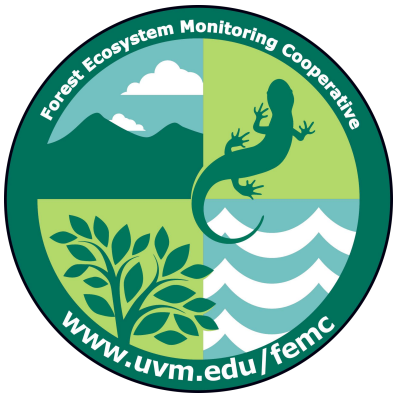

2021 FEMC ANNUAL CONFERENCE PROCEEDINGS

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, the Massachusetts Department of Conservation 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, the bulk of FEMC activities are accomplished by "in kind" contributions provided by the larger collaborative network.

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

VERMONT AGENCY OF NATURAL RESOURCES

The University of Vermont

USDA FOREST SERVICE

Proceedings of the December 16-17, 2021 Forest Ecosystem Monitoring Cooperative Annual Conference:

Facing Change: Reimagining Forested Communities in a Time of Disruption

Published March 15, 2022
From material presented at the FEMC Annual Conference
December 16 and 17, 2020
An Online Event
Burlington, VT, USA

Contributing Editors: Elissa Schuett, Naomi Cutler, James Duncan, Jennifer Pontius

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 Colin Beier, Jonathan Horton, Tim Howard, Anthea Lavallee, Amanda Mahaffey for their work on the Annual Conference Planning Committee, as well as Dr. Erika Svendsen and Dr. Julia Burton for their work in developing the plenary sessions; Dr. Nancy Mathews, Dean of the Rubenstein School of Environment and Natural Resources and FEMC Steering Committee Chair for moderating the morning plenary, and for providing financial support to graduate students; and our session moderators, Matthias Sirch, Alyx Belisle, and Naomi Cutler. We would also like to thank our invited speakers, workshop organizers, and paper 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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Executive Summary

The Forest Ecosystem Monitoring Cooperative held its 31st annual conference on December 16 and 17, 2021. The conference was held as a virtual event due to the ongoing coronavirus pandemic. The conference theme was "***Facing Change: Re-imagining forested communities in a time of disruption***." The conference explored a range of disturbances and disruptions, and 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, held as two half day sessions (Thursday afternoon and Friday morning) offered two plenary sessions, seven tracks for contributed talks, four working group sessions, and a poster session. Opportunities for networking were limited, but people were able to engage with the speakers by asking questions in Zoom (the online platform used for the conference). Nancy Mathews, the FEMC Steering Committee Chair opened the conference with introductory remarks. Each morning also had a plenary speaker, introduced by FEMC Director Jim Duncan. Dr. Erika Svendsen, a social scientist with the USDA Forest Service shared her work engaging communities to act as forest stewards, and asked the question of "how can we engage all of our capacities to cultivate new potential?" Her work has focused on engaging with communities in urban forests, identifying and connecting with "Green Responders," or those who respond to acute and chronic disturbances through greening and community building efforts. During the conference closing remarks, FEMC Principal Investigator, Dr. Jen Pontius asked "How can we as a cooperative, use these ideas and models to engage with our local communities others across the region to increase our ability to respond to change."

The second day of the conference opened with a plenary from Dr. Julia Burton, an associate professor from Michigan Technological University. Dr. Burton examines the how silvicultural management practices can be used to sustain functions and services in forests. She used her plenary to encourage the audience to not just consider species diversity or structural diversity in adaptive management strategies as a way to ensure ecosystem resilience.

With a second year of a virtual conference, connections and engagement continued to be limited. However, registration for the conference was 20% higher than in 2020 with more people attending from states outside of Vermont. The virtual platform (Zoom Events) was easy for people to move among concurrent talks, which many survey respondents appreciated. Survey responses also show continued support for a hybrid event in the future with options for both in-person and online attendance. The highlight for many people is regularly the contributed talks, but many people also enjoyed the working sessions that were offered this year. Conference planning will consider the best approach to engage with attendees from across the region.

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/2021

Facing Change: Reimagining forested communities in a time of disruption

A conference planning committee was formed to define the conference theme and recommend plenary speakers to invite. The committee included Anthea LaVallee (Hubbard Brook Research Foundation), Tim Howard (New York Natural Heritage Program), Jonathan Horton (New Hampshire Department of Natural and Cultural Resources), Amanda Mahaffey (Forest Stewards Guild), Colin Beier (SUNY ESF), as well as several FEMC staff: Elissa Schuett (Community Engagement Specialist), Jim Duncan (Director), John Truong (Monitoring Coordinator), and Jen Pontius (Principal Investigator).

Several sessions were held to discuss the conference theme, using guidance from the 2020 post-conference survey to identify the general theme of disturbance as a topic. Members were interested in the opportunity to consider how forested ecosystems and communities are being impacted by changing conditions as a result of various factors, including climate change, ongoing impacts of the coronavirus pandemic, and other disturbances. The selected theme was ***"Facing Change: Reimagining forested communities in a time of disruption."***

The plenary discussion was developed to learn how forest systems are impacted by disturbance and how people are responding to the change. The plenary speakers were invited to share their perspectives and research about disturbance and change. The planning committee was excited to identify Dr. Erika Svendsen as someone who could contribute to the discussion about social change, while Dr. Julia Burton provided the practical, silviculture and forest management scope of topic. Speakers who presented their research and monitoring findings during the contributed talks sessions shared a breadth of information to 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.

