2022 FEMC ANNUAL CONFERENCE PROCEEDINGS

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 twenty-nine 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 Partnership Committees –
https://www.uvm.edu/femc/cooperative/committees
FEMC staff – https://www.uvm.edu/femc/about/staff

Proceedings of the December 15, 2022 Forest Ecosystem Monitoring Cooperative Annual Conference:

Advances in Forest Science: The role of innovation and technology in stewardship and engagement

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Contributing Editors: Alison Adams, Elissa Schuett, Jennifer Pontius, Hanson Menzies

Acknowledgments: The Forest Ecosystem Monitoring Cooperative would like to thank everyone who participated in the planning and production of this conference, from those who coordinated all the details behind the scenes, to our speakers and workshop participants who made the meeting such a success. This conference would not have been possible without the continued support from the Vermont Agency of Natural Resources, the U.S. Department of Agriculture, U.S. Forest Service Eastern Region State and Private Forestry and the University of Vermont. We would especially like to thank Jess Wikle, Alana Russell, and Matthias Sirch, for their work on the Annual Conference Planning Committee, as well as Dr. Colin Beier for his work both on the planning committee and in developing the plenary sessions; Dr. Sara Kuebbing, Dr. Aidan Ackerman, and Jarlath O'Neil-Dunne for their work developing and participating in the panel discussion; and Dr. Allan Strong, Interim Dean of the Rubenstein School of Environment and Natural Resources for providing financial support to graduate students. We would also like to thank our contributed talk speakers, working session organizers, and poster presenters for their invaluable contributions. This work was produced in part through funding provided by the U.S.D.A. Forest Service Eastern Region State & Private Forestry.

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Introduction to the Proceedings

The Forest Ecosystem Monitoring Cooperative held its 32nd annual conference on December 15, 2022. The conference was held in-person at the Davis Center for the first time since 2019 as well as online; this was the first year in a hybrid format. The conference theme was Advances in Forest Science: The role of innovation and technology in stewardship and engagement. The conference explored a range of disturbances and disruptions, identified monitoring that can help us understand the response of the forest ecosystems, and learn about tools and resources available to help communities go from surviving to thriving during this time of change.

The conference offered a plenary session and panel discussion, brief updates from the state coordinators, seven tracks for contributed talks, three working group sessions, and a poster session. In-person attendees welcomed the return of the opportunity for networking between sessions, during lunch, and at the poster session. Justin Perry, the FEMC Steering Committee Chair, opened the conference with introductory remarks, followed by a brief presentation by FEMC's new Director, Alison Adams, about the work FEMC has done this year, changes within the organization and its broader network, and what FEMC is looking forward to in the coming year. Alison introduced the plenary speaker, Dr. Colin Beier, who is an Associate Professor of Ecology at SUNY-ESF. Dr. Beier shared reflections on the conference theme, asking how, why, and when we should use the newest technologies in forest science and stewardship work. Dr. Beier described both the promise and the limitations of a wide range of technologies created over the past several decades, placing each on the Gartner hype cycle. He then moderated a panel discussion about the use of emerging technology in forest science and stewardship with Dr. Sara Kuebbing (Director, Yale Applied Science Synthesis Program), Dr. Aidan Ackerman (Assistant Professor, SUNY ESF), and Jarlath O'Neil-Dunne (Director, UVM Spatial Analysis Laboratory).

More than 230 attendees registered for the conference, and approximately 50 attended virtually. The hybrid format 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. The virtual portion of the conference was offered via Teams, with a separate meeting link for each session. Attendees reported that this system was relatively easy to use and that the cameras and microphones provided a high-quality experience of the otherwise in-person event. Survey responses show strong support for continuing to offer a hybrid event in the future. Many people enjoyed both the contributed talks and the plenary session this year, with the latter being particularly engaging and relevant to the conference theme.

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, downloadable PowerPoint presentations are available at the conference webpage: https://www.uvm.edu/femc/cooperative/conference/2022

Advances in Forest Science: The role of innovation and technology in stewardship and engagement

A conference planning committee was formed to define the conference theme and recommend plenary speakers to invite. The committee included Jess Wikle (UVM), Alana Russell (University of Rhode Island), Dr. Colin Beier (SUNY ESF), as well as several FEMC staff: Elissa Schuett (Program Manager and Interim Director), Matthias Sirch (Data Specialist), and Dr. Jen Pontius (Principal Investigator).

Several sessions were held to discuss the conference theme, using guidance from the 2021 post-conference survey to identify the general theme of emerging technology as a topic. Members were interested in the opportunity to consider how new and emerging technology can contribute to advancing the scope, efficacy, and efficiency of forest science and stewardship work. The selected theme was "Advances in Forest Science: The role of innovation and technology in stewardship and engagement."

The plenary discussion was developed to encourage a lively discussion about both the promise and limitations presented by a range of emerging technologies that are being applied in forest management and forest science. The planning committee was excited to identify Dr. Colin Beier, a long-time cooperator with FEMC, as a creative and critical scholar thinking deeply about this topic. The panelists each brought a different perspective to the topic from the use of technology in their work, ranging from object-based classification systems and drone imagery to virtual environments. The theme of the role of technology continued through several of the contributed talks and posters, encouraging the FEMC community to critically consider which technologies can have the greatest impact on which aspects of forest ecosystem science, monitoring, and stewardship.

Promise vs. Practice

New technological advances, from drone and lidar technologies to simulation models for forest visualizations, hold great potential to improve the information we can collect and our ability to communicate it.

But how can we tell if these new technologies are worth the investment?

Our expert panel weighs in.

2022 Conference Plenary

The Role of Emerging Technology in Forest Science, Ecosystem Stewardship and Stakeholder Engagement

Advancements in technology present exciting opportunities to facilitate and accelerate the work that we do in northeastern forests. The research questions we are able to address, measurements we are able to collect, data we are able to analyze, and the management activities we implement are continually evolving and improving.

New technologies can facilitate landscape scale analyses, provide novel information about the forests we work in, and allow us to communicate forest science in new and exciting ways—but we need to carefully consider how, why, and when to implement these advances. While new technologies are exciting and filled with potential application, we must weigh their promises and limitations carefully to distinguish what will truly improve the work that we do versus what may not live up to the hype or may distract us from our goals.

Dr. Colin Beier, Associate Professor at SUNY ESF and Director of the Climate and Applied Forest Research Institute, led our discussion about the application of new technologies to forest science.

Colin Beier,
SUNY ESF

Aidan Ackerman,
SUNY ESF

Sara Kuebbing,
Yale University

Jarlath O'Neil-Dunne,
University of Vermont

Some advances have been incredibly useful, improving the accuracy and efficiency of forest inventories—consider the transition from transect tapes to laser rangefinders. Newer technologies have the potential to provide even more information in shorter times—consider the ability of terrestrial laser scanners to inventory and create 3D maps of forest structure. But true adoption and broad application of new technologies typically follow a cycle Dr. Beier described in his presentation.

By Olga Tarkovskiy - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=27546041

The Gartner Hype Cycle begins with a new technological discovery or research innovation. As experimentation with this new technology builds, so does the excitement around possible applications. But this also provides ample opportunity to discover the limitations of the technology; these limitations may include costs that place the technology out of reach for most practitioners, or the realization that the information provided is useful at scales that only serve certain niche applications. There may be equipment failures or user resistance. It may be difficult to reconcile the new information with historical methods, limiting our ability to understand how forests are changing over time. It is at this point that many potential adopters fall into the "trough of disillusionment".

But often new technologies have a group of committed experts and potential adopters who are willing to stay on and work through refinement of the technology, development of best practices, and an understanding of when and where any given technology is worth its various costs.

The Big Questions:

- Does new technology yield better data or is it a distraction?
- How will new technology interface with existing protocols and is the progress worth the upheaval?
- How to we parse reality from the sales pitch? Even if it delivers, how practical and scalable are its applications?

Excitement

- New sensors and platforms expand capabilities
- New modeling and machine learning possibilities
- Near real-time monitoring applications
- Open access tools lower barriers to entry

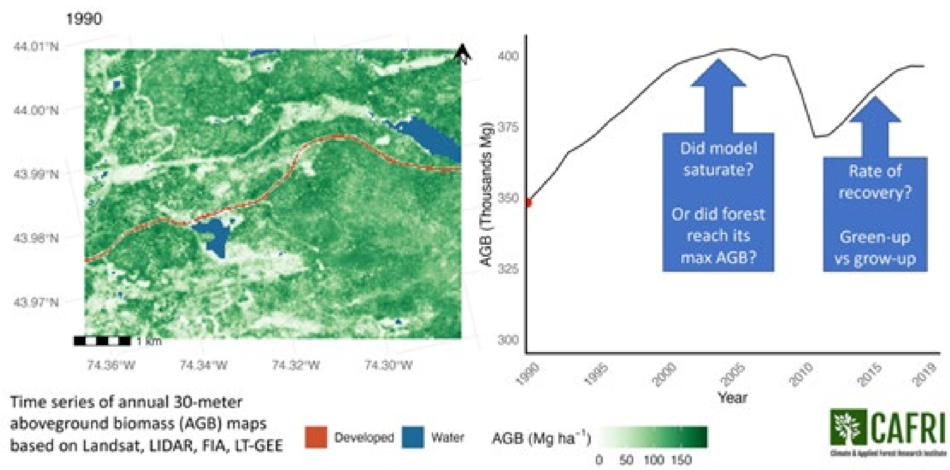
Skepticism

- Maps can hide uncertainty and accuracy is difficult to assess.
- Extracting meaning from data for useful application is often limited.

Promising Advancements: Remote Monitoring

The Promise

Sattelite and airborne technologies have been used for decades to monitor and quantify various forest cover, structure and functional metrics, and the resolution of these sensors, including spatial, spectral, and temporal information, continues to advance. The growing availability of laser scanners also provides new remote sensing information across larger landscapes. Combined with the freely available processing software from Google Earth Engine (GEE), remote sensing has the potential to fill important gaps in our understanding of forest cover change, carbon storage, species distributions, forest health, and productivity across broader regions. Currently offered freely, GEE also provides a broad user community with processing scripts that can be shared, increasing access to these tools.



Time series of annual 30-meter aboveground biomass (AGB) maps based on Landsat, LIDAR, FIA, LT-GEE

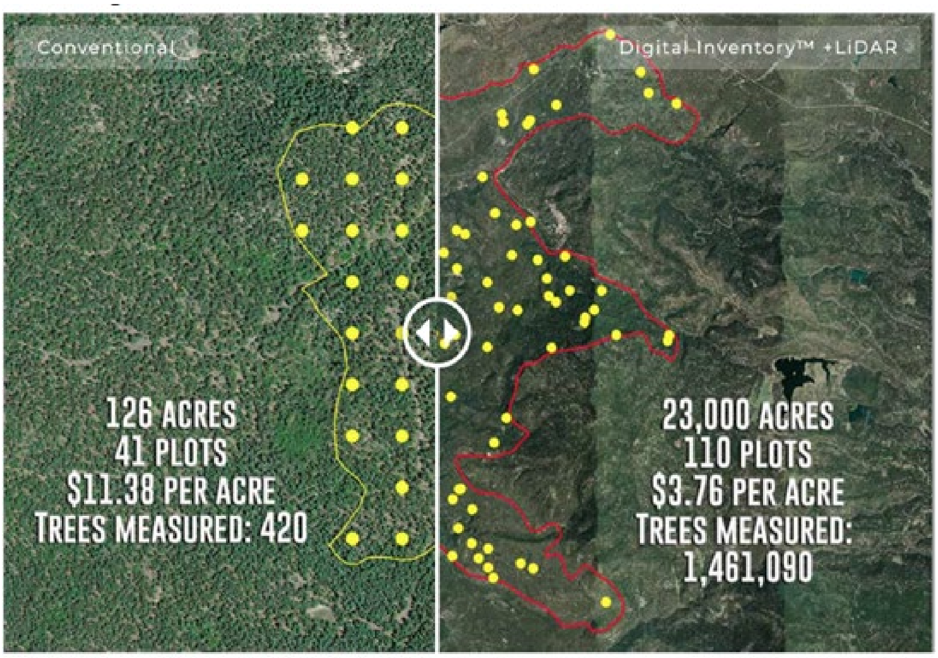
The Limitations

Geospatial data is particularly appealing, providing perspectives on the forest researchers can't achieve from the ground, but developing an understanding of the limitations of these technologies is essential to knowing how to interpret and utlize the information they provide. For example, while we may see harvested regions "green up" rapidly, we cannot conclusively determine whether this is due to increasing forest biomass or increasing ground cover; signals can saturate at high forest densities, limiting our ability to track biomass changes above certain thresholds; we can see the loss of canopy cover, but cannot easily attribute the nature (disturbance vs. defoliation) or cause of those changes (e.g., windthrow vs. pest outbreak).

Promising Advancements: Precision Forestry

The Promise

A range of new technologies has brought us to what some coin "a revolution in the woods." From 3-D forest modeling with terrestrial laser scanners to forest inventories conducted by drones, we have the potential for a larger-scale, more accurate, and more detailed evaluation of our forests. Similar to precision agriculture, this information can be used not only to inventory forests more efficiently and accurately, but also to target site-specific management activities and impliment fully mechanized harvesting integrated with supply-chain planning.



https://northwestmanagement.com/services/lidar-forestview/

The Limitations

Because of high start-up costs and proprietary software needed to process the data, forest managers often must rely on the growing number of for-profit companies looking to bring these technologies to a broader audience. However, in a capitalist landscape it can be difficult to separate the actual promise from the pitch. Costs can put these tools out of reach of smaller land-owners. Conversely, many technologies have limited scalability, making them cost-prohibitive for larger landscapes.

Excitement

- UAV's provide versatile, efficient integration with existing protocols
- Promise of improved forest inventory at lower costs
- Detailed maps can inform site-specific management and decision support.

Skepticism

- For-profit firms abound, but individual results may vary.
- Limited scalability may be cost-prohibitive for small & large landscapes.
- Potential incompatability among platforms, sensors and procedures.

Promising Advancements: Forest Visualization

The Promise

Forest science has benefited from developments in other disciplines. For example, new data visualization, computer animations and 3-D modeling tools from the computer gaming world present opportunities to bring the forest to millions of people who have less access to these landscapes in their everyday lives. New modeling software can allow forest managers to run different scenarios and visualize outcomes (Figure 1). These tools provide opportunities to tell "stories" about our forests that are, in the short term, essential to building relationships between people and forests, and in the longer term, can grow support for management efforts and policies that support forest ecosystems.

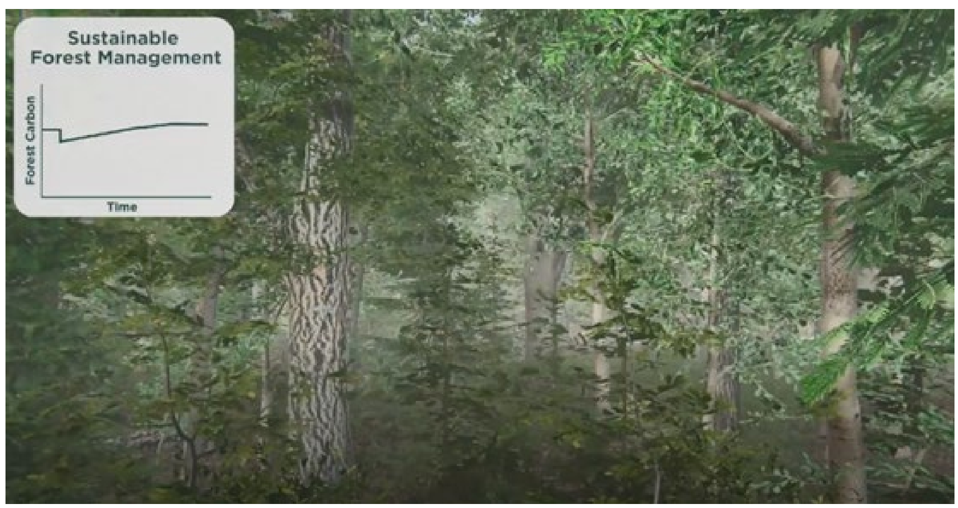


Figure 1 Forest & Climate Visualization Partnership (Michigan State University & SUNY College of Environmental Science & Forestry

The Limitations

While often visually stunning, virtual reality simulations are unlikely to provide a "silver bullet" to correct public misconceptions about forest ecology and management. As the development of open tools for data-driven visualization increases our ability to tell complex stories to a broader and more diverse audience, we must consider if more screen time is actually the answer.

Excitement

- Potential to increase public awareness and support for forest management
- Open source tools create data driven visualizations at relatively low cost.

Skepticism

- There is no substitute for a walk in the woods and no silver bullet to correct misconceptions
- Significant barriers to entry remain for developers and users alike
- Do we really need more screen time?

Thoughts from the Panel

We are moving from tools developed for forestry to tools adapted from other applications (e.g., military, entertainment, medical fields). This opens the door to new innovations that might be applicable but also creates a core mismatch in application.

The biggest risk is how few stakeholders can actually use these very specialized tools; are we becoming more specialized such those only a few can use these tools?

-Aiden Ackerman

Aidan Ackerman,
SUNY ESF

Scaling connects all of these big questions. We have data sets that we are collecting across vastly different scales, for applications that range from plots to regions. This often requires downscaling or upscaling data products in ways that can introduce errors. Best practices for working across these scales are becoming more and more important.

There is risk of the hype creating unfounded confidence in what we can do, skewing both interpretation and the allocation of resources.

-Sara Kuebbing

Sara Kuebbing,
Yale University

We need to be aware of what we lose as we adopt new technologies. While we are graduating more experts in technology are we losing the domain experts who can inform how to interpret and utilize these technologies?

We should always expect some measurement of accuracy in products we use, but we are limited in our ability to conduct robust accuracy assessment based on limited field data (temporally and spatially).

-Jarlath O'Neil-Dunne

Jarlath O'Neil-Dunne,
University of Vermont

What does the information provided actually mean? How do we connect that knowledge to desired outcomes? Do end-users know how to apply what they learn? This can present a potential hazard in applying these technologies in new spaces.

All models are wrong but some are useful. We do not want perfect to be the enemy of the good, but we do need to be aware of the uncertainty and incorporate that into our decision making.

-Colin Beier

Colin Beier,
SUNY ESF

Abstracts from Contributed Talks

Tools and Techniques 1

A tour of the Northeastern Forest Inventory Network (NEFIN)

Xana Wolf[1,2], Nancy Voorhis[1,2], Soren Donisvitch[1]

[1]Forest Ecosystem Monitoring Cooperative, [2]University of Vermont

There are numerous continuous forest inventories (CFI) that have recorded forest conditions across the Northeastern United States for the past several decades. The Northeast Forest Inventory (NEFIN) project was developed as a collaborative effort led by the FEMC to aggregate and standardize CFI data from various monitoring programs across the region into a consolidated online tool. The goals of this project are to (1) increase the accessibility and usability of forest inventory data from disparate collections in the northeastern US, (2) demonstrate how the research community can utilize this data for investigating trends in and drivers of forest growth and yield over time, and (3) enable greater exchange of information and expand collaborations around analyzing trends in northeastern forests. This talk will provide an overview of the tool developed under the NEFIN project that standardizes data from many different continuous inventory programs and provides ways to search, aggregate and download that data (Figure 2).

