Trotter and Shields, 2009, Orwig et al. 2002, Rentch et al. 2008, Evans et al. 2011, Brantley et al. 2017, Lany et al. 2018, McAvoy et al. 2025, Wildova & Rosenthal unpubl. data.; **Studies that documented hemlock mortality in the absence of HWA and EHS: McAvoy et al. 2025 in Southwest VA; NE region - Orwig pers. com.; Southeastern states – Rose 2006, USFS study. #this range and average reflect mortality levels only in the study's plots that were infested for 20yrs.*