Green Responders: Examining the role of environmental groups during times of acute and chronic disturbance

Dr. Erika Svendsen
Erika Svendsen is a social scientist with the USDA Forest Service. Erika is a leader in the field of environmental stewardship as it relates to governance, civic engagement, and urban forestry. Erika is also co-director of the NY Urban Field Station, a research-practice partnership committed to the co-production of knowledge and fostering collaboration among natural resource professionals. In recent years, Erika has focused her work on understanding the role of 'green responders,' or those who respond to acute and chronic disturbance through greening and community building efforts. She is a co-founder of STEW-MAP, a research project and sustainability to to visualize, amplify, and support the work of thousands of civic groups as they care for their local environment. Erika received her doctorate in Urban Planning from Columbia University, a M.S. from Yale School of Forestry and Environmental Studies, and a B.A. in Political Science from Allegheny College.

The effects of disturbance - such as extreme weather, fire, pests and pathogens, or drought - impact not just local ecosystems, but also the surrounding human communities. Some disturbances are acute – such as a hurricane or wildfire. Some disturbances are chronic – such as coastal flooding caused by sea level rise. These types of disturbance are often entangled, but both result in stress to ecosystems and human communities. Government resources through programs such as FEMA are often only focused on responding to acute disturbances, leaving a gap in response for many of the chronic disturbances. Dr. Svendsen explores the responses by human communities to disturbances – both environmental, as well as economic crises and the coronavirus pandemic - and how people come together to respond and restore disturbed environments.

Dr. Svendsen shared her work with Green Responders, stewardship groups who care for the environment and respond to disturbances. Green Responders take a variety of actions to improve their environment, such as tree plantings and community gardens. These actions not only improve the environment, but also build social trust in the community. Two examples were each focused on efforts in New York City, one following the attacks of September 11, 2001 and another during the 1970's fiscal crisis. Groups came together during each of these events – which were different types of disturbance – responding to the disturbance through beautification and community connection.

The responses by environmental groups to disturbances caused by Superstorm Sandy and "sunny day flooding" have similarities and differences to the responses to the social disturbance caused by 9/11. The acute disturbances often have government support and immediate response. Following the immediate aftermath of an event or with chronic disturbance, it is important that local groups are engaged and able to adapt to the changing needs. The local engagement not only provides response to the disturbance need, but also builds social trust with the community. Local knowledge provides environmental stewards with the connection to needs of the community, allowing them to pivot and respond quickly. The Black Lives Matter movement following events in 2020 became a unifying cause, with groups recognizing inequities in funding, access to nature, and environmental justice as important to the work of green responders. Environmental groups partnered with social service groups, spanning differences, to identify shared needs and resources. This sharing and connection did not occur at all places in the study, but was recognized as something that can develop.

This connection of community groups as part of a larger network is important to understand how larger-scale or regional disturbances impact ecosystems or communities. To understand community networks and connectivity, Dr. Svendsen developed STEW-MAP, or the Stewardship Mapping and Assessment Project (Figure 1). This project helps plan for the unplanned by bringing together green responders with forest resource managers.

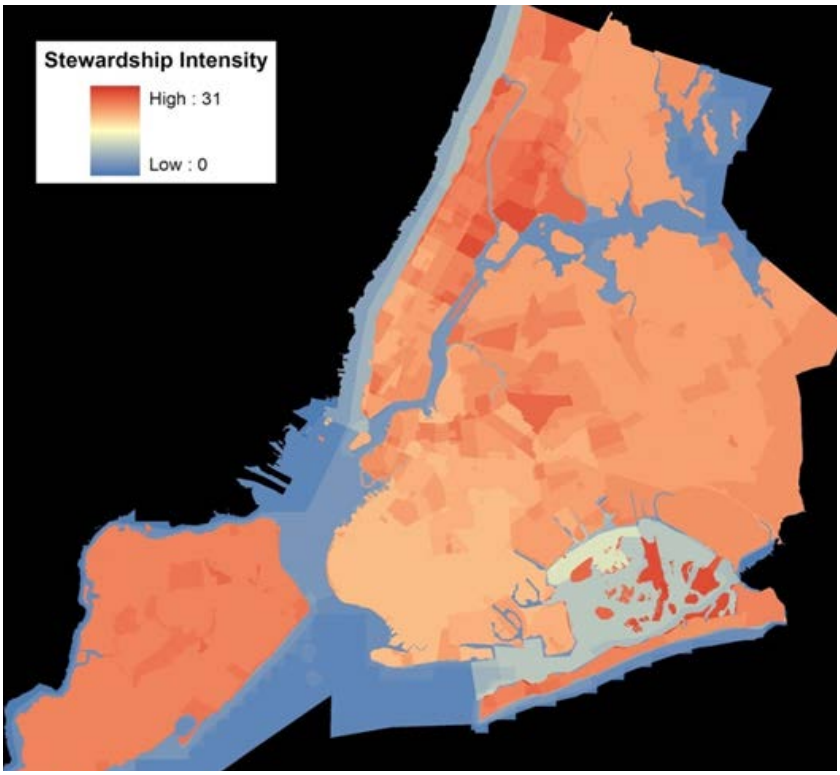


Figure 1 Stewardship intensity in New York City. Map from STEW-MAP project

As Dr. Svendsen stated, "Stewardship is powerful, a means to strengthen communities, empowerment, recover from disturbance." STEW-MAP makes these connections and the stewardship occurring more visual, mapping how we care for our natural resources. The project uses surveys to measure how, where, and why civic groups care for their environment. With this data, maps and networks are developed for natural resource managers to understand what groups are doing and where. This also helps identify the capacity of groups, and find gaps in stewardship. STEW-MAP also highlights and recognizes that people are behind the work in responding to disturbances.

The FEMC as a collaborative acts as a connector and convener, to share information and resources for groups to respond to disturbances and build a network of forestry professionals, researchers, and stewards across the northeastern U.S. forest ecosystems.