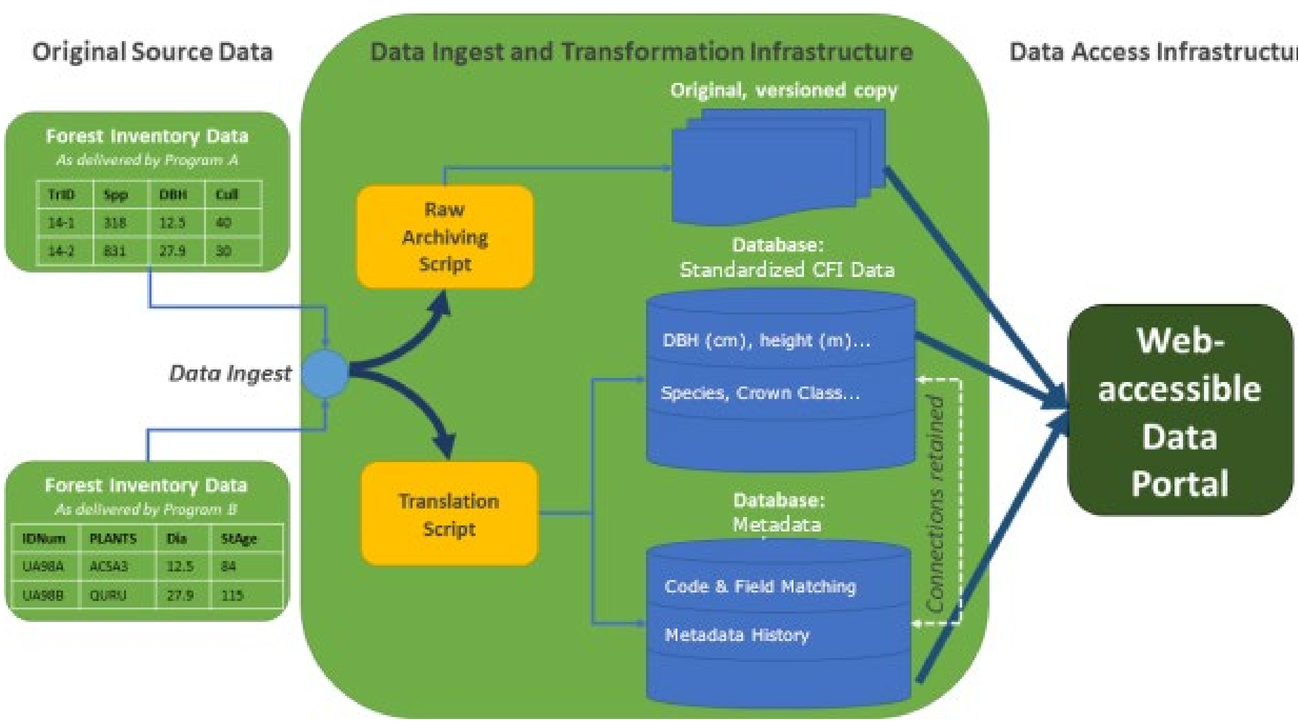


Figure 2 NEFIN Data Processing

Urban tree inventory tools and the road to healthy tree canopy cover

Joanne Garton[1]

[1]Vermont Urban & Community Forestry Program, VT Department of Forests, Parks, and Recreation

Updates to the Vermont Municipal Tree Inventory Tool are allowing volunteers, municipal staff, and students of all ages to collect current and precise information about the location, condition, history, and future needs of trees in public ways and public places. Paired with updated public tree policy and legislation, municipalities are using this state-supported tool to feed into urban tree management plans and the budgets they require to grow healthy tree canopy. Joanne Garton, the technical assistance coordinator for the Vermont Urban & Community Forestry Program, tells how three communities are utilizing these urban tree inventory tools, compares these free tools to commercially-available platforms, and explains how small and forested municipalities can still benefit from inventorying and assessing trees along roadsides, on village greens, and anywhere where people walk, drive, live, or play (Figure 3).

Figure 3 Demonstrating the inventory maintenance process

Relative effects of functional diversity and structural complexity on late-successional, northeastern hardwood forest carbon

Samantha Myers[1], Miranda Curzon[1], Paul Catanzaro`, Malcolm Itter[1]

[1]University of Massachusetts, Amherst, [2]Iowa State University

Understanding forest stand conditions that support high levels of carbon storage and sequestration is of critical importance given increasing regional interest in forest carbon management. While numerous carbon management approaches exist, there is limited stand-level guidance to support such management. Instead, traditional measures of species diversity and structural complexity are used as indicators of a forest ecosystem's capacity to store and sequester carbon. Though these traditional measures of diversity are relatively simple to measure, the diversity of species functional traits may provide valuable information on forest productivity and ecosystem resilience over time. To better understand the role of functional diversity on forest carbon dynamics, we paired existing continuous forest inventory (CFI) data from Massachusetts Department of Conservation and Recreation with local functional trait observations (leaf nutrient content, specific leaf area, and wood density) from trees bordering CFI plots within late-successional forests in western Massachusetts. We applied a Bayesian hierarchical model to quantify the relative effects of functional, species, and structural diversity on live aboveground carbon. Our model importantly synthesized local functional trait information with existing species-level mean trait values applying a multivariate structure that accounts for inherent trait syndromes. Across 323 plot-year combinations, we found that structural complexity, functional diversity, and total basal area explained most of the variability in live aboveground carbon (R2= 0.91 [0.90, 0.93]). Replacing functional diversity with species diversity explained slightly less variability (R2=0.89 [0.87, 0.91]). Contrary to expectations, we found that functional diversity had a negative relationship with live aboveground carbon, possibly due to functional redundancy of dominant late-successional species in high-carbon plots (Figure 4). Study results will inform adaptive forest carbon management by synthesizing new understanding of the relative contributions of forest structure and functional diversity to long-term carbon storage in late-successional hardwood forests in the northeastern U.S.

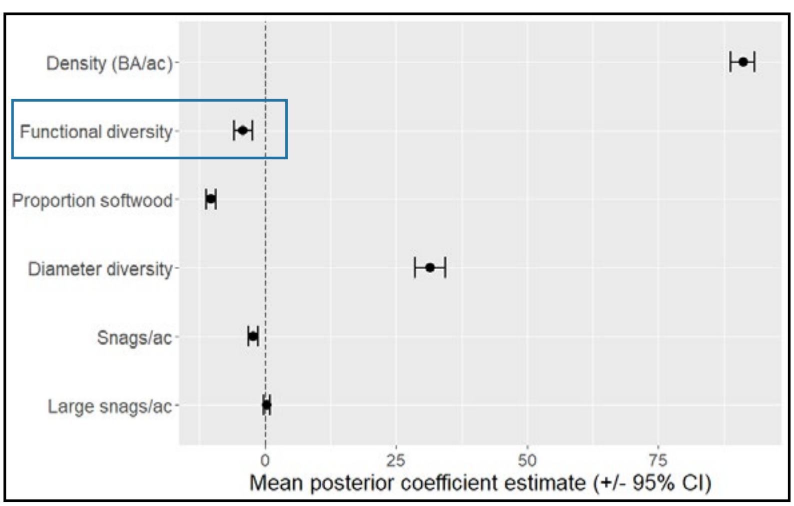


Figure 4 Functional diversity had a negative effect on live AGB

A map-based stock change approach for fine-scale biomass and carbon accounting in New York State

Lucas Johnson[1], Michael Mahoney, Colin Beier

[1]State University of New York College of Envronmental Science and Forestry

Field-based forest inventories, like the United States Department of Agriculture's Forest Inventory and Analysis (FIA) program, can provide unbiased stock change estimates of carbon fluxes but are limited by the density and temporal frequency of the sample. However, when field samples are combined with remote-sensing data, a spatially explicit representation of forest inventory information can be produced in the form of a map-based stock change assessment to estimate carbon fluxes at finer spatial and temporal resolutions than possible with field inventory information alone. Time series pixel predictions provide the flexibility to aggregate these individual predictions to units relevant to local forest management, opening the door to the promotion and incentivization of forest-based climate solutions. Landsat time series imagery and the accompanying open-source toolkit, including the Google Earth Engine cloud computing platform and the LandTrendr temporal segmentation algorithm, make this fine-resolution map-based stock change approach feasible.

Over 5,000 FIA plots sampled between 2002 and 2019 across New York State were coupled with Landsat spectral indices, disturbance metrics derived from LandTrendr, and topographic and climatic geodata to develop machine learning models for aboveground biomass (AGB) prediction. With these models we generated annual maps (1990-2019), at a 30m resolution, to characterize historical AGB stocks, changes, and spatial patterns across New York State. We then compared our map-derived estimates to a common set of FIA plots, and FIA aggregate estimates across time and across a range of scales. We present this approach and the resulting map products to meet continued demand for time series biomass prediction and mapping, and applications in carbon stock change estimation and ecosystem stewardship.

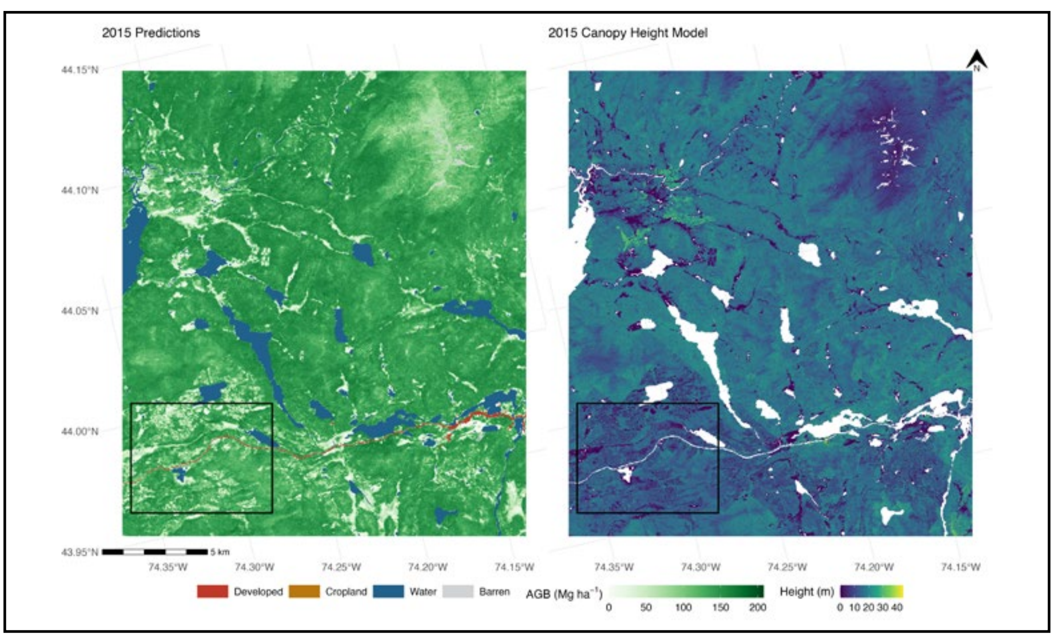


Figure 5 Huntington Wildlife Forest aboveground biomass for 2015

Barriers for emerging tree planting strategies in response to global change

Peter Clark[1], Anthony D'Amato[1], Brian Palik[2], Paul Dubuque[3], Greg Edge[4], Jason Hartman[5], Lucia Fitts[6], Maria Janowiak[2], Lucas Harris[1], Rebecca Montgomery[6], Mike Reinikainen[3], Christopher Woodall[2], Christopher Zimmerman[7]

[1]University of Vermont, Rubenstein School of Environment and Natural Resources, [2]USDA Forest Service, Northern Forest Station, [3]Minnesota Department of Natural Resources, [4]Wisconsin Department of Natural Resources, [5]Michigan Department of Natural Resources, [6]University of Minnesota, Department of Forest Resources, [7]The Nature Conservancy

Tree planting is increasingly being pursued as a strategy to mitigate, restore, or adapt forest ecosystems for global change. Although reforestation has long been central to forest management, the novelty and desired outcomes of emerging tree planting strategies are not without barriers linked to institutional capacity (e.g., tree nurseries) and knowledge gaps (e.g., best management practices). In this presentation, we summarize how planting strategies address global change and illustrate how factors primarily associated with seedling availability (e.g., insufficient diversity among species, genotypes/seed origin, stock types) will limit operationalizing these strategies (Figure 6). To overcome these challenges, we recommend avenues for advancement via 1) improved policy and financing, 2) resources and training, and 3) research and monitoring. Absent these advances, current seedling production capacity and practices will fall short of ambitious tree planting goals proposed for restoration, and adapting to, and mitigating the effects of global change.

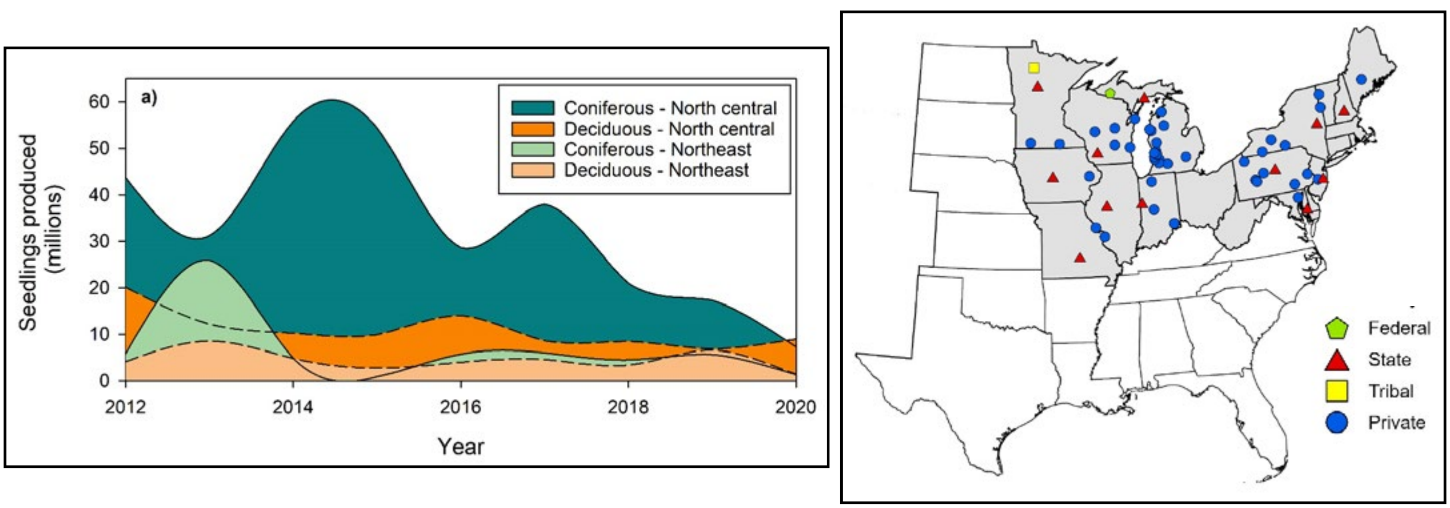


Figure 6 Regional seedling production at federal, state, tribale, and private nurseries in the Northern Forest Region

A community led wood ash recylcing program to restore forest nutrition in Muskoka, Ontario

Shaun Watmough[1], Shelby Conquer[1], Anne Sylvie-Dasne[1], Batool Syeda[1], Kayylen Foley[1], Kira Nixon[1], Katie Paroschy[2], Dawson Wainman[1], Norman Yam[2]

[1]Trent University, [2]Friends of Muskoka Watershed

Almost a century of acidic deposition combined with increasing pressures for forest harvesting have depleted nutrient stocks in soils over large parts of eastern North America. Wood ash has been used for decades in some parts of the world as a mechanism to increase soil fertility, but in Ontario, Canada, wood ash is classified as a waste product and cannot be applied without a permit and so most wood ash is landfilled. Over the past five years a community led wood ash recycling program has been initiated in Muskoka, Ontario. This program actively engages the community in "ash drives" to provide ash for field trials, provides public outreach, and supports ongoing research studies that are needed to identify the benefits and potential harms associated with wood ash additions and to allow wood ash to be reclassified as a fertilizer rather than a waste product (Figure 7). This presentation outlines the challenges and benefits of the program and reports on early results from field trials.

Figure 7 Citizen science engagement to improve soil nutrient stocks using wood ash.

Regeneration response to salvage logging following tornado disturbance

Colby Bosley-Smith[1], Shawn Fraver[1], Nicole Rogers[1], Anthony D'Amato[2]

[1]University of Maine, [2]University of Vermont

Understanding the influence of post-disturbance forest management practices on tree regeneration is critical for assessing ecosystem recovery and guiding future responses. Forests often show remarkable resilience to disturbance through recovery of fundamental structures and processes. Evidence suggests that ecosystem processes frequently remain relatively stable despite events prompting clear structural reorganization. While necessary for retrieval of lost timber revenue, post-disturbance management responses such as salvage logging may exacerbate disturbance impacts and disrupt or delay these natural processes. This study seeks to evaluate how salvage logging influences microsite and regeneration outcomes.

In July 2013, a rare tornado in northcentral Maine and subsequent salvage logging created an ideal situation in which to evaluate these influences. This series of events generated three clear "treatments": tornado blowdown, blowdown followed by salvage logging, and an undisturbed control. Nine years post-tornado, we inventoried tree regeneration within these treatments (16 plots per treatment) to examine differences in sapling abundance, species composition, and size structure. On these same plots, we also inventoried downed coarse woody debris (CWD), including height of each debris piece above the forest floor. Each sapling was evaluated for evidence of moose browse to determine whether abundant CWD in the blowdown created a 'caging effect,' thereby impeding access and browse by moose. Further, LiDAR data were analyzed to test for differences in canopy openness among treatments. Results revealed greater sapling abundance in the disturbed treatments compared to the control, but no apparent differences in sapling composition or size class (Figure 8). This difference in sapling abundance can be explained by lower canopy openness in the control, as evidenced by LiDAR data. The primary difference between blowdown and salvage was the observed 'caging effect'; that is, the greater volumes and heights of CWD in the blowdown translated to lower proportions of browsed saplings compared to the more structurally simple salvage treatment. Reduced browse in the blowdown may have implications for successional trajectories and future stand development. These results provide greater understanding of ecosystem recovery processes following the successive disturbances of blowdown and salvage logging.

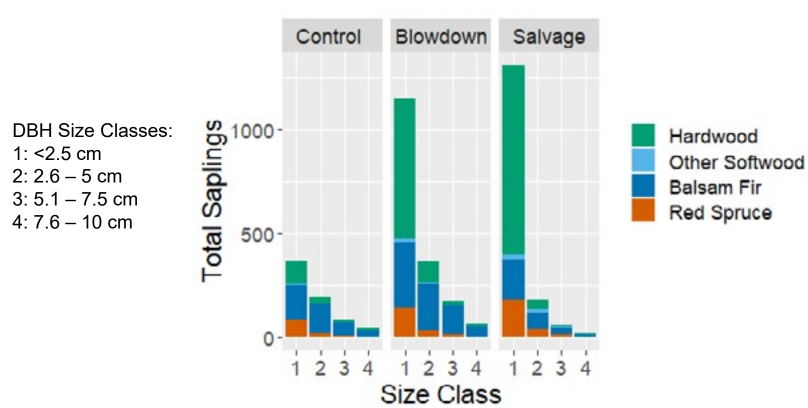


Figure 8 Salvage and blowdown tree regeneration is similar in composition and abundance.

Ground truthing forest change in working forests of the US Northeast

Madeleine Desrochers[1,2], Wayne Tripp[3], Stephen Logan[3], Eddie Bevilacqua[2], Lucas Johnson[1], Colin Beier[1,2]

[1]Climate and Applied Forest Research Institute, [2]SUNY Environmental Science and Forestry, [3]F&W Forestry

Remote monitoring tools are a powerful way to track changes to forests at a landscape scale, and the interest and need for these tools are increasing rapidly. A growing number of policies and regulations aimed at addressing climate change are putting more pressure on forest landowners to conserve their land and increase the storage of carbon in their forests. Forest carbon markets, along with other long-standing sustainable forestry certification programs require extensive monitoring and verification. Additionally, as consequence to our changing climate, forest disturbance regimes are expected to shift - with more severe weather events and escalating invasive insect outbreaks. Remote monitoring tools can be used to address these challenges and to provide actionable information on how and where disturbance is taking place - both to understand its effects on forest ecosystem structure, functions, and services and to inform stewardship actions in response.

However, while there are many disturbance detection algorithms available, they are largely untested for the disturbance regimes, forest types, and management practices of the northern forest region. Our recent study validated the outputs of three common satellite-based disturbance detection algorithms using detailed harvest records from 43,000 ha of working forest land in northeastern New York. The tested algorithms performed best in detecting clearcuts, but performed much worse and poorly overall in detecting the partial harvest prescriptions (e.g., shelterwoods, thinnings) that are far more common in the northern forest region (Figure 9). Of the three algorithms tested, the Landtrendr algorithm consistently outperformed the others at detecting partial harvests and estimating harvest intensity, but there is still substantial room for improvement. Overall, we suggest that disturbance detection algorithms need further training and tuning to be used for accurate monitoring of harvest-related activities in working forests of the US Northeast.