Forest ecosystem change through the lens of plant functional traits: measurement, management and monitoring

Dr. Julia Burton

Dr. Julia Burton will also join us as a plenary session speaker. Julia is an Associate Professor, Michigan Technological University, and holds an appointment as an Adjunct Associate Professor at SUNY College of Environmental Science and Forestry (ESF). Julia's research examines the role of silviculture in sustaining a broad range of values, functions and services in forests such as carbon sequestration, wildlife habitat, biodiversity and cultural values, as well as timber production. Her group develops robust experimental and analytical frameworks to determine whether and how silvicultural management can be used to sustain these values in the face of changes in climate and disturbance regimes.

Climate change has major impacts on plant communities and forests. Changes in climate can influence forest composition, density, and structure, as well as valuable ecosystem services such as carbon sequestration, wildlife habitat, biodiversity, cultural values, and timber production. Dr. Julia Burton focuses her research on how plant functional traits can inform our understanding of forest community response to climate change and the associated effects on ecosystem functions and services.

Dr. Burton defined plant functional traits as characteristics of plants that are related to the performance of the plant. For example, leaf traits can have a major impact on how a plant performs and how adaptable that plant may be to disturbance (Figure 2). Other traits that could impact adaptability are wood and root characteristics. These traits can be quantified as a community weighted mean trait by multiplying the abundance of the species with their average trait value. These trends can then be used across a variety of forest compositions, allowing researchers to standardize interactions between climate disturbance and forests across systems.

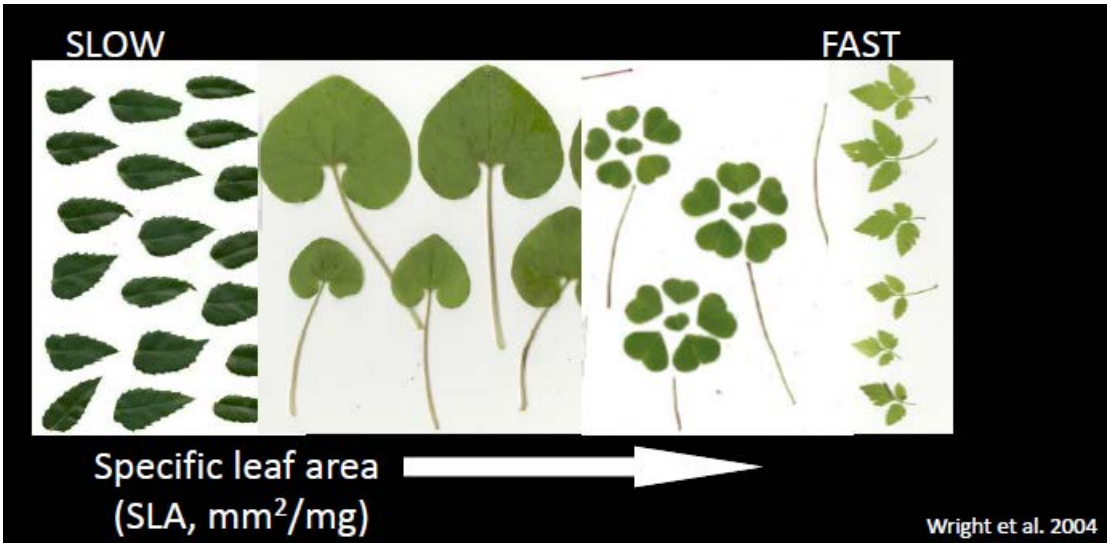


Figure 2 The worldwide leaf economic spectrum

Dr. Burton's talk provided a valuable dive into how we can use these models to manage forests for specific ecosystem services such as pollination services and indigenous cultural ecosystem services. Conventional silvicultural focuses on maintaining fully stocked stands by simplifying stand composition and structure, which also maintains high rates of carbon storage and productivity but reduces options for future adaptability. Additionally, in the Northeast and Great Lakes region, forests tend to struggle to regenerate because of high deer populations and beech bark disease. To respond to these issues, Dr. Burton's work focuses on building adaptive capacity in forests by managing for a more diverse range of ecosystem characteristics. This restoration and rehabilitation approach may store less carbon in the beginning, but overtime these adaptive capacities would store more carbon than taking no action (Figure 3).

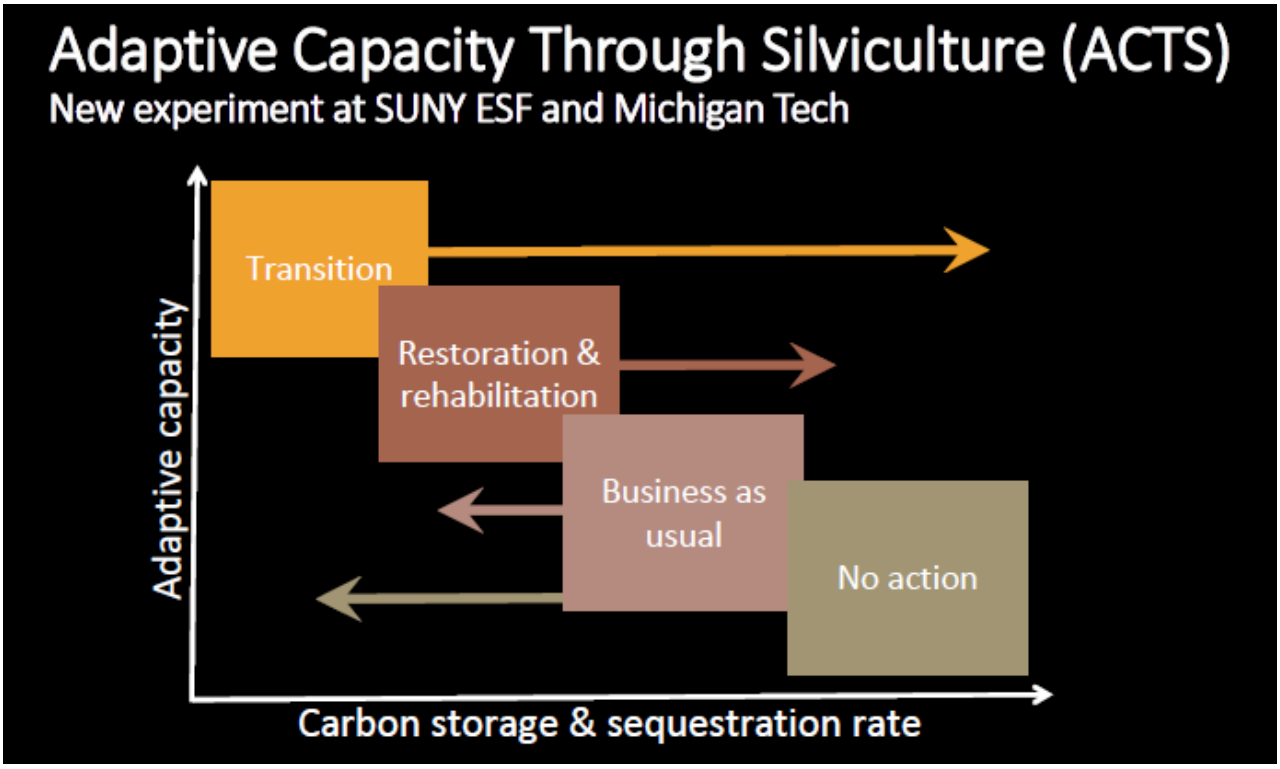


Figure 3 Carbon storage capacity for various silvicultural adaptations

Engagement is at the core of Dr. Burton's work. Her group has set up sites in New York and Northern Michigan to experiment with adaptive management techniques. These sites are an opportunity to look at the interactions between silvicultural management and climate, as well as an opportunity to engage land trust professionals, forest professionals, and students in this work as it continues to develop.

Forest Disturbance

Dragonfly Larvae as Mercury Biosentinels: From National Parks to National Forests

Kate Buckman[1], Sarah Nelson[2], Ralph Perron[3], Celia Chen[1]

[1]Dartmouth College, [2]Appalachian Mountain Club, [3]USDA Forest Service

Mercury (Hg) pollution is a persistent threat to global environmental health. In northern New England, atmospheric inputs of Hg from long-range transport and legacy point-source pollution can affect rural and developed areas alike, leading to bioaccumulation of Hg in aquatic food webs across the region. The forested landscapes in New England are known to enhance methlymercury bioavailability to food webs, making many forested ecosystems susceptible to Hg pollution.

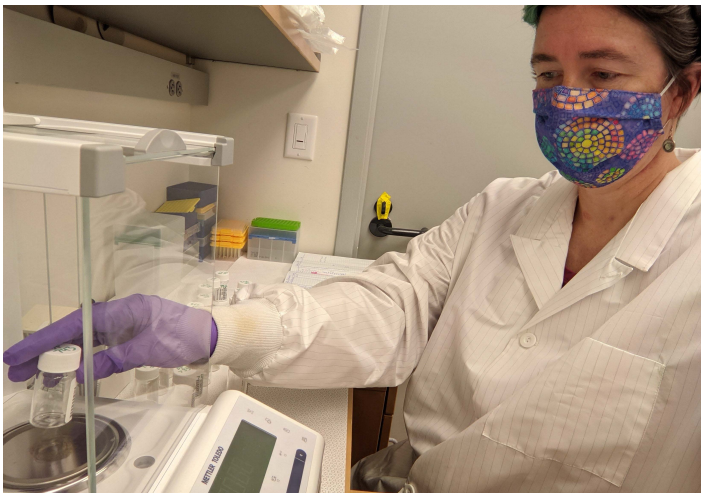


Figure 4 Larvae Samples collected for the study

The Dragonfly Mercury Project (DMP) is a nationwide study led by the National Park Service (NPS) and U.S. Geological Survey (USGS), in collaboration with Dartmouth College and the Appalachian Mountain Club. It has established a surveillance network for Hg in protected lands across the US by engaging community volunteers in the collection of dragonfly larvae as Hg biosentinels. The data generated through the DMP allowed for the creation of an integrated impairment index that informs wildlife and human health Hg risk based on dragonfly larvae Hg concentrations.

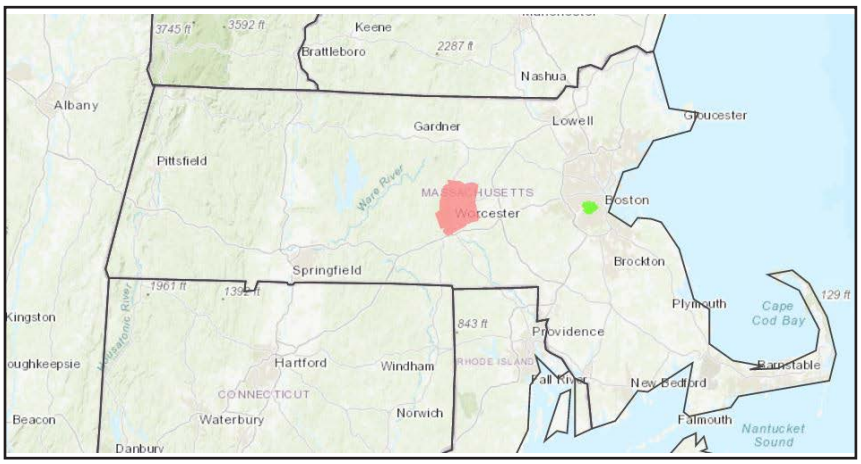
However, NH and VT locations are not well represented within the past DMP data, due to the scarcity of national park lands in these states. Sampling in National Forests provides an opportunity to expand across a larger land base targeting under-sampled areas. This includes incorporating managed lands, such as National Forests, to help identify the potential influences of land management practices on mercury accumulation and transport. Beginning in 2020, we piloted DMP sample collection in National Forests at four ponds in the White Mountain National Forest. Preliminary results from these ponds (mean~125-150 ppm, dry weight of Hg) indicate that dragonfly larvae pose moderate risk to upper-level predators, similar to most results for other national parks in the Northeast region. USDA and FEMC funding has allowed us to expand our community involved Hg biomonitoring efforts into additional new sites in the White and Green Mountain National Forests in 2021. Preliminary data from these recent sampling efforts and past data from the DMP will be presented and discussed.