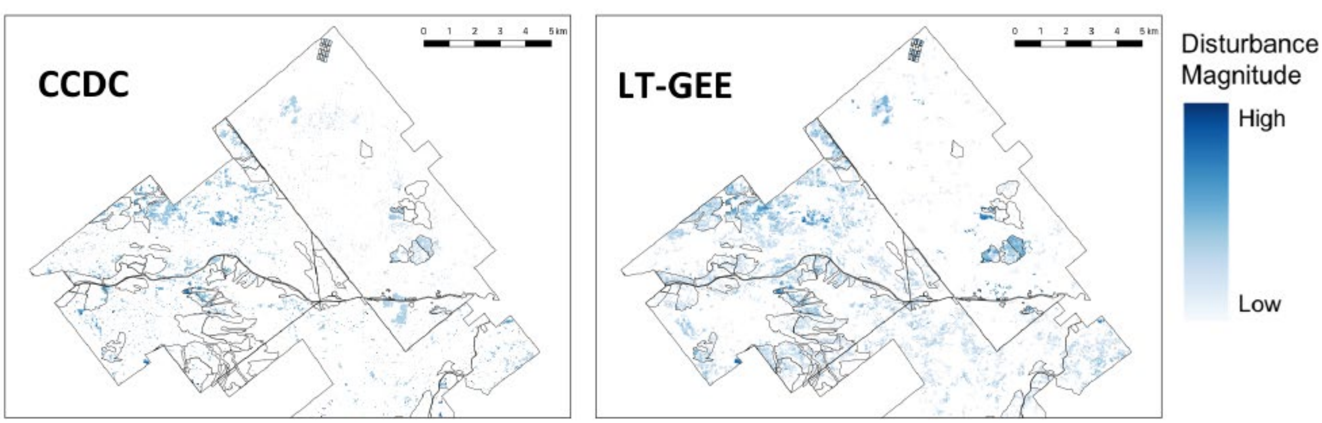


Figure 9 Continuous change detection and classification (CCDC) and LandTrendr Google Earth Engine (LT-GEE) were tested to detect partial harvest prescriptions.

Vermont's long-term rare plant monitoring in a changing world

Aaron Marcus[1]

[1]Vermont Fish and Wildlife

Vermont Department of Fish & Wildlife has been monitoring rare plants across the state for decades, with over 40 years of detailed monitoring data on the condition of thousands of plant populations. Now with the increase in community science and increasing capabilities of the Natural Heritage Inventory Database, trends in our plant populations are coming into sharper focus. One trend is an increase in the number of historical (undocumented for more than 25 years) vascular plant taxa being redocumented in recent years (Figure 10). The most well-known example of this is the small whorled pogonia (Isotria medeoloides), first reported by community scientists on iNaturalist, after being unreported for 120 years (Figure 11). An explosion of community science and a more expansive monitoring database have provided a framework for documenting overlooked plant populations that are persisting. Despite this, the Vermont Department of Fish & Wildlife is also simultaneously detecting a number of apparent decline trends for vascular plant species, with a particular concentrations in declines among the orchid family (Orchidaceae). Continued collaboration and analysis is needed to help the Vermont Fish & Wildlife and researchers focus limited resources toward priority management, adaptation, and further research.

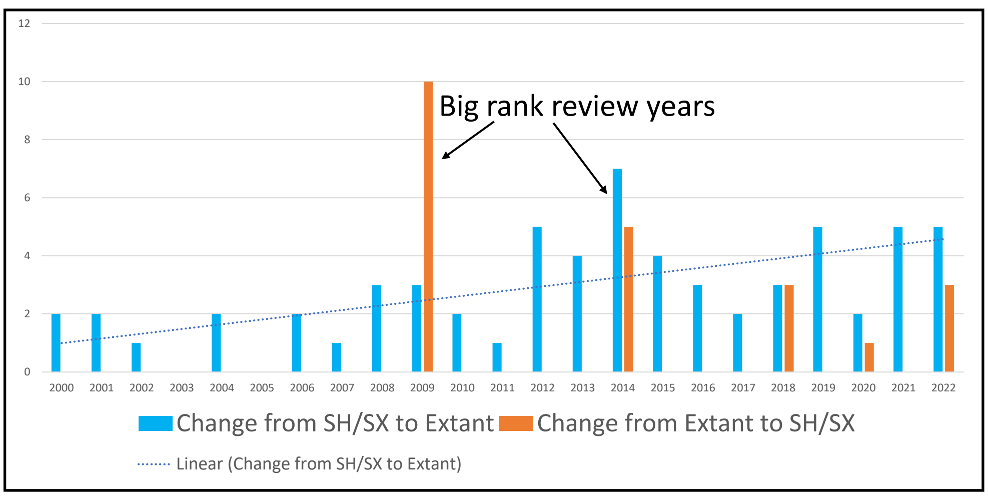


Figure 10 Tracking status of Vermont's rare vascular plant species from 2000-2022, changes to and from state historical (SH) and state extirpated (SX).

Figure 11 Small-whorled pagonia rediscovered by community scientists (photo by John Gange).

Leveraging community science to complement professional field surveys and fill data gaps for invasive insects

Mitchell O'Neill[1], Thomas Allgaier[2], Colleen Lutz[1], John Marino[1]

[1]New York Natural Heritage Program, [2]NYS Department of Agriculture and Markets

Invasive insects like spotted lanternfly (Lycorma delicatula) can cause major economic and environmental impacts, and monitoring the spread of these species on a broad scale requires extensive effort from many individuals and organizations. While professional surveys are integral to monitoring efforts, there are always temporal and spatial gaps. Data from community science platforms like iNaturalist are often used to supplement species distribution datasets. The value of community science to monitoring efforts increases further when we actively engage community scientists and direct them to conduct surveys of the greatest importance to natural resource managers. For example, we can direct volunteers to survey the locations, species, and ecosystems where information is most needed, or where help from volunteers is most needed to fill gaps between professional surveys.

In order to direct community scientists to areas where volunteer spotted lanternfly surveys are most needed to complement professional survey efforts, the New York Natural Heritage Program created an online volunteer sign-up map in collaboration with the NYS Department of Agriculture and Markets and the Partnerships for Regional Invasive Species Management (Figure 12). The interactive online map highlights 1km grid squares available for sign-up across New York State, with each block exhibiting high potential for spotted lanternfly introduction, public land access, or known tree-of-heaven infestations. Participants are trained to identify spotted lanternfly and tree-of-heaven (a preferred host plant) and enter presence and absence survey results into iMapInvasives. This concept of community scientists claiming locations to report observations to iMapInvasives has been applied to monitoring programs for forest pests including Beech Leaf Disease and Hemlock Woolly Adelgid, and could be applied to other large-scale volunteer survey efforts for invasive species.

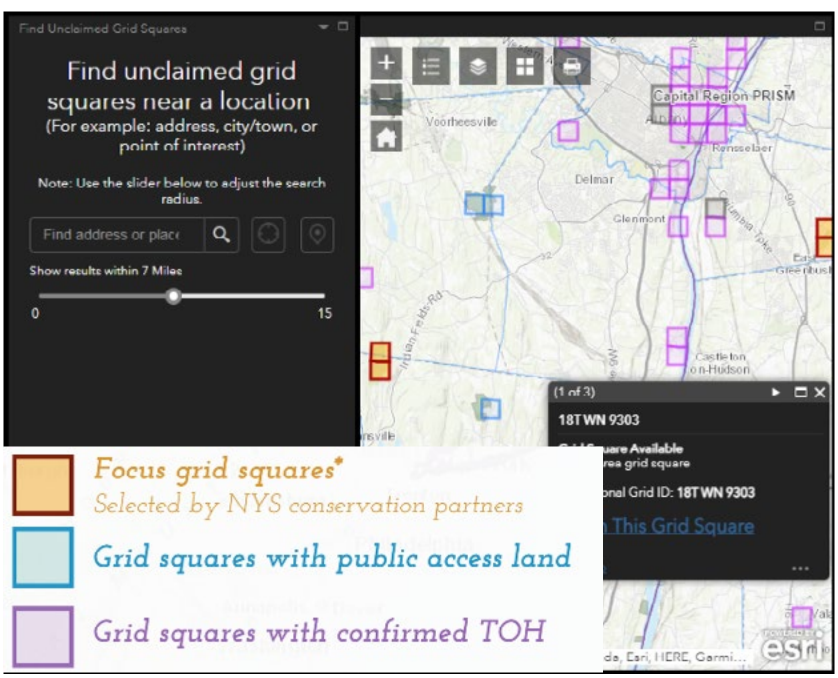


Figure 12 Volunteers can claim grid squares to conduct surveys for spotted lanternfly. Effort can be directed to high-priority locations to complement statewide efforts.

Population dynamics of montane invertebrates and birds

Jason Hill[1]

[1]Vermont Center for Ecostudies

Invertebrates perform essential, irreplaceable ecological functions and services, but invertebrate populations are likely experiencing precipitous declines worldwide and shifting to higher elevations and latitudes in response to climate change. These changes may be most pronounced in forested montane environments, where temperatures are warming at a rate of 2-5x the global background rate. This reshuffling of the invertebrate community will ultimately result in pronounced changes to metrics of forest health by altering existing stressors on trees (e.g., herbivory and disease transmission) and influencing avian communities that rely on these invertebrates for food during their breeding season. In June of 2022, we launched an effort to understand how the abundance of montane bird species relates to the local abundance and diversity of invertebrates(Figure 13). We conducted sampling for invertebrates using pitfall and window traps at four dozen montane locations across Vermont and New Hampshire, and collected nearly 5000 invertebrates, which we identified to taxonomic order. In addition, community scientists simultaneously conducted point counts at these same locations to record the abundance of 10 montane bird species through the Mountain Birdwatch program. We'll share insight from the field season about the challenges of conducting invertebrate sampling at remote locations, and examine the relationships between local bird and invertebrate populations.

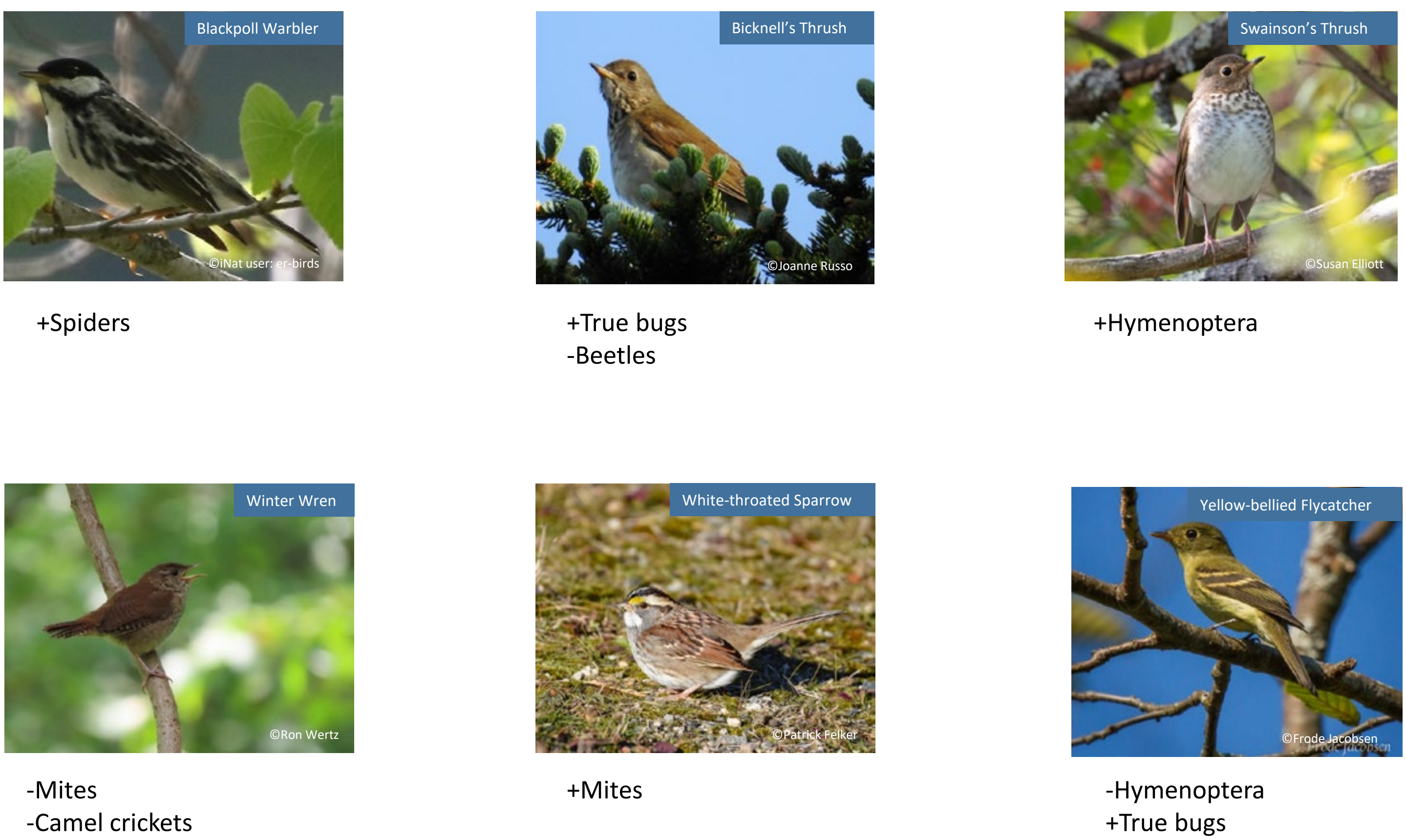


Figure 13 Avian communities rely on various invertebrates for food during the breeding season.

Mapping climate change exposure for northeastern tree species

Lukas Kopacki[1,2], Jennifer Pontius[2]

[1]Arborvox, [2]Forest Ecosystem Monitoring Cooperative

The uncertainty around the impacts of changing climate poses a significant challenge to sustaining forest ecosystems in the northeast. Important work has been done downscaling projected changes in climate conditions, modeling shifts in suitable habitat, and mapping disturbance patterns across the region. The goal of this project is to aggregate these valuable but disparate spatial data sets to quantify relative exposure to climate change impacts at the species, and community level. The resulting climate exposure maps provide insight to how the degree of potential risk exposure vary across the landscape and across species (Figure 14).

Results indicate that at the stand level, highest overall exposure to climate, disturbance, and limitations in suitable habitat for current species distributions occurs in mountainous regions throughout the region and southeastern Maine. Across the region relative exposure increases by 4 percent between low and high emission scenarios.

Much of our current management is guided by the outcomes of decades of silviculture research, yet many of the conditions under which those results were generated are rapidly changing. These relative exposure maps can inform where climate adaptation management applications may be most necessary over time.

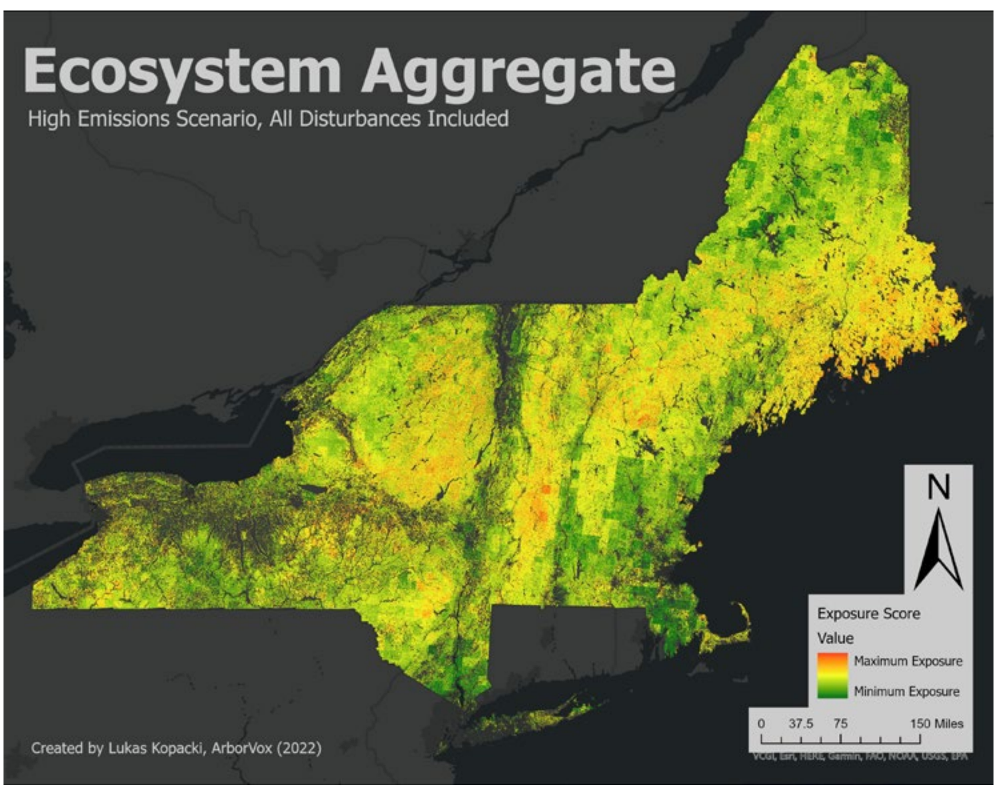


Figure 14 Climate exposure map showing how risk varies across the landscape.

Decadal changes in forest adaptability and vulnerability to climate, insects, and disease

Soren Donsivitch[1], Anthony D'Amato[1], Aaron Weiskittel[2], Chris Woodal[3], Jennifer Pontius, University of Vermont

[1]University of Vermont, [2]University of Maine, [3]USDA Forest Service Northern Research Station

United States forests east of the Mississippi are observed to be becoming more vulnerable to climate, insects, and disease, coupled with a general reduction in adaptability. The decadal changes in forest adaptability and vulnerability may be an indicator of increased stress on forest ecosystems. Utilizing USDA Forest Inventory and Analysis data coupled with national trait-driven scoring systems, this study seeks to capture the changes in forest functional trait space and evaluate functional drivers of the observed regional changes (Figure 15). Although a semi-national study, this presentation will focus on changes observed in the Northeastern United States. The Northeast, as a region, is undergoing regionally similar shifts in vulnerability and adaptability scores as well as in captured functional trait space.

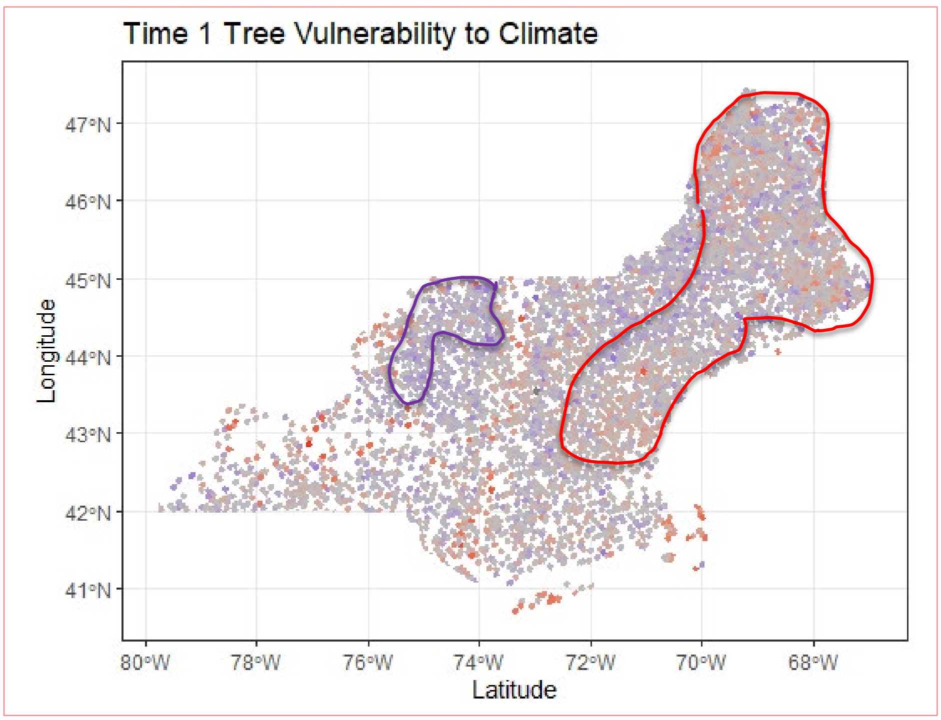


Figure 15 Spatial patterns show regions with higher vulnerability to climate (Northeastern Maine and central Acadian transition) and regions with less vulnerability to climate (north Adirondacks).