Updates On Federal Pest Deregulation And Status Of Pests Of Regional Concern

Judy Rosovsky[1],

[1]VT Agency of Agriculture, Food, and Markets

The US Department of Agriculture Animal Plant Health Inspection Service Plant Protection and Quarantine has deregulated or has taken steps to deregulate several pests from their Plant Pests and Diseases Program, including the emerald ash borer, chrysanthemum white rust, the light brown apple moth and the velvet longhorned beetle. The possible effects of these changes will be discussed and a brief mention will be made about which communities are able to participate in decision making about these regulations. Updates on recent pests of regional concern will be provided, especially on the spotted lanternfly, whose range continues to expand. Other pests of concern and their potential for forest disruption include beech leaf disease, the box tree moth, the brown-tailed moth, oak wilt, a few of the recent Exotic Wood Boring Bark Beetle trap finds and the Asian Giant Hornet.



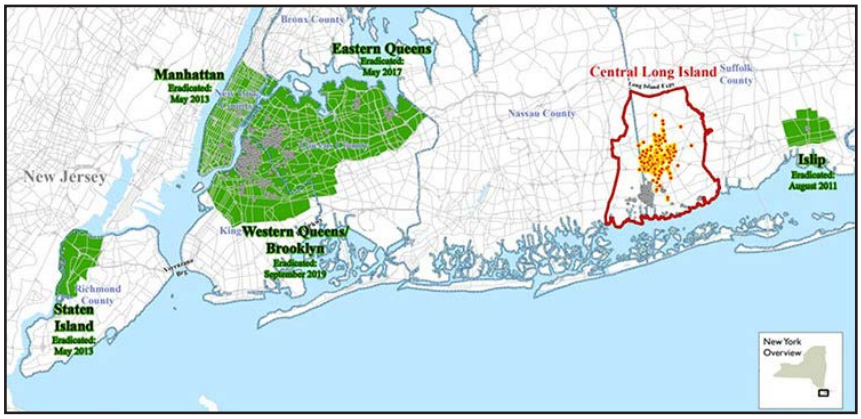


Figure 5 Asian Longhorn Beetle quarantine areas in the region

Multiyear Defoliations In Southern New England Increases Oak Mortality

Jeffrey Ward[1], Chad Jones[2], Joseph Barsky[1]

[1]Connecticut Agricultural Experiment Station, [2]Connecticut College

Since its escape in eastern Massachusetts in the 1860s, Lymantria dispar dispar L. (L. dispar; formerly gypsy moth) has spread to nineteen US states and five Canadian provinces After decades of multiyear defoliation episodes in southern New England, Lymantria dispar dispar populations diminished with the appearance of the L. dispar fungus in 1989. Multiyear defoliations did not occur again until 2015-2018. To assess the impact of the return of multiyear defoliations, we examined 3095 oaks on 29 permanent study areas in Connecticut and Rhode Island that were established at least eleven years before the latest outbreaks. This allowed us to compare mortality rates before and after the latest multi-year defoliation episode at both the stand and individual tree level. Pre-defoliation stand level oak mortality averaged 2% (three-year basis) and was higher on stands with higher oak density. Unsurprisingly, post-defoliation stand mortality was much higher in severely defoliated stands (36%) than in stands with moderate (7%) or low-no defoliation (1%), but did not differ between managed and unmanaged stands. Pre-defoliation mortality of individual trees differed among species, was lower for larger diameter trees and on unmanaged than managed stands. Pre-defoliation mortality over 12-19 years of northern red oak (5%) differed from white oak (9%) and black oak (12%) which differed from chestnut oak (17%). We found that post-defoliation mortality differed by defoliation severity, differed among species, and often but not consistently, varied with stand oak basal area. Consistent with previous studies, high levels of defoliation across multiple years (severe defoliation) greatly increased mortality; however individual tree mortality on stands with no to moderate defoliation was similar to pre-defoliation mortality levels. This study confirmed that mortality patterns are species specific, as northern red oak had lower post-defoliation mortality than white and black oak across all defoliation levels. However, comparison with other studies demonstrates that species susceptibility to L. dispar mortality can vary across time and space, so managers cannot assume that the species with the highest mortality in previous events will have the highest mortality in future defoliations. Effects of stand oak basal area and density, tree diameter, and management were much less consistent, suggesting the importance of site specific factors. Despite some indication of higher mortality in managed sites, forgoing management to reduce potential mortality is not recommended due to the difficulty in predicting outbreaks, potential loss of income, and the increased risk of hazard trees following severe defoliation in unmanaged stands. Natural resource managers should not assume that oaks that survived earlier multiyear defoliations episodes will survive future multiyear outbreaks, possibly because trees are older.

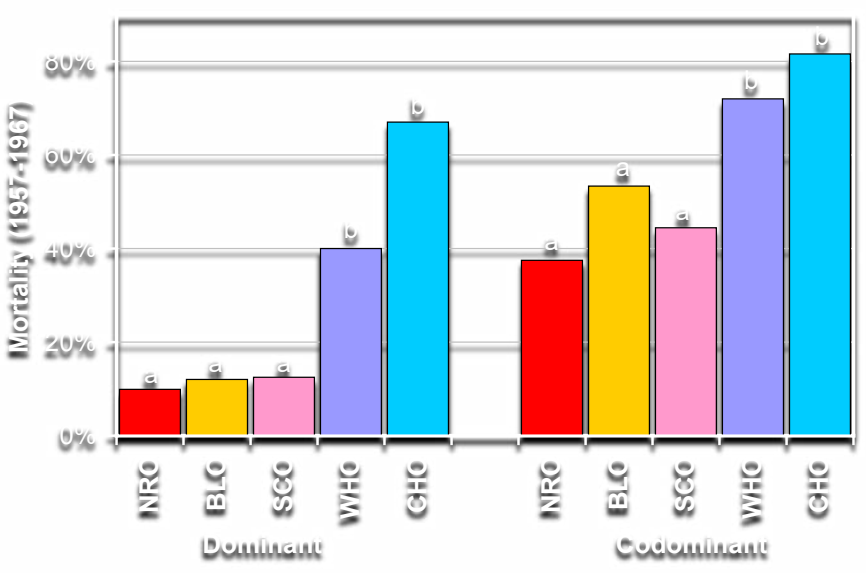


Figure 6 Oak Mortality in Red and White Oak

Monitoring Trends In The Severity, Extent, And Frequency Of Key Disturbance Regimes In Northeastern Forests

James Duncan[1]

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

Shifts in disturbance patterns across the Northeast are of increasing concern as the climate continues to change. In particular, changes in patterns of frequency, severity and extent of disturbance event may have detrimental cascading impacts on forest ecosystems and human communities. To explore how changing disturbance regimes might impact future forest health and management it is necessary to understand the historical trends and impacts of disturbance in the region. Although individual types of disturbance have already been analyzed, there is a need for a consolidated overview of the current state of disturbance in northeastern forests in a format that enables easy update, exploration and ongoing monitoring. To meet this need, FEMC developed a project titled "Tracking Shifts in Disturbance Regimes." Through this effort, FEMC gathered foundational datasets on key disturbance drivers and analyzed them for changes over time in extent, severity and frequency. In addition, we compiled a curated list of ongoing studies and projects that can be used to monitor disturbance regimes over time. These results are shared through an online tool that allows users to explore trends, find data and look for shifts in causes of and responses to disturbance regimes across northeastern forests. We will provide an overview of how to use the tool, discuss the types of data available. In addition, we will present the results of the trend analyses of key datasets looking at the extent, severity and frequency of disturbance by native and non-native insects and diseases, flooding, high wind, drought, and fire, including both regional and state-specific patterns.

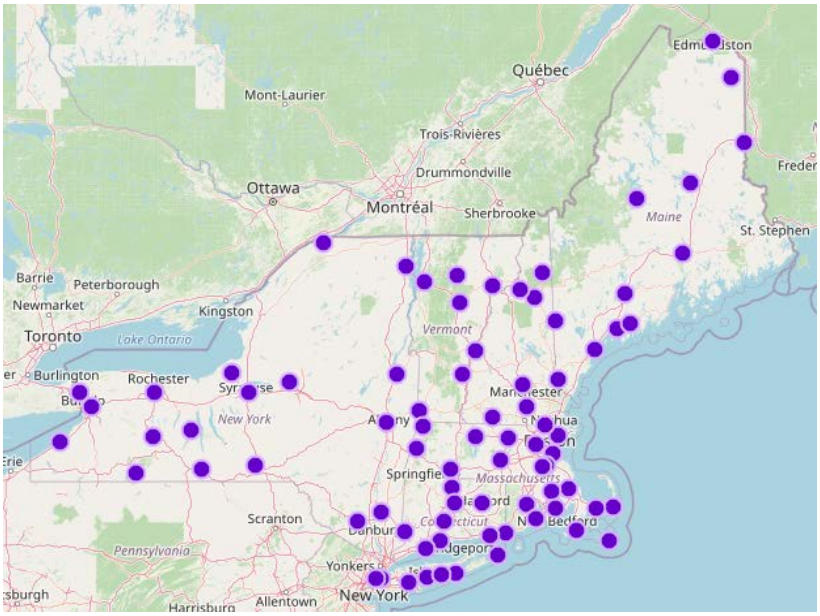


Figure 7 High Winds events in the region

Climate Change Adaptation Among Urban And Rural Foresters In The Northeastern Us: An Assessment Of Motivations, Practices, And Barriers

Tessa McGann[1], Rachel Schattman[2], Anthony D'Amato[1], Todd Ontl[3,]

[1]University of Vermont, [2]University of Maine, Northern Institute of Applied Climate Science

Presently, forests across the globe are facing change at a rate and scale not previously experienced. Due to the timing, severity, and compounding nature of stressors related to climate change and shifting socioeconomic demands, stakeholders around the world fear the disruption of the fundamental function and form of their forests and greater socio-ecological systems. Accordingly, urban and rural foresters are called to adapt their management to changing and uncertain conditions. However, studies of foresters across North America and the globe have documented significant gaps between the recommendation and implementation of adaptive management, with varying explanations. Despite previous research conducted in the northeastern United States, questions remain regarding the current nature, extent, and drivers of adaptation, particularly among urban foresters across the region. The research presented here is based on qualitative analysis of 32 in-depth semi-structured interviews with urban and rural foresters (n = 15 and n = 17, respectively) across New England and New York. According to the perspectives of those charged with choosing and implementing adaptive management, we present a summary of the i) important environmental drivers of adaptation; ii) commonly employed adaptive strategies; iii) significant barriers to adaptation; and iv) discussed approaches to working through named barriers. The goal is to provide stakeholders with a snapshot of the current state of adaptive management of forested systems across the region, both urban and rural, with a focus on opportunities for greater learning and support.