Patterns and drivers of woodland understory flower phenology and canopy closure

Jordan Tourville[1]

[1]Appalachian Mountain Club

Warming and changes in precipitation associated with climate change will likely impact the onset of spring flowering and other phenological stages for forest plants across the northeastern United States. Understory forbs of northern hardwood and montane spruce-fir forests may be sensitive to spring warming before canopy closure, however, detailed information on the spatial patterns and drivers of phenological change for these taxa is still lacking. Here, we discuss the results of a preliminary effort to summarize spring leaf out and first flower onset for several canopy tree, understory forb, and spring ephemeral species across elevational gradients in New England. We also compare woodland and alpine plant phenological sensitivity to regional warming. Phenological observations from the Appalachian Mountain Club's (AMC) Mountain Watch (MW) project, the National Phenology Network (NPN), and iNaturalist were collated and synthesized between 2004 and present (~800,000 observations). Phenological observations were paired with environmental variables and separated by year to uncover (1) spatial patterns of spring understory phenology (and how it relates to canopy closure timing), (2) critical climatic drivers of spring phenology, and (3) phenological responses of understory plants to warmer years. Median flowering time for each year of observation for 14 understory forb species and 10 alpine species, and median leaf out time for 4 canopy tree species were also calculated (Figure 16). Overall, we find strong negative relationships between elevation, spring mean temperatures, accumulated growing degree days (AGDD), and open flower timing for our understory forb species. Additionally, understory flowering times have been shifting earlier than canopy leaf out times, and alpine plant flowering does not appear to be as responsive to warming as lower elevation woodland plants. Our preliminary analyses provide much needed baseline information on woodland phenology across the region. Moving forward, these data will allow us to explore temporal trends in flower and leaf out timing in relation to patterns of warming and help us to better anticipate threats to understory plants.

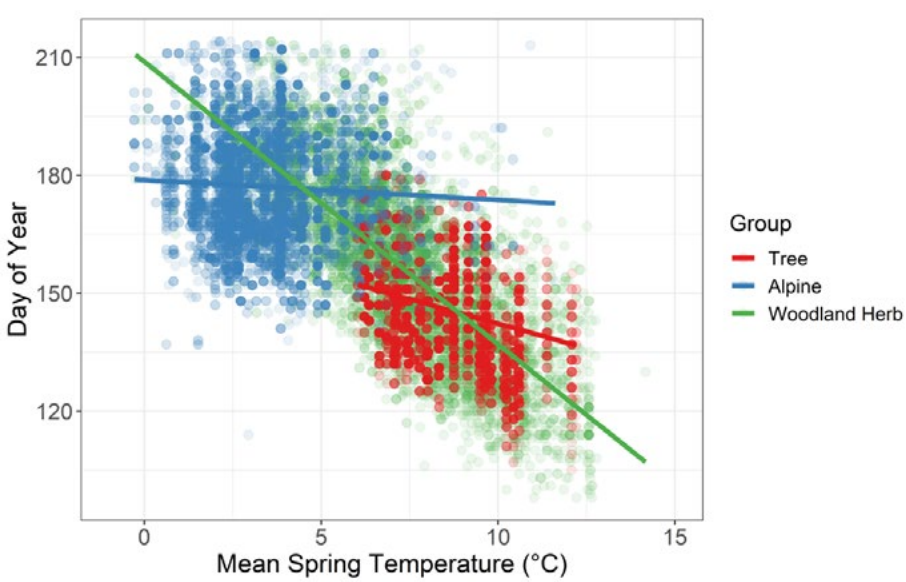


Figure 16 Spring phenology variation by vegetation group.

Virtual environments for communicating changing forests

Michael Mahoney[1], Colin Beier[1], Aidan Ackerman[1]

[1] SUNY College of Environmental Science and Forestry

Forests are dynamic systems, constantly developing as competition and mortality reshape stand composition and structure over time. However, these changes often happen too slowly for most stakeholders to notice, making it challenging to communicate the long-term impacts of disturbances and management. Visualizations and stakeholder outreach can help to close this gap, but currently most methods for depicting the long-term trajectory of a stand are tailored for expert use and are hard to adapt for a generalist audience.

This talk describes a new approach for communicating forest change over time to stakeholders, using interactive three-dimensional (3D) and virtual reality (VR) landscape visualizations to depict forests (Figure 17) before, during, and following key landscape changes. By providing a concrete visual explanation for what it means for a forest to change, these virtual environments can be powerful tools for communicating the impacts of forest management and natural disturbances over time to a wide variety of stakeholders. As a case study, we demonstrate how these tools can be used to visualize the impacts of beech bark disease on a stand in the central Adirondacks. We also briefly describe how improvements in technology, including the new "terrainr" and "unifir" R packages, are making the production of virtual environments easier and more reproducible.

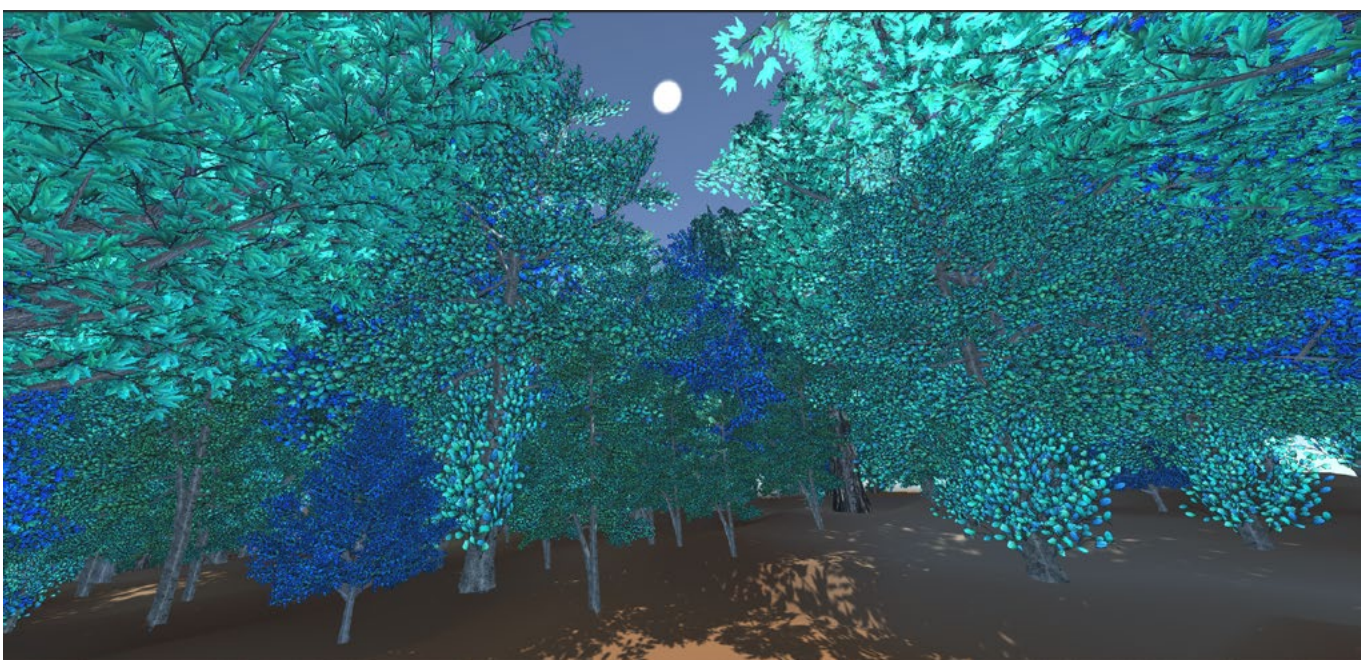


Figure 17 Example of using virtual reality.

Utilizing occupancy models to compare effectiveness of dogs and humans at detecting the invasive spotted lanternfly in vineyards and forests

Angela Fuller[1,2,3], Ben Augustine[2,3], Eric Clifton[3], Ann Hajek[3], Arden Blumenthal[4],Josh Beese[4], Aimee Hurt[5], Carrie Brown-Lima[6],

[1]U.S.G.S., [2]NY Cooperative Fish and Wildlife Research Unit, [3]Cornell University, [4]New York-New Jersey Trail Conference, [5]Working Dogs for Conservation, [6]NY Invasive Species Research Institute, Cornell University

Invasive species have the potential to decrease productivity of crop systems, forests, fisheries, and waterways resulting in negative ecological, economic, and societal impacts in the US and worldwide. Prevention and early detection of invasive species are championed as the most cost-effective and efficient strategies for reducing or avoiding these negative impacts on systems. Spotted lanternfly (SLF), Lycorma delicatula, is a recently introduced invasive insect that has been expanding rapidly and causing severe impacts to agricultural production, particularly grapes, since it was first discovered in Pennsylvania in 2014. Human visual surveys are the most common search method employed but can be ineffective due to the insect's cryptic egg masses and low density during early stages of infestation. Therefore, finding alternative SLF early detection methods has become a priority for agencies tasked with addressing SLF management and use of detection dogs has been increasingly considered for this purpose. This study served to test experimentally whether utilizing detector dogs could improve the likelihood of detecting SLF in both agricultural and natural settings. We surveyed transects in 20 vineyards in PA and NJ and used a multi-scale occupancy model to estimate detection probability of human observers and trained detection dogs as a function of SLF infestation level and weather covariates. We hypothesized that 1) occupancy rates vary across sites as a function of the overall SLF infestation level at a site and 2) human and dog detection probability is higher at sites with higher infestation levels because there should be more SLF eggs available for detection. We modeled transect-level occupancy of SLF as a function of infestation level, habitat, topographic position index, and distance to forest. We found that occupancy probability of SLF was higher on vines within the vineyards compared with in the forest and was higher at high infestation sites compared to low infestation sites. Occupancy probability declined with increasing distance from forest which is informative for future search efforts. Detection probability of SLF was lower in forested sites and was higher at high infestation sites (Figure 18). Detection dogs had a lower detection probability than humans in the vineyard, but a higher detection probability than humans in forested sites. The higher detection probability of detection dogs in forested sites was offset by longer dog search time compared with humans. Our study suggests that detection dogs could be more effective than human visual searches as an early detection method for SLF in natural areas and utilizing detector dogs could strengthen SLF early detection efforts.

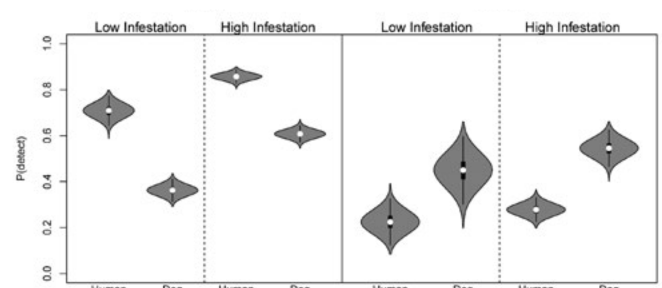


Figure 18 Higher infestation sites had higher detection probabilities by both humans and dogs.

Forest monitoring for early successional species in the Green Mountains

Laurence Clarfeld[1], Katy Gieder[2], Scott Wixsom[3], Chris Bernier[4], Alexej Siren[1], John Peckham[1], Robert Abrams[3], Suzanne Gifford[3], Sue Staats[3], Luke McNally[5], Therese Donovan[1],

[1]Vermont Cooperative Fish and Wildlife Research Unit, [2]Vermont Department of Fish and Wildlife, [3]U.S. Forest Service, [4]Vermont Department of Fish and Wildlife,[5]Ruffed Grouse Society

Near the turn of the century, most of Vermont's forests had been cleared for logging and pasturing. The past hundred and twenty years has seen a remarkable recovery with > 60% increase in forest cover throughout the state. This has been a great success story for the state's forest-dwelling wildlife species. However, as forests have matured, species that required early successional habitat (ESH) have declined. In spring 2022, the Vermont Cooperative Fish & Wildlife Research Unit, Vermont Fish and Wildlife Department, and Green Mountain National Forest, with financial support from Forest Ecosystem Monitoring Cooperative and Ruffed Grouse Society, began acoustic monitoring of nearly 50 sites in the Green Mountain National Forest. Some sites were near recent cuts while others were at control sites in mature forests. The AMMonitor data management and analysis ecosystem is being used to organize, process, and interpret monitoring data and infer the effect of timber harvest on target species that favor ESH, such as Ruffed Grouse, Eastern Towhee, Blue- and Golden-winged Warblers, Mourning Warbler, and others. A more concerted monitoring effort is needed to assess the role of a diversified forest structure on these high priority species. In this talk, we'll provide an overview of this new research endeavor and an update on preliminary findings (Figure 19).

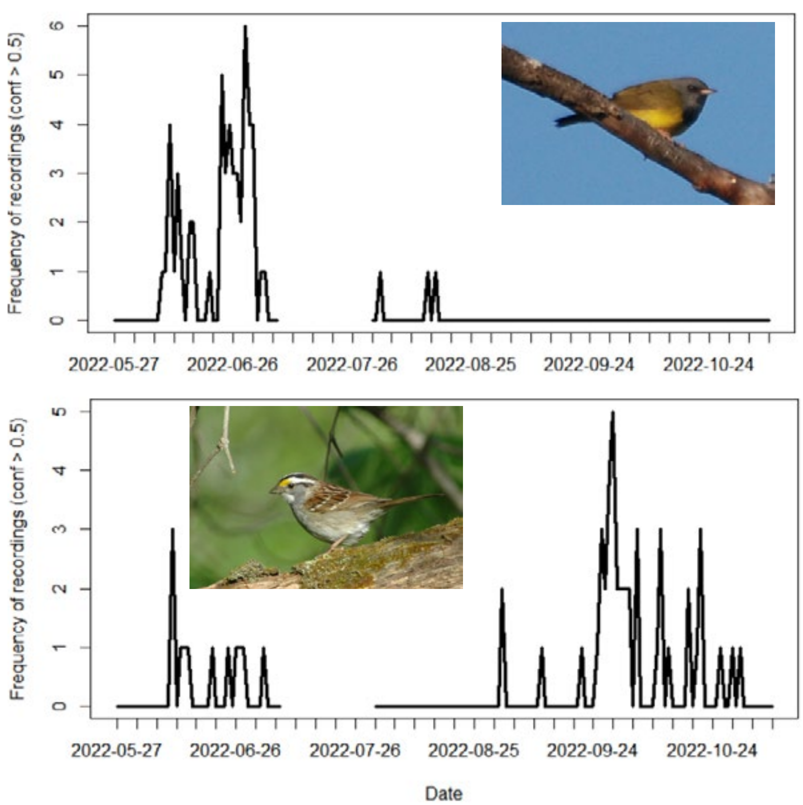


Figure 19 Frequency of recordings of two early successional species (top: mourning warbler; bottom: white-throated sparrow) as part of preliminary data.

Northeastern mountain science and stewardship networks

Joshua Benes[1], Nat Scrimshaw[2]

[1]University of Vermont, [2]World Trials Network - Hub for the Americas

Alpine ecosystems are islands across the northeastern region and are isolated due to their geography. They are also very important places to study and steward, as they contain species sensitive to the impacts of climate change and are unique ecosystems in the region. Joshua Beneš, with the University of Vermont, gave an overview of some historic and recent initiatives to develop regional alpine monitoring and research networks in the northeast and how these networks could integrate into international programs. Nat Scrimshaw, with the World Trails Network Hub for the Americas, shared his plans for developing a regional alpine stewardship center. This working group session sought feedback from participants, both online and in-person, about how to design inclusive, effective, and sustainable mountain science and stewardship networks in the region.

Discussions about the benefits of creating a multidisciplinary long-term alpine monitoring network in the northeast started in 2011 but a network never took shape. Recently, staff from the Atmospheric Sciences Research Center (ASRC) in New York, the proposed Mount Mansfield Science and Stewardship Center (MMSSC) in Vermont, the Sleepers River Research Watershed on the Kitteridge Hills in Vermont, and the Mount Washington Observatory (MWO) in New Hampshire, have started to meet over 2022 to explore the idea of forming a northeast network of mountain observatories for climate change monitoring and research. This group has begun conversations with the National Weather Service and American Association for State Climatologists and is considering collaborative opportunities for monitoring each of these mountains at different elevational gradients. The formation of this group has rekindled the idea of designing an inclusive network that meets the needs of interdisciplinary monitoring and research coordination across all mountains in the region.

Running concurrently to this research and monitoring-focused group, a new group of staff and volunteers from a variety of alpine stewardship nonprofits are considering similar questions around forming a regional stewardship group. Initial projects of the “Northeast Alpine Stewardship Center” include: 1. A paid 10-week summer college internship based on the World Trails Network - Hub for the Americas (WTN Americas) summit steward program. Through this internship program that has been running for five years, interns work at sites throughout the northeast with partner organizations. 2. A five-week interdisciplinary academic summer semester program focused on northeast alpine resource management, hosted by Binghamton, State University of New York. 3. Paid trail crews specializing in sustainable trail construction and maintenance with an emphasis on alpine trail management in high-use areas. 4. International fellowships, hosting visiting scholars and professionals from around the world at trail sites throughout the northeast.

Exploring benefits and challenges of phenology monitoring in the Northeast

Alyssa Rosemartin[1], Alana Russell[2]

[1]USA National Phenology Network, [2]University of Rhode Island Biocontrol Lab

Phenology is critical to ecosystem processes, from carbon cycling to pollination, and monitoring phenological events can be key to understanding ecosystem response to climate change. In this working session the organizers provided a summary of examples of phenology monitoring in the region. The participants together explored the benefits, challenges and next steps to embarking on a coordinated phenology monitoring effort.

Current Status

State Efforts

- VT (partnered with FEMC)- bud break, fall color and leaf drop, invasive plant spp. phenology
- CT- piloting invasive understory mapping; Persian lilac springtime development; first bloom monitoring
- RI- Plant Phenology Project (PPP); citizen science; bud break, leaf color, leaf drop, flower and fruiting
- MA- Landscape Message; plant and pest development; site-specific records

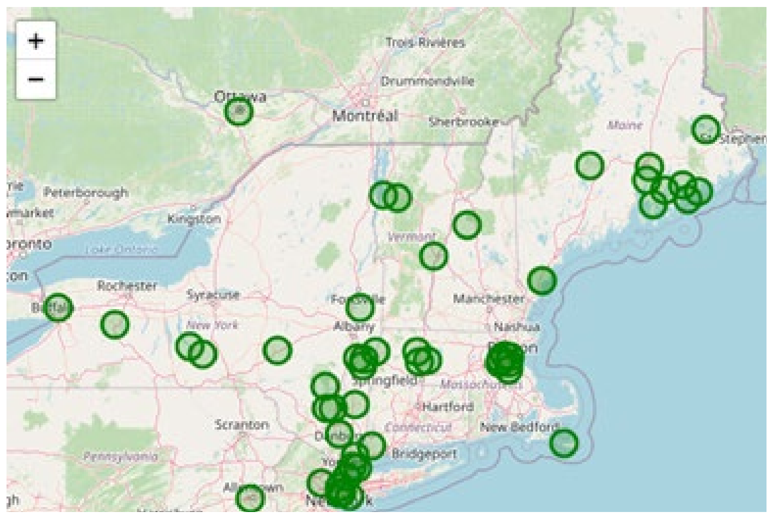


Figure 20 Nature's Notebook local phenology projects.

What can states be doing? What can phenology monitoring look like?

Participants identified many areas of opportunity, including the opportunity to make science-informed decisions related to invasive species, mismatch, and climate response, particularly at the regional scale (beyond geopolitical boundaries). There is an opportunity in discovering and sharing legacy datasets, as well as in analyzing existing data and sharing insights. There is also great potential in automated monitoring, from PhenoCams and other forms of repeat photography, audio recording and remote sensing, and in observational programs like iNaturalist and the USA-NPN's Nature's Notebook program. It is important to bring the various information sources together in the right configuration (considering strengths and limitations, and the data appropriate to the question). Phenology can also be a powerful tool for making climate change accessible to various audiences.

What are the challenges to (coordinated) phenology monitoring?

Figure 21 Jamboard with participants contributions on the challenges to phenology monitoring.

What can regionally coordinated phenology monitoring look like?

There was enthusiasm among participants for a meeting to pull more of the players together to build collaboration and coordination. This event could identify priorities for needed information, in terms of species and locations, and set the stage to apply for funding to fill the gaps. This was seen as a ready next step. More aspirational ideas were shared, including:

- Incorporating phenology monitoring into existing forest health monitoring.
- Heavy instrumentation, to have automated data flows of forest phenology (light meters, cameras, audio recording).
- Develop citizen science monitoring with existing programs.
- Creating a phenology data hub that automates analysis (images, Instagram dataming, iNat, Nature's Notebook etc).
- Pursuing root questions, for example, you may know that climate is having an impact, but what does this mean in terms of ecosystem function or ecosystem services?
- Pursuing the application of phenological information in conservation decision-making (for example in the 30x30 and 50x50 initiatives, using data to make ecologically-framed land acquisition decisions.

We are grateful to all the participants who engaged in the lively discussions, and are enthusiastic about the potential to have a focused meeting and explore FEMC support and funding opportunities.

Forest management across property boundaries: The Woodlots Program Toolkit

Monica Przyperhart[1], Nancy Patch[2]

[1]Cold Hollow to Canada, [2]VT Department of Forests, Parks and Recreation

With over 80% of land in Vermont in private ownership, maintaining forest health and resilience relies heavily on the decisions and actions of landowners. Cold Hollow to Canada (CHC) has addressed this challenge by creating a program that convenes neighboring landowners in high priority forest blocks who together learn strategies for maintaining forest resilience, receive technical assistance, and when possible are connected with funding opportunities to put plans into action.

News of the program's success has spread throughout Vermont and even out of state, and Cold Hollow to Canada has been asked by numerous groups for detailed information on how to initiate similar programs, methods for running them, and guidance on how to make similar initiatives successful elsewhere. Thanks to funding from the High Meadows Fund and a Vermont Watershed Grant, CHC has developed an online "Woodlots Toolkit" to enable adoption by conservation groups in other geographies.

In this session, Cold Hollow to Canada began by sharing the recently-released Toolkit (https://woodlots-toolkit.coldhollowtocanada.org/) and providing tips on its intended use.

We then shifted to an engaged discussion about how groups can use or adapt this tool to advance forest stewardship and conservation in locations with different social and physical settings. The 25 individuals in the room represented 16 different groups spanning the geography of the FEMC region. Many of those present indicated an interest in implementing similar programs, and so discussion focused around several aspects of program initiation.

Depth vs. Breadth

Many of the groups present currently work with private forestland and/or landowners in some capacity. It was observed that often, there is a focus on engaging high numbers of landowners in programming. In these efforts, it can be challenging to then get continued engagement by the same landowners. The Woodlots Program flips this. Because the program focuses on long-term relationships among neighbors, a single program is limited in the number of landowners it can engage. Instead, the focus is on continued engagement and individualized attention, providing each group of landowners with the tools and depth of engagement required to move from vague interest to engaged stewardship to, in some cases, land conservation.

Geography Matters

The conversation also centered around where this type of program is best applied. Because it requires time, energy, and resources, organizations may need to think carefully about the best locations on which to expend their resources. Furthermore, geography impacts group size and culture. Cold Hollow to Canada generally convenes groups within a single town. However, some rural towns with small populations can't support a group on their own, so two towns have been combined. In locations presented by participants, the appropriate geography in some cases crossed town boundaries OR represented only a portion of a town, based on how/where people convene, parcel size, or important boundaries of ecological priorities. Cold Hollow to Canada has found that between 10 and 20 parcels is a group size that works well, and the size of a location needed to engage this number of interested landowners in a place of ecological concern may vary from one place to another.

Invitation Only

One aspect of the Cold Hollow to Canada Woodlots program that is different from many is its "invitation only" approach. Instead of opening the program to anyone who is interested, participation is limited to those who own a certain acreage of forestland, are actively managing that land, and who have demonstrated some interest in sustainable management or conservation. These program requirements assure that landowners will all find overlap between their interests and will be able to work together as they learn about management techniques or conservation options. While some fear that this type of program is then only "preaching to the choir," Cold Hollow to Canada has found that the approach assembles a "choir" that will then be able to actively and supportively pursue goals of forest health as a team that would not have been accomplished by each individual alone. Furthermore, this small community then has a place within the larger community, and the ideas learned by the group spread to additional neighbors and friends.

Follow Up

Shortly after this session, Cold Hollow to Canada followed up with a webinar on the same topic that was available to the public. That webinar was recorded and is available here: https://www.youtube.com/watch?v=4mlZ_598AmA.

Poster Session

A poster session was held in-person during the event.

1. Approaches to increase the utility of tree regeneration inventories: Characterizing drivers of sapling recruitment and seedling survival

Lucas Harris[1], Christopher Woodall[2], Anthony D'Amato[1]

[1]USDA Forest Service Research and Development, Forest Inventory and Analysis, [2]University of Vermont

2. Bat activity and forest characteristics in managed Adirondack forests

Julia Rizzo[1], Vanessa Rojas[2], Stacy McNulty3, Gregory McGee[4]

[1]SUNY-ESF, [2]SUNY-ESF Ranger School, [3]SUNY-ESF Adirondack Ecological Center, [4]SUNY-ESF Syracuse

3. Beetle in a haystack: successfully engaging volunteers in early detection and monitoring efforts for southern pine beetle (Dendroctonus frontalis) at Mohonk Preserve

Kate O'Connor[1]

[1]Mohonk Preserve

4. Effects of cold-air pooling microclimates on species composition in New England forests

Aimee T. Classen[1], Anthony W. D'Amato[2], Marie E. English[2], Jane R. Foster[2], Karin Rand[2], E. Carol Adair[2,3]

[1]University of Michigan Biological Station, [2]Rubenstein School of Environment and Natural Resources, University of Vermont, [3] Gund Institute for Environment, University of Vermont

5. Establishing a low-cost sensor network to address local and regional research questions and support STEM education across the Northern Forest Region

Alix Contosta[1]

[1]University of New Hampshire

6. Forest management and climate change impacts on understory microclimates

Daniel Hayes[1], Laura Kenefic[2,3], Jessica Leahy[1], Jay Wason[1]

[1]School of Forest Resources, University of Maine, [2]U.S. Forest Service Northern Research Station, [3]Penobscot Experimental Forest

7. Identifying species and ecotypes suitable for assisted migration in the Northeast U.S.

Matthew Vadeboncoeur[1], Heidi Asbjornsen[1], Cameron McIntire[2], Jay Wason[3], Anthony D'Amato[4], Jackson Ehmett[1]

[1]University of New Hampshire, [2]USFS, [3]University of Maine, [4]University of Vermont

8. Mount Mansfield Science and Stewardship Center

Joshua Benes[1],

[1]University of Vermont

9. Mycorrhizal-Mediated Silviculture

Amelia Fitch[1], Eva Legge[1], Sarah Goldsmith[1], Tony D'Amato[2], Caitlin Hicks Pries[1]

[1]Dartmouth College, [2]University of Vermont

10. Northeast Silviculture Library

Tony D'Amato[1], Jill Levine[1]

[1]University of Vermont

11. Regional Expansion of the Forest Health Monitoring Program at FEMC: Insights from 2021

Matthias Sirch[1], Benjamin Porter[1], Elissa Schuett[1], Hanson Menzies[1]

[1]Forest Ecosystem Monitoring Cooperative

12. Songbirds in the Sugarwoods: Assessing the Impact of Forest Structure and Diversity on Bird Communities in Vermont Sugarbushes

Liza Morse[1], Steve Faccio[2], Steve Hagenbuch[3]

[1]University of Vermont: Rubenstein School of Environment and Natural Resources,

[2]Vermont Center for Ecostudies, [3]Audubon Vermont

13. Twenty years into a 150-year soil monitoring study, significant results!

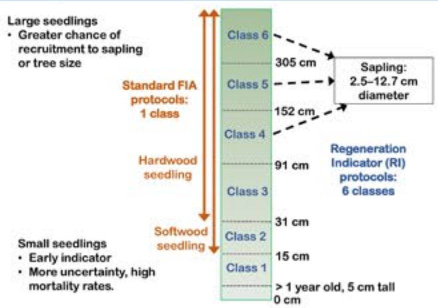
Donald Ross[1], Thomas Villars[2], Angelica Quintana[3], Jenny Bower[1], Joshua Halman[4], James Shanley[5], Benjamin Porter[6]

[1]UVM, [2]NRCS-retired, [3]USDA Forest Service, [4]Vermont Dept. of Forests, Parks and Recreation, [5]US Geological Survey, [6]Forest Ecosystem Monitoring Cooperative

Approaches to increase the utility of tree regeneration inventories: Characterizing drivers of sapling recruitment and seedling survival

Lucas B. Harris[1], Christopher W. Woodall[2], Anthony W. D'Amato[1]
(1) Rubenstein School of Environment and Natural Resources, University of Vermont
(2) USDA Forest Service, Research and Development, Forest Inventory and Analysis

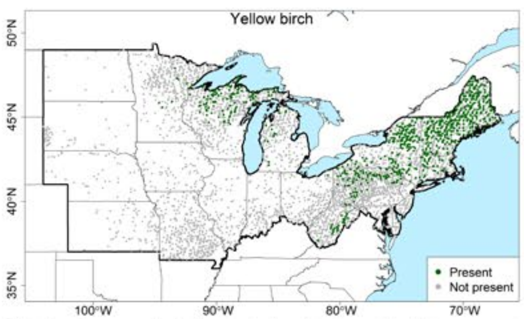
Accurately interpreting tree regeneration patterns to assess how forests are changing is increasingly important in the context of global change drivers such as climate change and shifting disturbance regimes. Tree seedling growth and development is controlled by a set of environmental filters such as climate, competition and substrate whose effects may vary in strength and even direction depending on seedling size. We are developing approaches to use seedling size class tallies from forest inventory plots to characterize influences on seedling survival and to better predict future forest composition from observed tree regeneration patterns.



The six seedling height classes tallied under the detailed RI protocols compared with the single size class normally used for FIA plots.

Tree regeneration data

Since 2012, the USDA Forest Service Forest Inventory and Analysis (FIA) program has conducted tree regeneration surveys using six seedling height classes instead of the traditional single size class for a subset of its field plots across the northeastern US. Because FIA plots are remeasured at 5–7-year intervals, plot remeasurements are just now becoming available from this "Regeneration Indicator" (RI) dataset (McWilliams et al. 2015). FIA plots contains four circular subplots (168 m²) in which trees are measured, each with a microplot (13.5 m²) in which seedlings and saplings are measured. Data on understory vegetation and ground cover, terrain and substrate characteristics, and more are also collected.



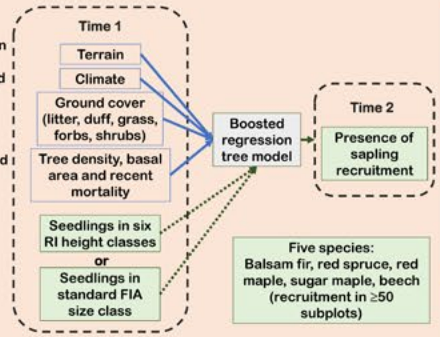
RI plot locations across the Northeast, showing plots where yellow birch was present as an example.

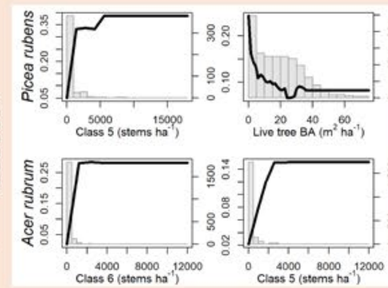
Approach: Predicting sapling recruitment

A key goal of surveying tree regeneration is to predict how patterns of seedling abundance will translate into sapling and eventually tree recruitment down the road. We created models to predict sapling recruitment in subplot remeasurements from seedling abundance in the prior measurement and other stand and site-level factors.

Questions:

- Does using seedling height classes improve predictions of sapling recruitment?
- How does influence on recruitment vary by height class?
- How does seedling abundance interact with other factors to determine recruitment?





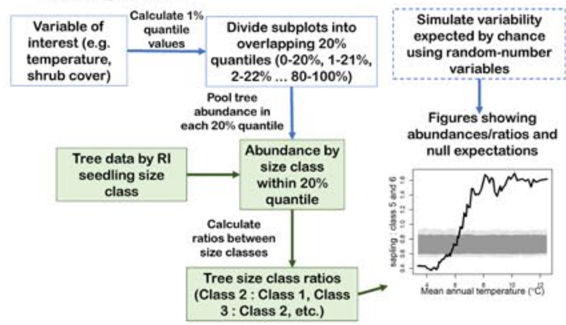
Influence on sapling recruitment likelihood (y-axis) for the two most important variables in the red spruce and red maple models. BA is basal area. Bars show the distribution of each variable among the RI subplots.

Findings

- Use of the six height classes improved models for all species
- Tallest seedlings (Class 5 and 6) were the best predictors of sapling recruitment across species
- Shorter seedlings (Classes 1-4) were omitted from most models
- Other influences are also important: tree basal area/density, harvesting, ground cover, climate

Approach: Seedling survival by size class

The influence of factors like climate and competition is likely to change as seedlings grow, but how these influences change by size class is not well-understood. We are developing a method to characterize influences on seedling abundance and survival across successive size classes using ratios of seedling abundance.



Workflow for using tree regeneration tallies by size class from forest inventory data to examine the effect of a given variable on abundance by size class and relative survival rates based on ratios between size classes

Effects of shrub cover on survival, as inferred from ratios of abundance, across seedling size classes for 10 common tree species.

High shrub cover had a generally positive effect on survival of small seedlings (< 1 m tall) but a negative effect on tall seedlings. This shift from facilitation to competition may be related to herbivory.

Conclusions

We found that tallies of seedlings > 1.5 m tall are important for predicting near-term sapling recruitment, and that the common practice of lumping seedlings into a single size class may hamper our ability to predict future forest composition from tree regeneration surveys.

Our analysis of seedling survival across size classes suggests that shifts in strength and directionality of key influences on survival as seedlings grow are common. These complex and sometimes opposing influences on seedling survival are important to understand when predicting and managing for successful tree recruitment and future canopy tree composition.

In future work, we plan to use these methods to assess how abundance of key tree species may shift across the Northeast as climate, vegetation and management strategies change.

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FEMC

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Bat activity and forest characteristics in managed Adirondack forests

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ABSTRACT

Insectivorous bats play important roles in forest ecosystems and their protection is critical. However, *Myotis* bat populations in North America have declined rapidly and are threatened due to white-nose syndrome (WNS) and habitat degradation. Apart from mitigating WNS, we can also assist the recovery of *Myotis* species by incorporating forest management strategies that improve summer roosting and foraging success. We analyzed bat acoustic activity in the central Adirondack region of New York at an experimental forest management site at SUNY-ESF Huntington Wildlife Forest and at a nearby traditionally managed shelterwood site. To determine the link between bat habitat use and forest structural characteristics, we compared bat acoustic activity and vegetation data at these sites. Our analyses show that forest variables such as canopy cover and sapling density affect probability of bat habitat use. The results of this study can inform forest management decision-making and aid in the conservation of imperiled bat species.

OBJECTIVES

- Determine probability of *Myotis* habitat use at differently-managed shelterwood sites and an unmanaged control site
- Evaluate which forest structural characteristics are most informative in predicting *Myotis* habitat use

STUDY SITES

Location of Electric Fence (EF) site within SUNY-ESF HWF and Goodnow Flow (GF) study site

EF site has 7 blocks with irregular shelterwood cut and 7 uncut control blocks. GF site has commercial shelterwood management.

EF Control

EF Irregular Shelterwood

GF Commercial Shelterwood

GF site removed understory beech but did not purposely retain large trees

METHODS

VEGETATION SAMPLING

- 5 fixed-radius plots at every detector
- Counted saplings, recorded size class
- Recorded canopy cover at plot center
- Recorded DBH and Tree-Related Microhabitats (TReMs) of trees >10cm (Larrieu et al. 2018, Basile et al. 2020)

ACOUSTIC SAMPLING

- Pettersson D500x ultrasonic detectors
- EF: 16 points; ≥ 14 nights each summer, 2021-2022
- GF: 6 points; ≥ 14 nights, summer 2022
- Analyzed using Kaleidoscope Pro software

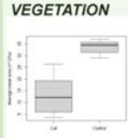
OCCUPANCY MODELING

Detection variables	Occupancy variables
Temperature (°C)	Canopy cover (avg %)
Relative humidity (%)	Sapling density (avg #/ha)
Wind speed (m/s)	Distance from water (m)
Precipitation (cm)	Average basal area (m^2/ha)
Day of year	TReM variables: Average density of snags, cavities, rot holes, and peeling bark (avg #/ ha)

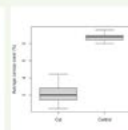
Used occupancy modeling and Akaike's Information Criterion (AIC) to determine the relationships between bat habitat use and forest characteristics. We fit models allowing occupancy (Ψ) and detection probability (*p*) to vary by detector location (MacKenzie et al. 2017). Ran 6 detection models for single and multi-season models. Ran 9 occupancy models for single-season model and 4 for multi-season model.

RESULTS

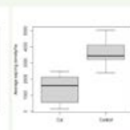
VEGETATION



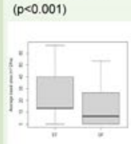
Average basal area (m^2/ha) was significantly different between cuts and controls ($p<0.001$)



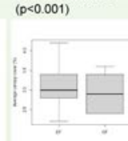
Average canopy cover (% classes) was significantly different between cuts and controls ($p<0.001$)



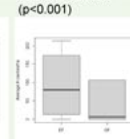
Average sapling density/ha was significantly different between cuts and controls ($p<0.001$)



Average basal area (m^2/ha) was significantly different between EF and GF cuts ($p<0.05$)

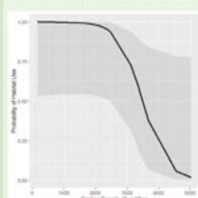


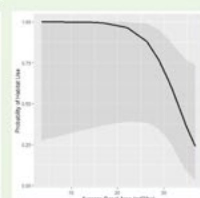
Average canopy cover (% classes) was not significantly different between EF and GF cuts ($p=0.5406$)



Average # of trees with cavities/ha was not significantly different between EF and GF cuts ($p=0.1263$)

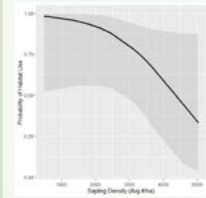
SINGLE-SEASON MODELS





Probability of habitat use in relation to sapling density and basal area. Includes summer 2022 data from EF and GF cuts and control sites.

MULTI-SEASON MODELS



Probability of habitat use in relation to sapling density. Includes summer 2021 and 2022 data from EF cut and control sites.

DISCUSSION

- We found the structure between the EF and GF cuts and the control site to be significantly different. The reduction in canopy cover and removal of sapling layer led to increased probability of *Myotis* habitat use. This is consistent with previous findings in the study region (Gallagher et al. 2021).
- Differences in Tree-Related Microhabitat (TReM) (e.g., cavities, rot holes, peeling bark) densities were not significant between EF and GF sites. The retention of green trees did not significantly increase TReM densities, these variables did not influence *Myotis* habitat use.
- Green-tree retention may be important for providing roost trees on managed landscapes, though it did not affect foraging habitat use.
- Further studies using mist netting and radiotelemetry are needed to see if *Myotis* bats are using the retained trees in the managed landscape.

REFERENCES

Will provide references upon request.

ACKNOWLEDGEMENTS

Monica Edgerton, Laurel Schuster, Alexa Carlson, and Hannah Allen for help with project development and data collection. F&W Forestry and Bill Van Gorp for access to Goodnow Flow study site. NYS Mesonet for weather data. T. Urling and Mabel Walker Research Fellowship Program, McIntire Stennis Seed Grant, American Society of Mammologists Grants-In-Aid, SUNY-ESF GSA Research Award, SUNY-ESF GSA Professional Development Award, Holohil Grant Program, and the Cross Apprenticeship for funding.

Beetle in a Haystack: Successfully Engaging Volunteers in Early Detection and Monitoring Efforts for Southern Pine Beetle (*Dendroctonus frontalis*, SPB)

Kate O'Connor

Mohonk Preserve ◦ 3197 Rt 44 55 Gardiner, NY 12525

A (Not So) Tiny Problem

Community science programs can be a valuable tool for land managers to identify and monitor emerging invasive species threats. However, relying on volunteers to correctly identify small, less charismatic organisms and collect quality data can pose a challenge.

By assembling a suite of existing, free, or low-cost tools, the Mohonk Preserve staff were able to create a cost-effective volunteer program to successfully detect and monitor the southern pine beetle (*Dendroctonus frontalis*, SPB) at Mohonk. SPB is native to the southern US but is undergoing range expansion due to climate change. It has caused widespread mortality in vulnerable pitch pine communities in New York.

Over five months in 2022, the Mohonk Preserve BeetleBusters program trained 10 volunteers to perform field surveys and maintain pheromone-baited funnel traps. The program saved 105 hours of staff time, made the first detection of southern pine beetle at Mohonk, and monitored stands for signs of outbreak.

Community Tools

A suite of free tools were used to schedule volunteers, collect data, and track project hours.