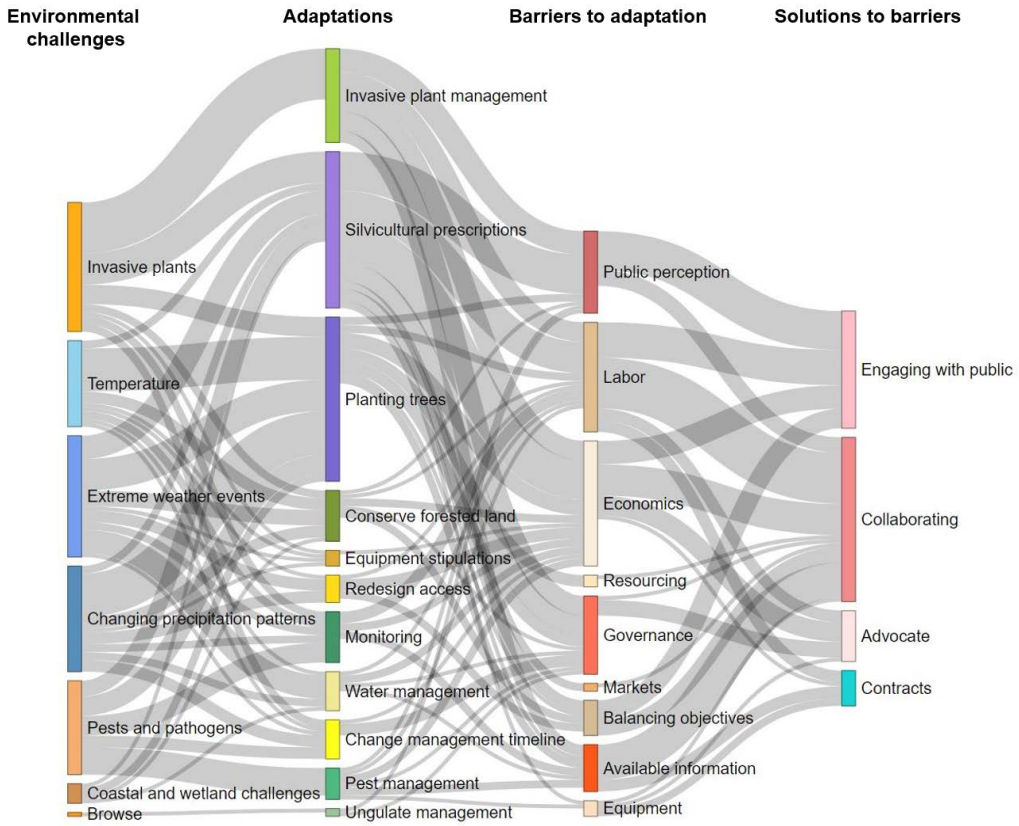


Figure 8 Adaptive Management Motivations in Urban Foresters

Forest on the Move: Tracking Climate Related Changes of Treelines in Montane Systems of the Northeast

Jordon Tourville[1], David Publicover[2], Sarah Nelson[2]

[1]SUNY-ESF, [2]AMC

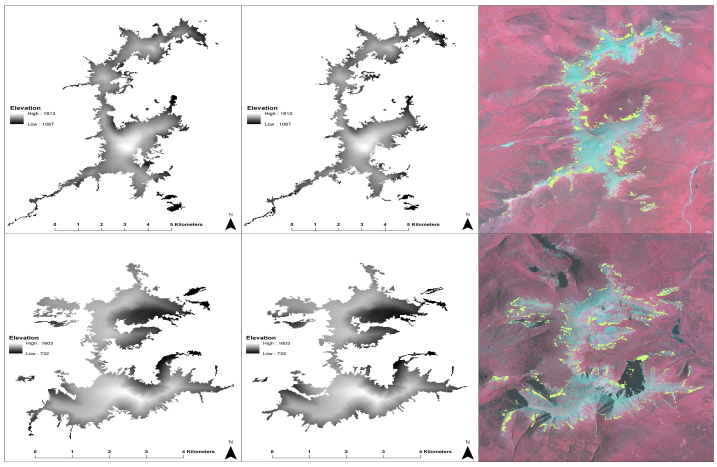


Figure 9 High Alpine Treeline Changes in NH

High elevation forests and mountain alpine zones are integral parts of the cultural heritage and physical landscape of the northeastern US. These areas harbor rare species, provide important ecological services, and are known nationally for their contribution to conservation and recreation. The upper elevation treeline, the elevation at which trees can no longer sustain a tall upright form due to harsh climatic conditions, has often been used as a barometer for the impact of climate change. As the climate warms, we hypothesize that treelines will noticeably advance upslope at the expense of often unique and diverse alpine ecosystems of mountain summits, with the rate of advance potentially indicating ecosystem sensitivity to changing climate. We used current and historical high resolution aerial imagery from the Presidential Range of New Hampshire and Mount Katahdin in Maine to quantify the regional advance of treelines over the past several decades. Physical copies of historical imagery were digitized and georeferenced (1978 from New Hampshire and 1991 from Maine). NAIP imagery from 2018 as well as state produced DEM's were downloaded and superimposed onto historical imagery. Treeline location, as determined by dramatic decreases in tree height and density, from each set of images were manually classified using ArcGIS 10.8. This approach was coupled with ground surveys of forest vegetation and topological features to ground-truth manual treeline classification based on tree height and density, and to provide information on additional possible drivers of treeline location. Differences in altitude and direction of treeline shifts between historical and current imagery were calculated from rasterized versions of our manual treeline classification. On average, on both the Presidential Range and Katahdin, treeline positions have significantly shifted upslope over the past several decades. This was seen largely as an increase in diffuse treeline form (i.e., an increase in area of isolated pockets of trees into the alpine zone). Topographical features, such as slope, aspect, and soil depth seemed to play a role in defining the upper limits to which treeline location could advance. At this point, while climate change cannot be directly implicated in these observed shifts in treeline, the direction of the shifts is consistent with our hypothesis that climate change is facilitating an upward movement of trees on mountain slopes. Taken together, these results contribute valuable knowledge to Appalachian Mountain Club's longstanding mountain research program and serve as a baseline to promote better management of regional mountain communities. Results from this work will also be foundational for researchers and land managers in prescribing potential climate adaptation strategies. Most importantly, the people who enjoy these irreplaceable areas will benefit from the improved conservation and understanding of our mountain peaks in a warming world.