- SignUp.com (free) was used to schedule field training sessions, weekly volunteer shifts for surveys, and funnel trap checks
- The iMapInvasives platform (free) offers an app to record invasive species presence, absence, and treatments in the field. All records are verified by designated species experts. Records can be visualized or exported from the webmap.
- Volgistics (paid) volunteer software to track hours

Program Development

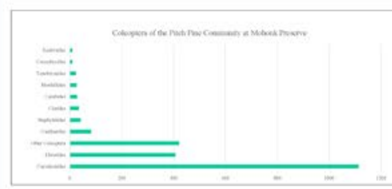
Recruitment and Orientation → Tools and Field Training → Monitoring and Data Collection → Engagement and Retention

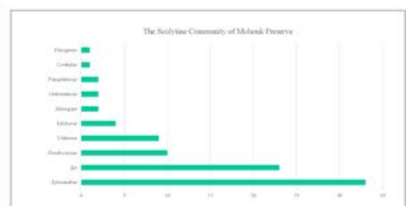
- 30 volunteers were recruited in June through social media and email lists
- Google Forms and SignUp.com were used to schedule trainings and weekly volunteer shifts
- Volunteers attended a 1-hour field training session. They learned to identify and document signs and symptoms of SPB, collect samples from and maintain Lindgren funnel traps baited with pheromone lures (*frontalin*, alpha-beta pinene, and *endobrevicomin*), and to use the iMap Invasives app to record data.
- Volunteer hours were reported weekly and tracked using Volgistics
- Trap samples were processed by staff and trained interns
- iMap detections were confirmed by experts at the New York Department of Environmental Conservation
- Monthly e-newsletters shared trap collection information, photos, and iMap stats to keep volunteers engaged

Top: volunteer Erika Liguori changes trap pheromone lures. Bottom: the iMapInvasive platform provides a simple app for expert verified community data collection and a web map for visualizing and exploring records.

2022 Results

- Volunteers reported a total of 104 hours of effort which included training, Lindgren funnel trap collections, and survey effort for signs and symptoms of SPB between June and October 2022.
- SPB was first collected from a Mohonk trap by a volunteer on 9/2/2022.
- The 2022 trapping season recovered a total of 11 SPB (4 female, 6 male, 1 unknown).
- Field surveys did not find signs of SPB outbreak in pitch pine (*Pinus rigida*) stands.
- A total of 2,226 specimens were collected, including SPB predator *Thanasimus dubius*, other native bark beetles, and a high relative abundance of the invasive bark beetle *Xylosandrus crassiusculus*.





Top: Count of coleopteran collected from baited Lingren funnel traps in 2022.

Bottom: Count of scolytines collected from traps in 2022.

Future Work

- Train select volunteers to use dichotomous keys and a reference collection to assist with specimen ID in the future.
- Continued monitoring of SPB and predator abundance, sex ratios, and survey for signs of outbreak in Mohonk's pitch pine stands.
- 2022 bycatch to be sequenced to provide a more extensive guide to the insect community of the Mohonk's pitch pines.
- Use bark beetle community composition and abundance data to assess the impacts of wildland fire, changing weather patterns, and silvicultural strategies (e.g. prescribed fire, thinning) in Mohonk's pitch pine forests.

Mohonk Preserve protects the Shawangunk Mountain region and inspires people to care for, enjoy and explore the natural world.

Acknowledgements

Jess Cancilliere & Liam Somers - New York State Department of Environmental Conservation. Penny Adler Colvin – Mohonk Preserve

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Effects of cold-air pooling microclimates on species composition in New England forests

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Background & Objectives

Cold-air pooling is a globally occurring meteorological phenomenon that results in temperature inversions with lower temperatures at low relative to high elevations[1]. These inversions are often formed when radiative surface cooling after sunset forms dense, cold air that drains downslope and pools in sheltered, low-lying areas, like depressions or valleys. Cold-air pools can be diurnal or may persist for days and, due to a lack of vertical mixing, air in these inversions becomes partly decoupled from the overlying free atmosphere[2]. Thus, cold-air pooling areas may serve as microrefugia that buffer organisms from climate change by enabling species persistence and facilitating species range shifts[3]. By favoring and excluding certain tree species, cold-air pooling may also influence ecosystem functions linked to plant traits, such as soil carbon storage[1].

We aimed to determine whether cold-air pooling influences the vegetation composition of northern forests. We hypothesized that sites with more frequent cold-air pooling would display unexpected patterns in vegetation composition across elevation, such as more cold-adapted species at low elevations.

Check out our new concept paper!
Pastore et al. (2022) Ecology[1]

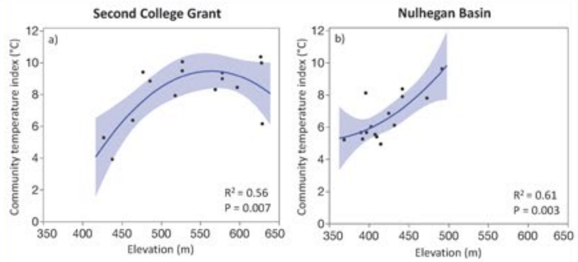
Methods

Above: Map of study locations across Vermont, New Hampshire, and Maine. Light blue sites were added this summer and are not included in the results.

Approach:

- Established elevation transects at each location spanning cold-air pooling gradients
- Surveyed plot forest composition and converted to 'Community Temperature Index' using historical distribution and climate data[4]
- Measured soil carbon, nitrogen, pH, and other site characteristics
- Deployed high-frequency sensors, such as iButtons that measure air temperature 1.5 m above the ground surface

Results



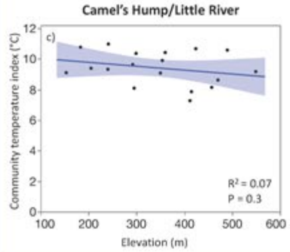


Figure 1. Community temperature index (CTI) for each plot at a site. CTI is the community weighted mean of species' temperature preferences. Best fits shown in panels a and b were achieved using quadratic fits, and a linear fit is shown for c. Shaded areas represent 95% confidence intervals. Seasonal cold-air pooling metrics for each transect within a site are provided in Fig. 2.

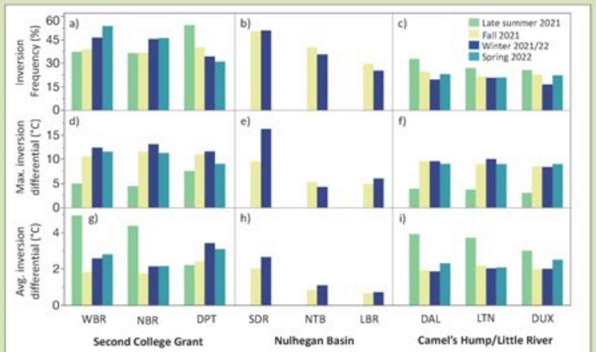


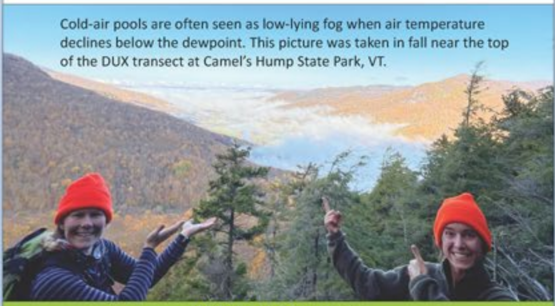
Figure 2. Cold-air pooling metrics for each transect by season: (a-c) frequency of temperature inversions, calculated as a percentage of hourly timesteps; (d-f) maximum temperature differential between the highest and lowest plot during temperature inversions; (g-i) average temperature differential between the highest and lowest plot during temperature inversions. No data were collected for summer and spring at the Nulhegan Basin.

Key Findings

Sites with more **cold-air pooling** displayed **inverted forest composition** patterns across **elevation.**

- Cold-air pooling occurred at all sites, but was most frequent at the Nulhegan Basin and Second College Grant (Fig. 2).
- Where cold-air pooling was frequent, the lowest elevations were dominated by cold-preference species and higher elevations were dominated by warm-preference species (Fig. 1). The nonlinearity observed at Second College Grant suggests that the highest plots are above the cold-air pooling boundary (Fig. 1a). No strong vegetation pattern across elevation was observed in the westernmost site where cold-air pooling was less common (Fig. 1c).
- Forest stands in cold-air pooling areas were composed of species with traits that facilitate slow organic carbon turnover. These areas may therefore maintain plant communities linked to key ecosystem functions like carbon storage in the face of climate change.

Above: Forest composition transitions from evergreen to deciduous as elevation increases along the SDR transect at the Nulhegan Basin, VT.



Acknowledgments

This work was supported by a USDA McIntire-Stennis grant, NSF Award 1920908, and the University of Vermont. We thank many UVM interns for their assistance in the field, as well as several partners for allowing research on their lands: VT Agency of Natural Resources, US Fish and Wildlife, USDA Forest Service, Maine Bureau of Parks and Lands, Appalachian Mountain Club, Dartmouth University.

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Establishing a low-cost sensor network to address local and regional research questions and support STEM education across the Northern Forest Region

Karin Rand[1], Alix Contosta[2], Anthony D'Amato[1], Emma Hazaard[3], David Lutz[3], Scott Ollinger[2], Apryl Perry[2], Aaron Weisskeitel[4]

[1]University of Vermont, [2]University of New Hampshire, [3]Dartmouth College, [4]University of Maine

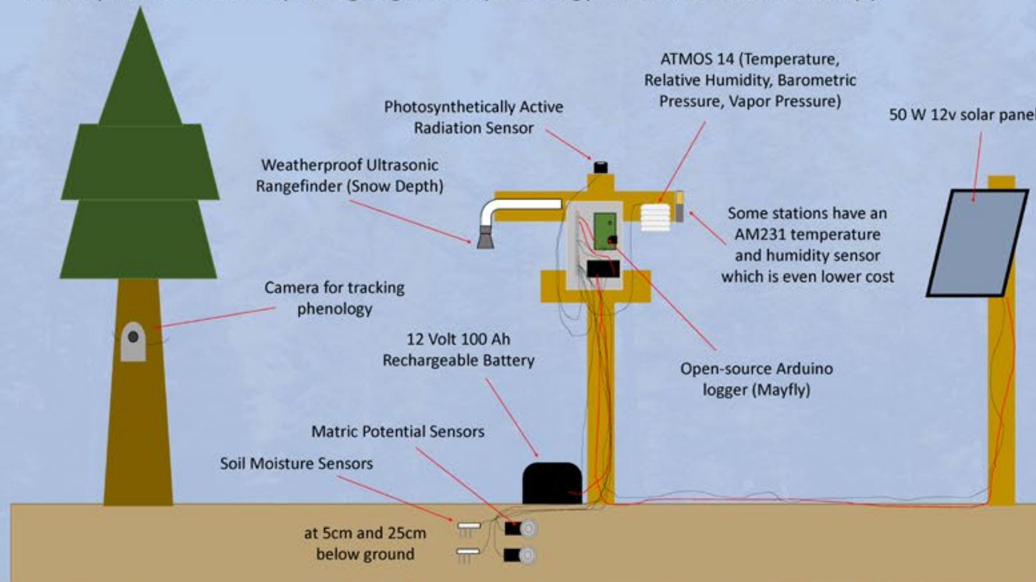
Overview of the Sensor Network

Our low-cost, energy-efficient sensor network monitors biophysical properties of forests across the region (Fig. 1). The data are informing novel research questions and supporting K-12 education.

Figure 1. Distribution of sensor network. Sites host different numbers of stations: Vermont Commons School (1), Nulhegan Basin (3), Clements woodlot (9), Second College Grant (2), Bartlett (1), Thompson Farm (1), Van Buren (1), Debouille (1), Maine Woods Initiative (2), Penobsccot Forest (2), Schoodic Institute (1).

Sensor Suite Layout

The sensor suite features instruments for measuring air temperature, relative humidity, photosynthetically active radiation, soil temperature, soil moisture, and snow depth, as well as a time-lapse camera for capturing vegetation phenology beneath the forest canopy.



Building the Network

Alix Contosta (UNH) demonstrating sensor wiring to Vermont Commons School students while building a station on school woodlands in Charlotte, VT.

Karin Rand (UVM) explaining the application of sensor networks in Corinth, VT for examining impacts of the emerald ash borer on Northern Forests as part of workshop and field tour for foresters and other natural resource managers.

Teachers from VT, NH, and ME assembling the solar panel for sensor station during INSPIRES teacher workshop at the Schoodic Institute, ME.

Preliminary Data

Sensors currently record hourly or half-hourly. Data is then downloaded from the SD card onsite. Initial data collection shows differences across a subset of sites (Fig 2).

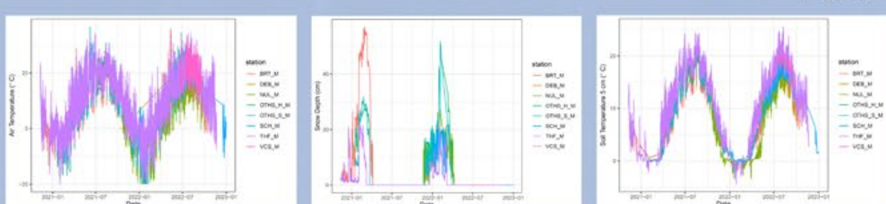


Figure 2. Preliminary data from a subset of sites showing time series of air temperature, snow depth, and soil temperature at 5cm below ground from late winter 2019 to late fall 2022

Future Goals

- Continue to grow the network
- Add new sensors for soil respiration and dendrometry
- Clean and analyze incoming data
- Support teachers in using large datasets in STEM curriculum

Forest management and climate change impacts on understory microclimates

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Introduction

- Forests create their own microclimates. If you've ever stepped into a cool forest on a hot summer day you've felt the effect of the forest canopy buffering the understory from extreme conditions (**Figure 1**).
- As the climate continues to warm, this buffering effect may become increasingly important for advance regeneration of climate sensitive tree species at their southern range margins[1].
- Management and climate change stressors can alter forest stand structure and composition in ways that may reduce understory buffering and surpass critical climate thresholds for regeneration[2,3].
- Therefore, there is a need to better understand how stand structure and composition relate to understory microclimates in the face of climate change.

Goal & Objectives

GOAL: Better understand how forest stand structure affects understory responses to climate change.

OBJECTIVES

1) Determine the extent to which forest stand structure and composition drive understory microclimate buffering in different times of year
2) Determine the effectiveness of airborne measurements for predicting landscape-level microclimate buffering

Methods

Microclimate buffering: the difference between forested and non-forested climate conditions at any given time

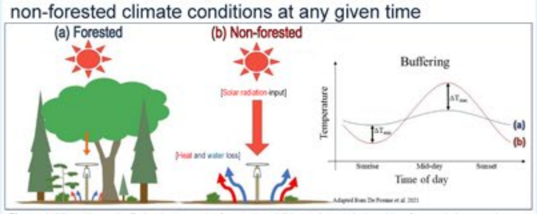

Figure 1. Microclimate buffering between (a) forested and (b) non-forested sites. Non-forested sites receive greater solar input and release more heat and moisture compared to forested sites, which can lead to larger daily fluctuations in temperature and relative humidity.

- We established 60 survey plots across a broad range of canopy structures and compositions in managed stands at the Penobscot Experimental Forest in Maine
- Microclimate (temperature and relative humidity) was sampled every 2 hours at each site with remote data loggers
- We measured basal area, stem density, and canopy closure using traditional forest inventory methods and airborne laser scanning (ALS, airborne lidar; **Figure 2**).

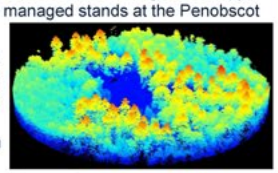

Figure 2. 3D point cloud of a microclimate survey plot at the Penobscot Experimental Forest generated from NASA G-LiGHT (https://glihit.gsfc.nasa.gov/).

Preliminary Results

- Non-forested sites reach higher daily maximum temperatures and vapor pressure deficits than forested sites (**Figure 3**).

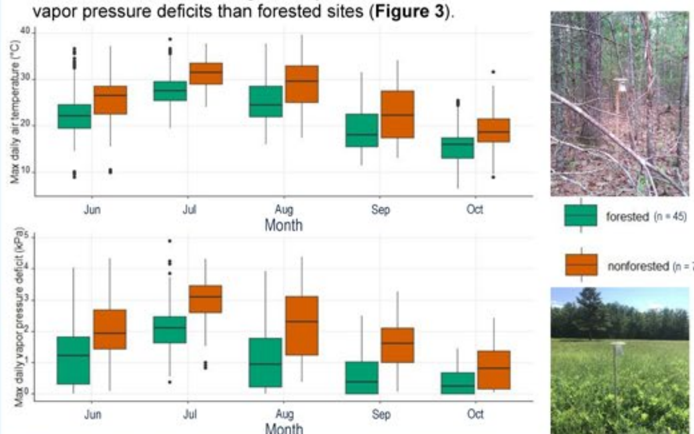

Figure 3. Monthly averages of daily maximum temperature (top) and vapor pressure deficit (bottom) for forested and non-forested sites from June-October 2022. Vapor pressure deficit (VPD) is a standardized measure of air aridity calculated from relative humidity and temperature.

- Microclimate buffering varies widely by day, although effects are fairly consistent across months. On average, forest understories reach daily maximum temperatures that are 3°C cooler with 27-67% lower maximum VPD during the growing season (**Figure 4**).

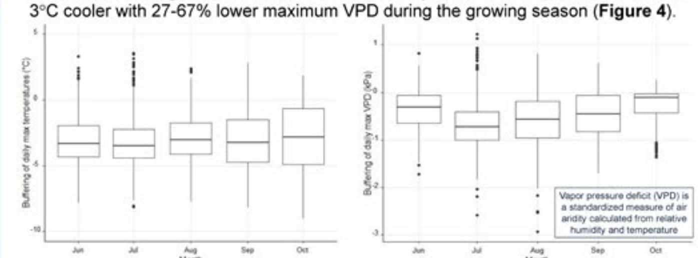

Figure 4. Monthly average buffering of daily maximum temperature (left) and vapor pressure deficit (right) for forested sites from June-October 2022.

- Microclimate buffering increases with basal area and canopy closure (**Figures 5, 6**).

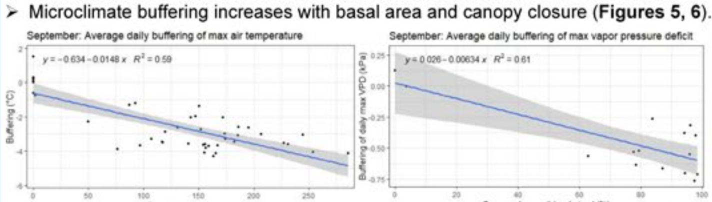

Figure 5 (left). Relationship between basal area (sq.ft/acre) of all trees > 1cm DBH and buffering of daily maximum temperature for all sites in September 2022.
Figure 6 (right). Relationship between lidar-derived canopy closure and buffering of daily max vapor pressure deficit for all sites in September 2022.

Preliminary Results cont'd

- On the hottest days, stands with higher basal area have an even stronger buffering effect than on cooler days (**Figure 7**).

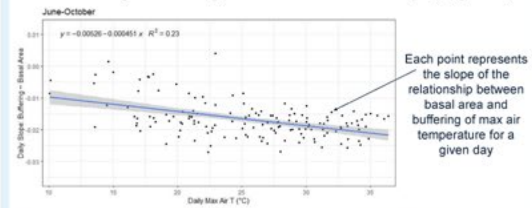

Figure 7. The relationship between basal area and buffering of maximum daily temperatures is stronger when ambient conditions are warmer. Each point represents the slope of the relationship for one day.

- Airborne lidar accurately estimates canopy closure (**Figure 8**).

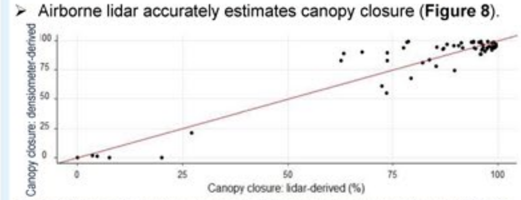

Figure 8. Comparison of canopy closure derived from lidar versus from a spherical densiometer in the field. The 1:1 line of agreement is shown in red. Lidar-derived canopy closure was estimated from first returns only with a 1-meter height cutoff at 1-meter spatial resolution. Raster values were averaged over a 30-meter radius.

Conclusions & Future Research

- Understory temperature and vapor pressure deficit vary greatly between sites with different forest structures and compositions.
- Next, we will build linear mixed effects models to quantify contributions from each predictor variable.
- Models will be combined with wall-to-wall lidar metrics to estimate microclimate buffering across the 4,000-acre forest at different times of day and year (**Figure 9**).

Figure 9. Lidar-derived canopy height model at the Penobscot Experimental Forest, with microclimate survey plots overlaid.

Acknowledgements

This project was made possible by the USDA Forest Service Northern Research Station, the University Forest Research Operations Team, the Wheatland Geospatial Laboratory and all collaborating private landowners who allowed us to establish survey plots on their land. I would like to thank my co-advisors, Jay Wason and Jessica Leahy, for their ongoing support and guidance. I would also like to thank Bean Bein for their hard work in the field. This project is funded by the National Science Foundation NRT-Conservation Science program and the Maine Economic Improvement Fund. This project is part of McIntire Stennis Project Number ME0-42121 administered through the Maine Agricultural and Forest Experiment Station.

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Identifying species and ecotypes suitable for assisted migration in the Northeast U.S.

Sam Zuckerman[1], Heidi Asbjornsen[1], Matthew Vadeboncoeur[1], Cameron McIntire[2], Jay Wason[3], Anthony D'Amato[4], Jackson Ehmett[1]

[1]University of New Hampshire, [2] U.S. Forest Service Durham, NH office, [3]University of Maine, [4]University of Vermont

INTRODUCTION

- In the Northeast US, climate change will likely cause hotter temperatures, more sporadic and extreme precipitation, and increased pressure from droughts within the next century
- Forestry assisted migration, the movement of tree genotypes adapted to the future climate of a region, has gained attention for its potential to mitigate climate change impacts on forest health and productivity
- Several studies have measured establishment success of assisted migration seedlings but lack in-depth physiological explanations for local species
- Understanding which species and source locations (ecotypes) perform best under forestry assisted migration in the Northeast US could improve implementation success

RESEARCH QUESTIONS

When grown in a common garden...

1. Does ecotype influence seedling success?
2. Is seedling performance affected by drought exposure?
3. Does ecotype influence capacity for drought acclimation?

METHODS

- ➢ Seedlings from 7 species and 3 source regions (ecotypes) were planted in a modified polyhouse at the UNH MacFarlane Greenhouses (photo right; Durham, NH)
- ➢ Once acclimated, plants were divided into control (n=146) and drought (n=300) treatment groups
- ➢ Control plants were drip irrigated each morning and droughted plants were withheld water for 22 days (7/18-8/8)
- ➢ Water content and tree physiology were measured throughout the experiment (table below)

Measurement	Tool	Frequency
Stomatal conductance	Porometer	Twice/week (n=90)
Stomatal conductance	Li6400xt	Weekly (n=60)
Photosynthetic assimilation	Li6400xt	Weekly (n=60)
Predawn water potential	Pressure bomb	Weekly (n=60)
Midday water potential	Pressure bomb	Weekly (n=60)
Height and diameter	Tape, calipers	4 times (n=450)
Phenology	Visual	Will measure in yr. 2

HYPOTHESES

1. In terms of growth, I expect that local ecotypes will outperform assisted migration seedlings in the control group. In the drought treatment group, I expect the southern ecotype (VA) to outgrow the other ecotypes
2. Physiological responses between ecotypes will be greatest in species that do not tightly regulate stomatal control e.g., black cherry and red oak

University of New Hampshire

The University of Vermont

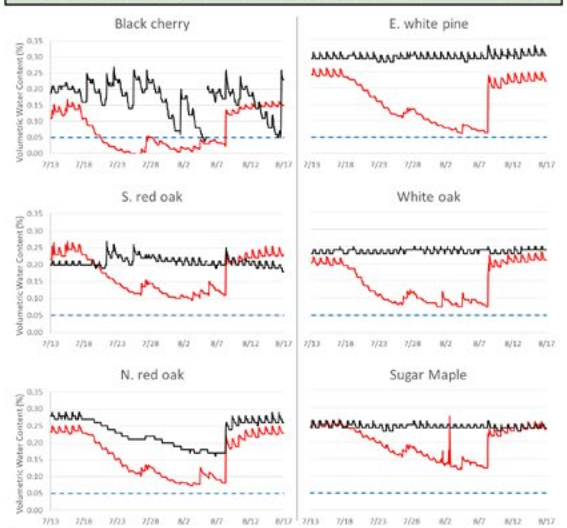
The University of Maine

Acknowledgements: We thank the UNH greenhouse staff for providing valuable feedback and assistance throughout the project. This project was supported by the NH Agricultural Experiment Station and the Northeastern States Research Cooperative through funding made available by the USDA Forest Service. The conclusions and opinions in this poster are those of the authors and not of the NSRC, the Forest Service, or the USDA. This institution is an equal opportunity provider.

THE DROUGHT

Seedlings were randomly assigned into blocks and allowed to acclimate for >1 month before they were assigned an experimental group (above). Seedling survival was relatively low for southern red oak and since virtually no black walnut from MI survived, this ecotype was removed from the study (below).

Ecotype	N. red oak	E. white pine	Sugar maple	Black cherry	White oak	Black walnut	S. red oak
NH	n = 33	n = 33	n = 33	-	-	n = 32	-
MI	n = 33	n = 34	n = 33	n = 33	n = 32	-	-
VA	n = 33	n = 32	-	n = 33	n = 33	-	n = 19

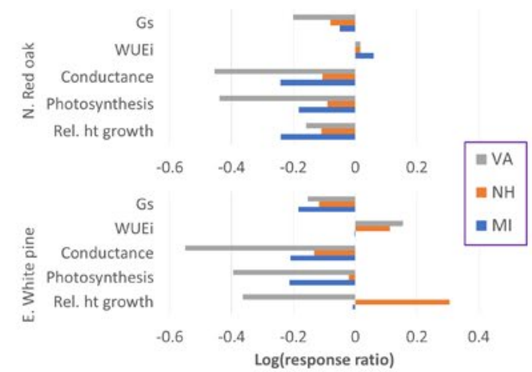


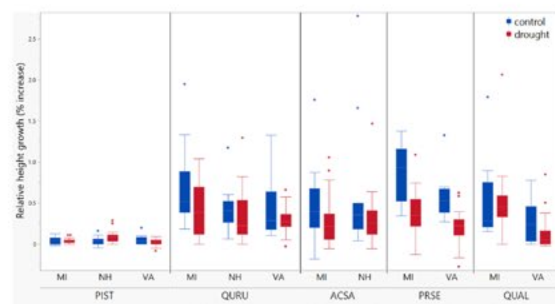
Black = control Red = treatment Blue = 5% VWC threshold

On average, black cherry experienced the greatest number of days under 5% VWC with individuals recorded at 0% VWC with a Teros10 soil moisture sensor buried mid-pot

RESULTS & DISCUSSION

- Height growth (bottom figure)
  - Pines grew least with little treatment or ecotype effect
  - In other species, a weak trend of MI > NH > VA
  - Black cherry growth was most limited by the drought
- Physiological traits (below)
  - Seedlings from VA displayed the strongest response to drought stress in photosynthesis and conductance
  - Interestingly, the local NH ecotype, showed the least effect to the drought treatment for the above traits
- I suspect initial height and leaf area played major roles in the length and severity of drought experienced by seedlings
- Two drought treatments will be applied in the second year of this study, 2023





Proposed Mt. Mansfield Science and Stewardship Center

Contact: Joshua Beneš – jbenes@uvm.edu – (802) 656-7716

Introduction

Several organizations have partnered to establish a vision for a new hub of mountain science and stewardship in the Mount Mansfield Summit Station, a 64ft x 40ft building located on a forested ridgeline in the Green Mountains of northern Vermont (Figure 1). Initiated by the Vermont Center for Ecostudies and the University of Vermont (UVM), the collaboration also involves the Forest Ecosystem Monitoring Cooperative (FEMC), the Green Mountain Club, and the Vermont Department of Forests, Parks, and Recreation. Together, these organizations envision a community of scholars, educators, and natural resource managers working alongside students and visitors to understand and sustain mountain ecosystems. The Mount Mansfield Science and Stewardship Center will serve this community by facilitating investigations of natural and human-induced change in a remote, living laboratory.

Figure 1. Located on Vermont's highest mountain, the Summit Station offers ready access to montane fir-spruce forest, large alpine and talus communities, as well as lower-slope northern hardwoods. The building is surrounded by a UVM Natural Area (400 acres) and Mount Mansfield State Forest (44,444 acres). Monitoring and research are encouraged on both properties. Photo credit: Rick Paradis

Mission

The Mount Mansfield Science and Stewardship Center's mission is to catalyze collaborative science and stewardship for healthy mountains, watersheds, and communities. The foundation for this work consists of: a long-term scientific record that spans air, forest, soil, water, and wildlife; a tradition of information sharing and networking; and a commitment to science-based natural resource policy and management

Goals

- Build knowledge of mountain ecosystems and changes affecting mountain flora and fauna.
- Advance understanding of relationships among mountains, streams, and lakes.
- Provide place-based education and outreach on mountain ecology, conservation issues, and stewardship.
- Develop, implement, and demonstrate management actions that lead to improved conservation of mountain environments.
- Provide a platform for scholarship and instruction in fields that address social dimensions of mountain environments, such as engineering, human health, economics, education, and the humanities.
- Foster connections among UVM schools and programs and between the University and the Vermont State College system.

Foundation

Mount Mansfield is an exceptional site to do research. The mountain is the State's highest peak, standing at 4,393ft. It contains about 200 of the 275 acres of tundra in Vermont. The toll road, going up to the forested ridgeline of the mountain, provides easy access to the high-elevation environment.

Between 29,000 and 45,000 people pass by the Mount Mansfield Summit Station each year, bringing high visibility to the research while offering an exceptional educational opportunity for the public.

Ecological and meteorological monitoring has been taking place on Mt. Mansfield for decades. Table 1 provides the start year for some of the current types of monitoring that are still taking place on and around the mountain. Figure 2 shows the geographical distribution of these monitoring sites.

Table 1. Mount Mansfield has been the subject of scientific study for over 170 years. The Forest Ecosystem Monitoring Cooperative, a collaboration between UVM, the US Forest Service, and the New England and New York state natural resource agencies, has coordinated and sponsored standardized monitoring of air, forest, soil, water, and wildlife since 1991.

Monitoring Target	Start Year
Weather	1955
Precipitation chemistry	1980
Ambient air quality	1988
Forest health	1991
Avian demographics	1991
Amphibian & stream invert population	1991
Plant phenology	1992
Hydrology and water quality	2001
Soil moisture and climate	2000
Soil chemistry and tree nutrition	2002
Alpine plant communities	2004
Mercury flux	2004

Guiding Principles and Practices

- Integration of research, education, and stewardship is needed to sustain ecosystems and their services to society.
- Strategic collaboration increases the impact of science and conservation by aligning resources, skills, and knowledge.
- Standardized, long-term monitoring and short-term experimentation play essential and complementary roles in science and stewardship. Together, they provide a vital record of the past, reveal ecological patterns and processes, and form a basis for projecting future conditions under different scenarios.
- Science, stewardship, and education must adapt as conditions change and techniques improve.
- Ecological and economic sustainability are fundamental to implementing responsible science, stewardship, and education programs.
- Cooperative and proficient information management creates valuable opportunities for researchers, educators, and natural resource managers.
- Place-based science, stewardship, and education offer unique advantages over other approaches to building and applying knowledge.

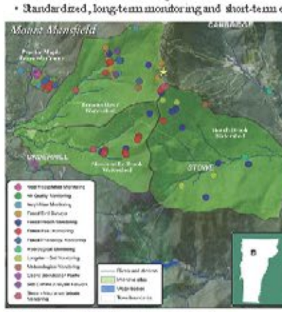


Figure 2. The FEMC has supported long-term monitoring and multi-disciplinary research on Mount Mansfield since 1991. The yellow star indicates the location of the Summit Station, the proposed home of the Mount Mansfield Science and Stewardship Center.

Collaborative Research

There is an opportunity to develop integrative, hypothesis-driven research projects that capitalize on existing long-term datasets on and around Mt. Mansfield.

Currently, there are a wide variety of research studies already taking place on the mountain. This includes but is not limited to:

- Ongoing monitoring of the Bicknell's Thrush, a rare bird that depends on alpine habitat in the northeast by the Vermont Center for Ecostudies.
- An ongoing 20+ year paired watershed hydrology research study managed by Dr. Beverley Wemple at UVM and Dr. Jamie Shanley with the US Geological Survey.
- The Vermont Forest Ecosystem Management Demonstration Project that is managed by Dr. Bill Keeton at UVM.

There are many opportunities to build upon existing monitoring and research networks on and around the mountain and connect these to regional and global networks. One example of this already in development focuses on building a regional network of mountain observatories for global change monitoring and research.

Key personnel within the Atmospheric Sciences Research Station on Whiteface Mountain in New York and the Mt. Washington Observatory have been convening to discuss the opportunity to collaborate with the proposed Mt. Mansfield Science and Stewardship Center. The group has been establishing connections with UVM, the National Mesonet Program, the American Association of State Climatologists, and the National Weather Service to identify potential areas of collaboration. The first opportunity identified would be to deploy temperature/relative humidity sensors at different elevational gradients on each mountain. This would provide the opportunity to enhance modeling of thermal profiles that would benefit regional weather forecasting and satisfy the requirements of a newly forming international monitoring program called the Unified High Elevation Platform (UHOP, see Figure 4). The model is being developed by Dr. Nick Pepin and the Global Network of Mountain Observatories.

Figure 3. The Proposed Mt. Mansfield Science and Stewardship Center in relation to other mountain observatories in the northeast. A potential regional network of mountain observatories is currently being explored with these other field stations.

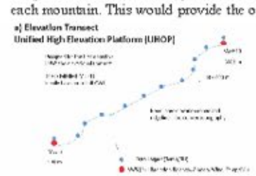


Figure 4. An example of a potential elevational transect model developed by Dr. Nick Pepin at the University of Portsmouth in the United Kingdom.

UHOP aims to have a consistent global model to monitor mountain environments to enhance climate simulation models, which currently perform poorly in mountainous environments.

This poster was adapted from a 2014 poster developed by J. Daniel Lambert (High Branch Conservation Services), Christopher C. Rimmer (Vermont Center for Ecostudies), and Richard Paradis (University of Vermont).

Mycorrhizal-Mediated Silviculture

Scan the QR code to take a short survey!
The purpose of this survey is to gauge interest in mycorrhizal fungi-related forest research.

Amelia Fitch, Eva Legge, Sarah Goldsmith, Tony D'Amato, Caitlin Hicks Pries
Department of Biological Sciences, Dartmouth College, Hanover NH 03755

Introduction

- Arbuscular (AM) and Ectomycorrhizal (EcM) fungi have an extraordinary capacity to enhance the success of reforestation efforts.
- They provide soil nutrients to roots and allow resources like nitrogen to travel between seedlings and mature trees through common mycorrhizal networks.
- After timber is harvested, the legacy of mycorrhizal association (AM or EcM) and the proximity of remnant trees may affect seedlings survival and growth.

Driving Questions

1. Do AM and EcM- associating seedlings differ in survival and growth when planted in soils previously dominated by AM or EcM associated adult trees?
2. If so, does access to mycorrhizal networks explain observed differences in seedling growth and survival?

Methods

- Study conducted in experimental forest in Corinth, VT, as part of the Adaptive Silviculture for Climate Change Project, led by Tony D'Amato (Fig. 1).
- Planted 4 AM and 4 Ecm tree species in 8 quarter acre logged gaps, previously dominated by AM or EcM trees (Fig. 2).
- Measured seedling growth and survival at the end of the growing season.
- Collected leaf samples to measure δ15N (indicates mycorrhizal mediated nitrogen).
- Measured soil available nitrogen 1 month during gowing season.

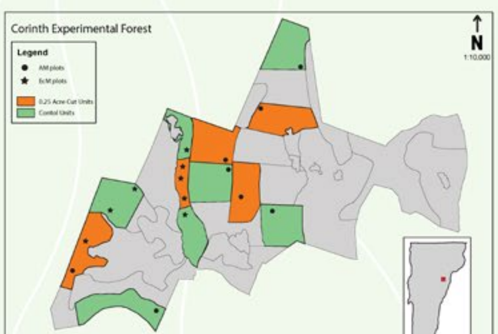


Figure 1.

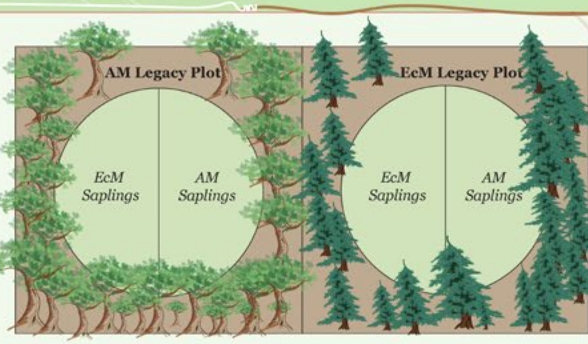


Figure 2: Eight quarter-acre gaps were established in the winter of 2021. Eight quarter-acre control plots were also established: four in EcM-dominated and four in AM-dominated areas.

Results:

Figure 3.

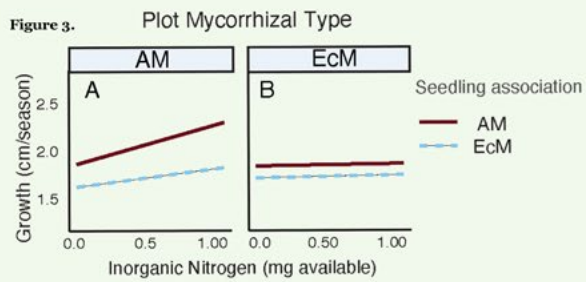
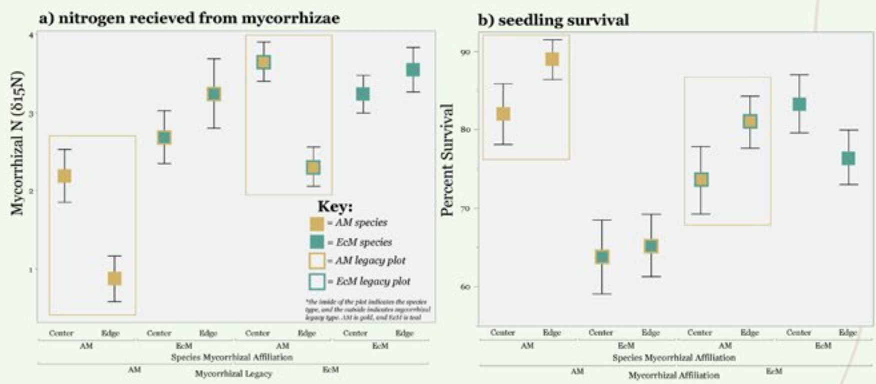


Figure 4.



Discussion

- AM but not EcM seedlings had higher survival (8%) and growth (9%) in AM legacy plots, **likely driven by access to common mycorrhizal networks**.
- AM seedlings had higher survival and more mycorrhizal-mediated N ($p<0.0001$) when closer to potential donor trees (Fig 4b).
- AM seedling growth also benefited from connections to my corrhizal networks:
- AM seedling growth had a positive relationship with soil nitrogen availability (Fig 2; $p = 0.021$).
- **This nitrogen likely came from mycorrhizal networks as growth** was positively related to mycorrhizal-mediated nitrogen (Fig 4a; $p = 0.006$).

Conclusions

Nutrient acquisition via AM fungal networks is a vital factor affecting seedling regeneration and growth for trees including Acer saccharum and Fraxinus sp. EcM-associated seedlings may be more affected by the species of fungi present in the soil. We are currently analyzing soil fungal community data to better answer this question.

Next Steps

In June 2022, we established a root-exclusion study in selectively harvested and ¼ acre gap plots at Corinth to build on our current hypothesis that AM-associated seedlings require access to mycorrhizal networks and adult AM trees for survival and growth of Acer saccharum, Prunus serotina, and Nyssa sylvatica.

Acknowledgements

This work was supported by a grant from the Northeastern States Research Cooperative (NSRC) and the Kaminsky Family Fund Award. Thank you especially to Tony D'Amato and Kevin Evans for incredible help and support throughout this study. Additional thanks to Tony's field crew for helping planting 1,280 seedlings.

We would love to hear from you with questions/comments/ suggestions!

amelia.a.fitch.gr@dartmouth.edu

NESL | Northeast Silviculture Library

A new online symposium of silvicultural prescriptions and associated outcomes of actual on-the-ground management activities.

Grace Smith, Tony D'Amato, Jill Levine
University of Vermont, Rubenstein School of Environment and Natural Resources, Burlington, VT

Background

The Northeast Silviculture Library (NESL) was conceived with the idea that every silviculture treatment is an experiment and every forest manager is both a teacher and a learner. It is a place for foresters and other resource managers to exchange real, on-the-ground examples and outcomes of their management activities, with the overall goal of increasing knowledge of how to best steward the changing landscape of the Northeast to promote sustainability and adaptability.

Why contribute to NESL?

- Engage in a community of practice with other foresters and resource managers
- Contribute to knowledge base used to address current and emerging management challenges
- Exchange silviculture prescriptions real-time in rapidly changing environments

www.uvm.edu/nesl/ nesl@uvm.edu

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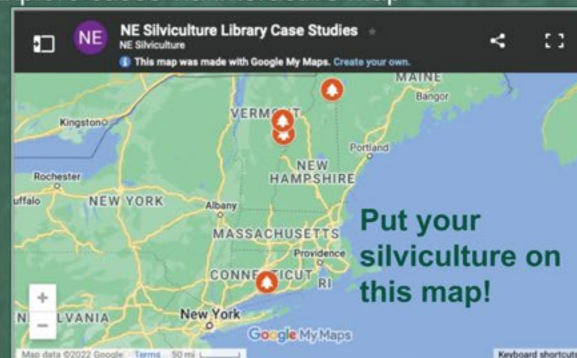

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Explore cases that are designed to address forest health issues like Hemlock Woolly Adelgid, Emerald Ash Borer, White Pine Blister Rust, climate change, etc.

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Discover cases by goals achieved by the project, such as forest adaptation, ecological restoration, invasive species management, wildlife habitat, etc.

Check out our recent case studies

"La Playa" Beech Management (Groton State Forest, Vermont)

Description: Reduce abundance of diseased beech to encourage regeneration of healthy beech, yellow birch, red spruce, sugar maple, and eastern hemlock while preserving habitat value and structure.

State/Province: Vermont

Forest Type: Northern Hardwoods

Citation: Scott Machinist, 2020, "La Playa" Beech Management (Groton State Forest, Vermont), Northeast Silviculture Library, University of Vermont. Accessed 12/08/2022 at https://www.uvm.edu/nesl/webform/new_case_study/submissions/28.

Howard B. Field Forest

Description: The landowner is interested in maintaining forest health and tree species diversity, while simultaneously not

Find us here!

Regional Expansion of the Forest Health Monitoring Program at FEMC: Insights from 2021

FEMC

The University of Vermont RUBENSTEIN SCHOOL OF ENVIRONMENT & NATURAL RESOURCES

Matthias Sirch[1,2]; Benjamin Porter[1,2]; Elissa Schuett[1,2]; Hanson Menzies[2,3]

[1]University of Vermont Rubenstein School of Environment and Natural Resources, [2]Forest Ecosystem Monitoring Cooperative, [3] ECO Americorp Program - Vermont Department of Environmental Conservation

VERMONT AGENCY OF NATURAL RESOURCES

USDA

After successfully establishing and conducting annual assessments on Forest Health Monitoring (FHM) plots in Vermont for almost three decades, the FEMC has begun its expansion of the FHM program into surrounding states to yield a more complete picture of forest health across the Northeast.

Introduction

In 1991, the Forest Ecosystem Monitoring Cooperative (FEMC), then the Vermont Monitoring Cooperative (VMC), and the Vermont Department of Forests, Parks and Recreation (FPR) created a Forest Health Monitoring (FHM) network located in study sites on Mt. Mansfield that were surveyed annually (Figure 2). By 2018, the network had grown to include 49 plots in Vermont. After successfully conducting annual assessments on FHM plots in Vermont for almost three decades, the FEMC began to expand its FHM program into surrounding states to yield a more complete picture of forest health across the region. By the 2021 field season, FEMC worked with state partners to establish plots in Connecticut (15 plots), Maine (35), Massachusetts (25), New Hampshire (30), and Rhode Island (7), with New York (35) completing the 7-state expansion effort in 2022. These new sites were primarily co-located at established, long-term forest health monitoring plot locations, representing the major forest types and geographies on public lands in each state.

At each plot, FEMC FHM crews assess seedling and sapling regeneration, and record tree height, tree diameter at breast height (DBH), as well as vigor, dieback, transparency, defoliation, and discoloration of the tree's canopy. Lastly, crews note pest and pathogen damages for each tree, invasive species presence within the plot, and degree of browse pressure observed.

Plot Layout

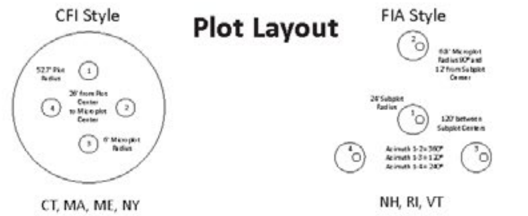

Figure 1. The two plot layouts adopted by the FEMC Forest Health Monitoring program accommodates plot layouts from each state's historical forest health monitoring efforts. Our CFI-Style FHM plots (left) show the overstory plot (large circle) and four regeneration microplots (small circles at cardinal directions, based upon the MA style CFI plot network. Our FIA-Style FHM plots (right) show the 4 subplots and four regeneration microplots within each, based upon the USFS FIA style plot network.

Results

From the 6,594 trees (≥5 inch DBH) measured across FEMC's 154-plot network, average live overstory tree density in 2021 was 183 stems per acre (SPA) and 123 ft^2/ac basal area. Regeneration assessments show sapling densities of 493 live SPA with balsam fir and American beech (*Fagus grandifolia*) representing the most abundant sapling species. Red maple was the most abundant seedling tallied in 2021 (24% composition, 5,709 SPA), followed by sugar maple (22%, 5,317 SPA), and balsam fir (12%, 2,794 SPA).

Damage related to beech bark disease (BBD) was the most common damage agent recorded, with 38% of the plots (58) impacted and approximately 73% of live American beech trees showing symptoms of the disease. Asian longhorned beetle, emerald ash borer, hemlock woolly adelgid, and sapsucker damage was observed on <1% of trees assessed.

While there are a wide range of stressors and vulnerabilities impacting Northeastern forests, data from the 2021 season suggest that the region's forests are overall diverse, vigorous, and healthy. We will monitor these threats as our program expands into New York in 2022 and continues to collect valuable forest health data year after year.

Figure 2. Original Vermont Monitoring Cooperative (VMC) Forest Health Monitoring plot network established between 1992 and 1997 on Mount Mansfield and within the Lye Brook Wilderness area.

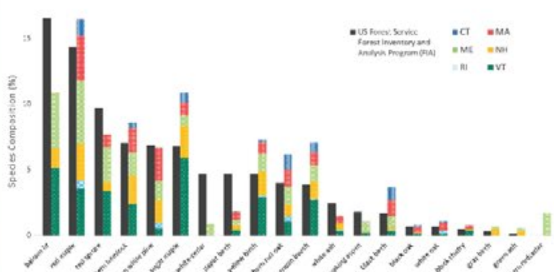

Figure 3. Percent live species composition for CT, MA, ME, NH, RI, and VT from the FEMC Forest Health Monitoring 2021 season alongside FIA estimates of live growing stock (≥5 inch DBH; USFS 2019).

Forest Health Monitoring Program Plots in 2021

Figure 4. One hundred and fifty-four (154) plot locations of the FEMC Forest Health Monitoring program in 2021. New York plots were established in 2022 and are not yet included in analyses.

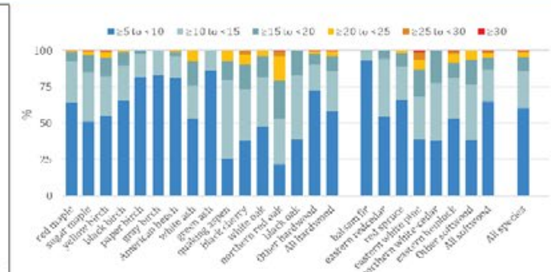

Figure 5. Size classes of live trees by diameter at breast height (DBH; inches) across the FEMC FHM plot network in 2021.

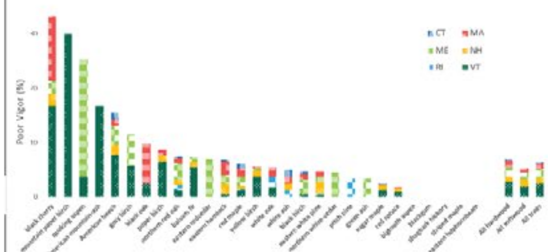

Figure 6. Percentage of trees with a 'poor vigor rating' sampled in 2021 across the six states in the FEMC FHM network. Percent poor vigor is the proportion of trees per species that were classified to be 'in decline' (vigor ratings of 3 or 4).

Songbirds in the Sugarwoods

Assessing Forest Structure and Bird Diversity in Vermont Sugarbushes

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ABSTRACT

Maple syrup production in Vermont has increased by 45% since 2012, with similar growth across the Northern Forest, a region that also provides some of the highest-quality breeding bird habitat in North America. Expansion of the maple industry may, therefore, have implications for forest and forest bird diversity since some sugarbush management practices favor maple at the expense of other tree species. To address this issue, Audubon Vermont, the Vermont Maple Sugar Maker's Association and Vermont Department of Forests, Parks, and Recreation formed the Bird-Friendly Maple Project in 2014 to promote sugarbush management practices that increase forest structural and species diversity, with an aim to improve forest health, bird habitat quality, and ecosystem service provisioning. However, there is a lack of research explicitly examining the effects of sugarbush management practices on forest birds. To address this gap, a team of researchers at the University of Vermont, Vermont Center for Ecostudies, and Audubon Vermont initiated a project to survey birds, arthropods (an important food source for breeding birds), and vegetation in sugarbushes across northern and central Vermont. Here, we present preliminary results from three years of data collection on forest structure and diversity and bird communities in 16 active sugarbushes. This works shows how bird communities in sugarbushes vary with vegetation structure and composition and arthropod biomass, and will provide guidance on updating BFM management recommendations. Future analysis will drive a better understanding of how sugaring operations and sugarbush management affects forest structure and diversity, illuminating potential compliments and tradeoffs with biodiversity goals.

METHODS

Bird Surveys

Point counts were established in a 200 m grid at each site. The number of points per site varied depending on the size and configuration of the forest stand. At each survey point, three 4-minute, fixed-radius (50 m) independent point counts (12-minutes total/point) were conducted during the month of June. Bird surveys began between 0430 and 0500 on days with suitable weather conditions (no rain, light winds), and ended by 0930.

Vegetation Surveys

Vegetation surveys occurred at bird point count locations. Data was collected on the following metrics using a modified James & Shugart (1970) approach:

Center plot:

- Overstory Trees & Snags
- Canopy Cover
- Large Sapling
- Small Saplings & Shrubs
- Litter Depth
- Ground Cover
- Regeneration (Woody spp)
- Downed Woody Material

Subplots:

- Overstory Trees & Snags
- Canopy Cover
- Herbaceous, woody vegetation, & DWD cover

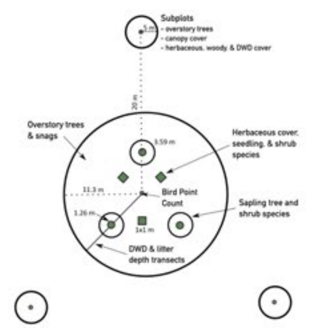
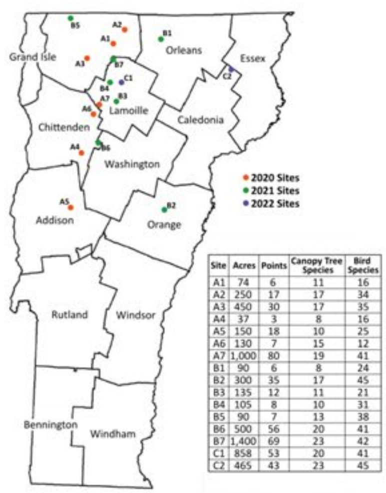


Figure 1. Layout of center sampling plot and subplots. The center plot was an 11.3 m radius plot (1/10th acre; 0.04 ha). The subplots were 5 m in radius located 20 m from the centroid of the center plot.



Site	Acres	Points	Canopy Tree Species	Bird Species
A1	74	6	11	16
A2	250	17	17	34
A3	450	30	17	35
A4	37	3	8	16
A5	150	18	10	25
A6	130	7	15	12
A7	1,000	80	19	41
B1	90	6	8	24
B2	300	35	17	45
B3	135	12	11	21
B4	105	8	10	31
B5	90	7	13	38
B6	500	56	20	41
B7	1,400	69	23	42
C1	858	53	20	41
C2	465	43	23	45

Figure 2. Map of study sites by year. The accompanying table shows acreage, the number of sample points, and the bird and canopy tree species richness of each site.

16 sugarbushes
37 canopy tree species
73 bird species

Check out the Bird-Friendly Maple guidelines

RESULTS

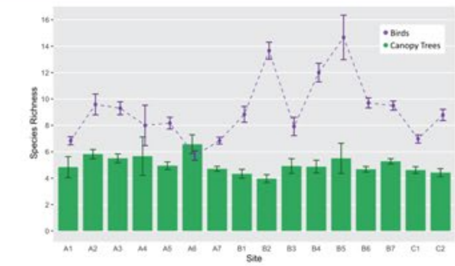
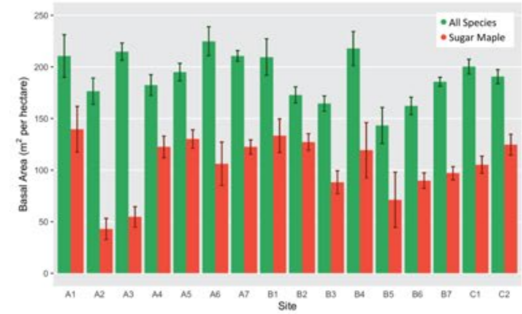


Figure 3. Mean species richness and standard error of birds and canopy trees by site.

A total of 73 bird species and 37 overstory tree species (with 2 additional overstory tree species documented as snags) were observed in 16 sugarbushes. Initial data show little variation in species richness of canopy trees between sugarbushes, but more substantial variation in bird species richness. The majority of sugarbushes had at least 50% basal area in sugar maple, with the lowest being 24.4% and the highest at 73.6%. That puts all sugarbushes surveyed within the Bird-Friendly Maple guideline of a maximum of 75% sugar maple by basal area.



Site	% Basal Area Sugar Maple
A1	66.2
A2	24.4
A3	25.4
A4	67.1
A5	66.7
A6	47.2
A7	58.1
B1	63.6
B2	73.6
B3	53.7
B4	54.7
B5	49.8
B6	55.4
B7	52.3
C1	52.5
C2	65.4

Figure 4. Mean basal area and standard error of all tree species and of sugar maple by site. The accompanying table indicates the average percent basal area of sugar maple by site.

NEXT STEPS

- Collect data on sugarbush management and operations metrics via sugarmaker survey
- Survey unmanaged reference sites for comparison with managed sugarbush stands

ACKNOWLEDGEMENTS

Immense thanks to the many field technicians who have collected data for this project and without whom this work would not have been possible. Thank you also to the sugarmakers who agreed to participate in this project. This project was supported by the McIntire-Stennis Cooperative Forestry Research Program through funding from the USDA National Institute of Food and Agriculture, the Northeastern States Research Cooperative through funding made available by the USDA Forest Service, the Blake-Nuttall Fund, the Lintilhac Founcation. The conclusions and opinions in this paper are those of the authors and not of the NSRC, the Forest Service, or the USDA.

TWENTY YEARS INTO A 150-YEAR SOIL MONITORING STUDY, SIGNIFICANT RESULTS!

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Introduction

- Ongoing monitoring of soils is essential for detecting, predicting and addressing environmental change.
- We have established a long-term soil monitoring study on 'unmanaged' forested sites in Vermont.
- Five 50 x 50 m plots are located in protected areas, three on Mt. Mansfield and two in the Lye Brook Wilderness Area (Fig. 1, Table 1).
- We have been monitoring carbon, nitrogen, exchangeable cations, and mercury (Hg).

Methods

- Each plot contains 100 5 x 5 m subplots with sampling dates assigned randomly (10 subplots are sampled on each date). See plot plan below (Fig. 2).
- Small pits are dug in the center of each subplot and the soils described and sampled by horizon. Typical soil profiles are shown in Fig. 3.
- Large samples are also taken of the Oi/Oe, the Oa and/or A, the top 10 cm of the B, and 60-70 cm depth (usually a C). Separate samples for Hg were taken from a fresh pit face from the Oa or A horizon.

Results

- Plots have been sampled five times, every five years beginning in 2002. Data from the 2022 sampling are not yet available.
- Carbon concentration in the Oa/A horizon (Fig. 4a) has had a wide range among sites. Carbon in the upper B horizon (Fig. 4b) has been less variable among sites.
- Except for the Mansfield Ranch site, exchangeable Ca in the B horizon (Fig. 4c) has been low while exchangeable Al (Fig. 4d) has been high.
- **Significant increases ($p < 0.05$) were found in Oa/A carbon at both Lye Road and Mansfield Underhill. The latter site also had significant increases in upper B horizon carbon concentrations and both exchangeable Ca and Al (Fig. 5).**
- Average total mercury (THg) concentration in the Oa or A horizon at each site has ranged from 144-505 µg/kg (Fig. 6), with no temporal trends yet detected. An interesting pattern appeared in the 2017 results in that samples with carbon higher than 30% (300 g/kg) had decreasing concentrations of THg (Fig. 7).

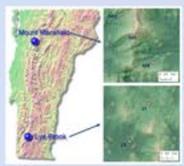

Figure 1. Location of monitoring plots.

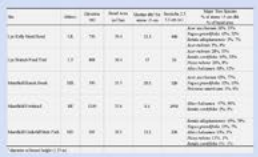

Table 1. Site characteristics

Figure 2. Example of a plot plan.

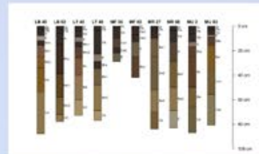

Figure 3. Typical soil profiles at each site

Carbon, exchangeable calcium and exchangeable aluminum results

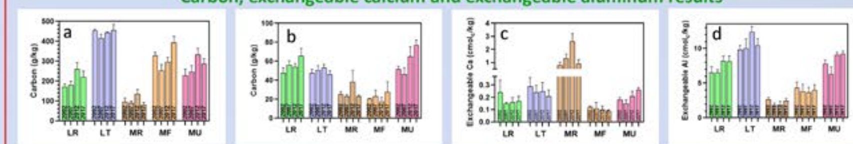

Figure 4. (a) Carbon concentration in the Oa/A horizon by site and year. (b) Carbon in the B horizon. (c) Exch. Ca in the B horz. (d) Exch. Al in the B horz.

Significant temporal trends in carbon and cations

2.4% annual increase in carbon in the Oa/A horizon ($p = 0.047$)

3.7% annual increase in carbon in the B horizon ($p = 0.006$)

3.3% annual increase in exch. Ca in the B horizon ($p = 0.033$)

1.5% annual increase in exch. Al in the B horizon ($p = 0.017$)

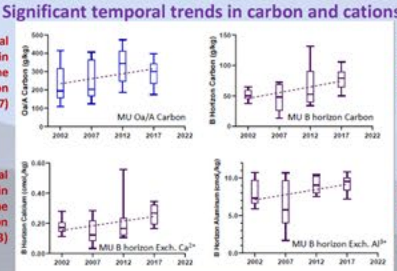

Figure 5. Significant temporal trends at the Mansfield Underhill sites.

Results have been published!

...in the Journal of Environmental Analysis and Assessment (2021) 193:776

Data and methods are also published and available on the FEMC website.

Mercury results

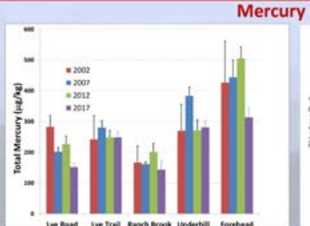

Figure 6. Total mercury in the Oa or A horizon by site and year

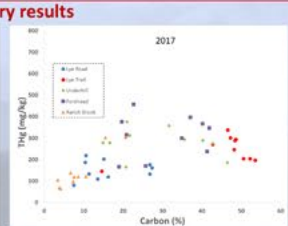

Figure 7. Total mercury trends from the 2017 sampling. Note the increase and then decrease in THg with increasing soil carbon.

Going Forward

Monitoring will continue on a five-year cycle to provide a time-series of data capable of detecting change. Samples are being archived to allow reanalysis over time. Current plans are to sample for 130 more years.

We need the next generation of soil scientists to join the project. Please contact us if interested. dross@uvm.edu

Vegetation monitoring

A suite of vegetation measurements are also performed every five years. There were nonsignificant trends for species composition at Mansfield Underhill, with decreasing *A. balsamea* and increasing *P. rubens*; and at Lye Trail, with decreasing *B. cordifolia.*

Above: Images from the 2022 sampling. Below: A suite of soil profiles from the five different sites.

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