The Effect of Harvesting on Lowland Northern White-Cedar Stand Structure and Composition

Katlyn Schulz[1], Jay Wason III[1], Laura Kenefic[2]

[1]University of Maine, [2]US Forest Service

It is important to understand the mechanisms limiting regeneration and recruitment of lowland northern white-cedar (Thuja occidentalis), one of the least-studied commercially valuable tree species in its region. Future climate is expected to change the environmental conditions of lowland cedar stands, which will likely impact the growth, survival, and competitive dynamics of cedar and its main competitor, balsam fir (Abies balsamea). This study aims to increase our understanding of how partial harvesting impacts the structure and composition of cedar stands, in support of efforts to create suitable conditions for cedar in managed stands within a context of climate change. Stand structure, composition, and relationships to abundance of cedar and fir regeneration were quantified using a network of permanent sample plots in eight lowland stands in central and eastern Maine; three of these were then harvested following an irregular shelterwood prescription and re-inventoried. Goals were to increase growth of residual trees, maintain structural complexity, and regenerate cedar. Preliminary results suggest that the range of conditions associated with successful regeneration of cedar is narrower than those associated with successful regeneration of fir. Harvesting appears to have impacts that are both favorable (e.g., increased downed deadwood) and unfavorable (e.g., greater canopy openness) for cedar regeneration relative to that of balsam fir over the long term. Findings suggest that continued work is needed to identify strategies for regeneration of cedar that will prove reliable in an uncertain climate future; continued monitoring is needed to confirm long-term results.

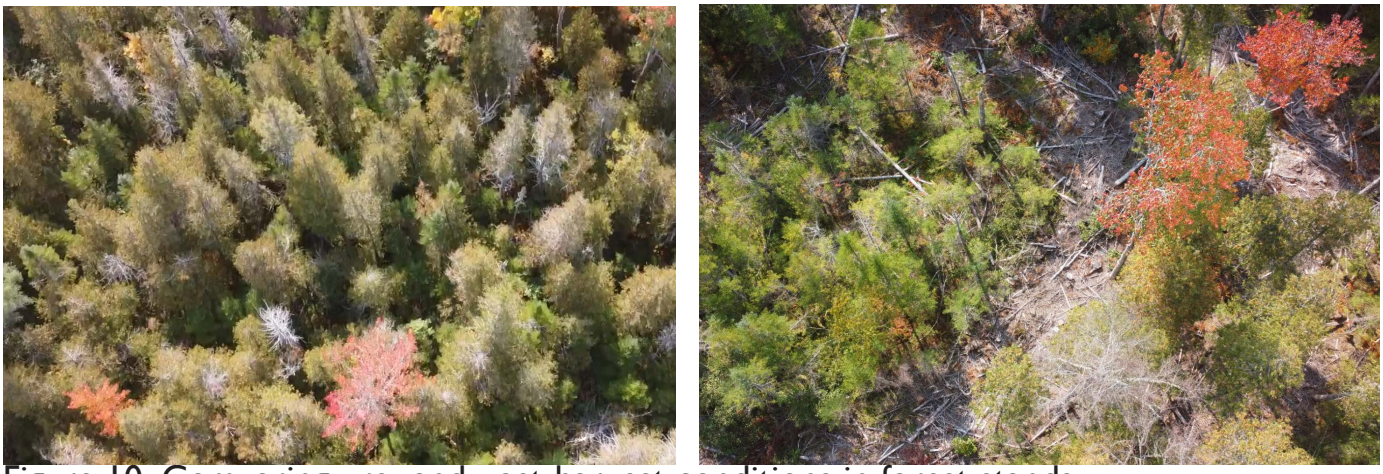


Figure 10 Comparing pre- and post-harvest conditions in forest stands.

Wildlife & Trail Recreation: Understanding, Managing, And Monitoring Recreation Effects

Meredith Naughton[1]

[1]UVM Field Naturalist Program

Trail recreation is growing in popularity as our society looks to the outdoors for wellness, camaraderie, and connection to the natural world. Vermont has seen this as particularly true because of the Covid-19 pandemic, which led more long-time residents and recent migrants to seek the enjoyment of our lands. However, trail recreation is not ecologically neutral and leads to disturbance of forests and wildlife. But how do we manage trails to minimize their disturbance, and what do we know about the effect trail recreation has on wildlife? This presentation describes graduate research on the synthesis of scientific knowledge about the effect of trail recreation on wildlife of the northeast. Wildlife response patterns were found across the literature, informing management recommendations for balancing wildlife protection and recreation opportunities. Despite the many challenges of this topic affecting land managers across the region, there is scientifically informed work that can be done to promote an ecologically functional landscape.

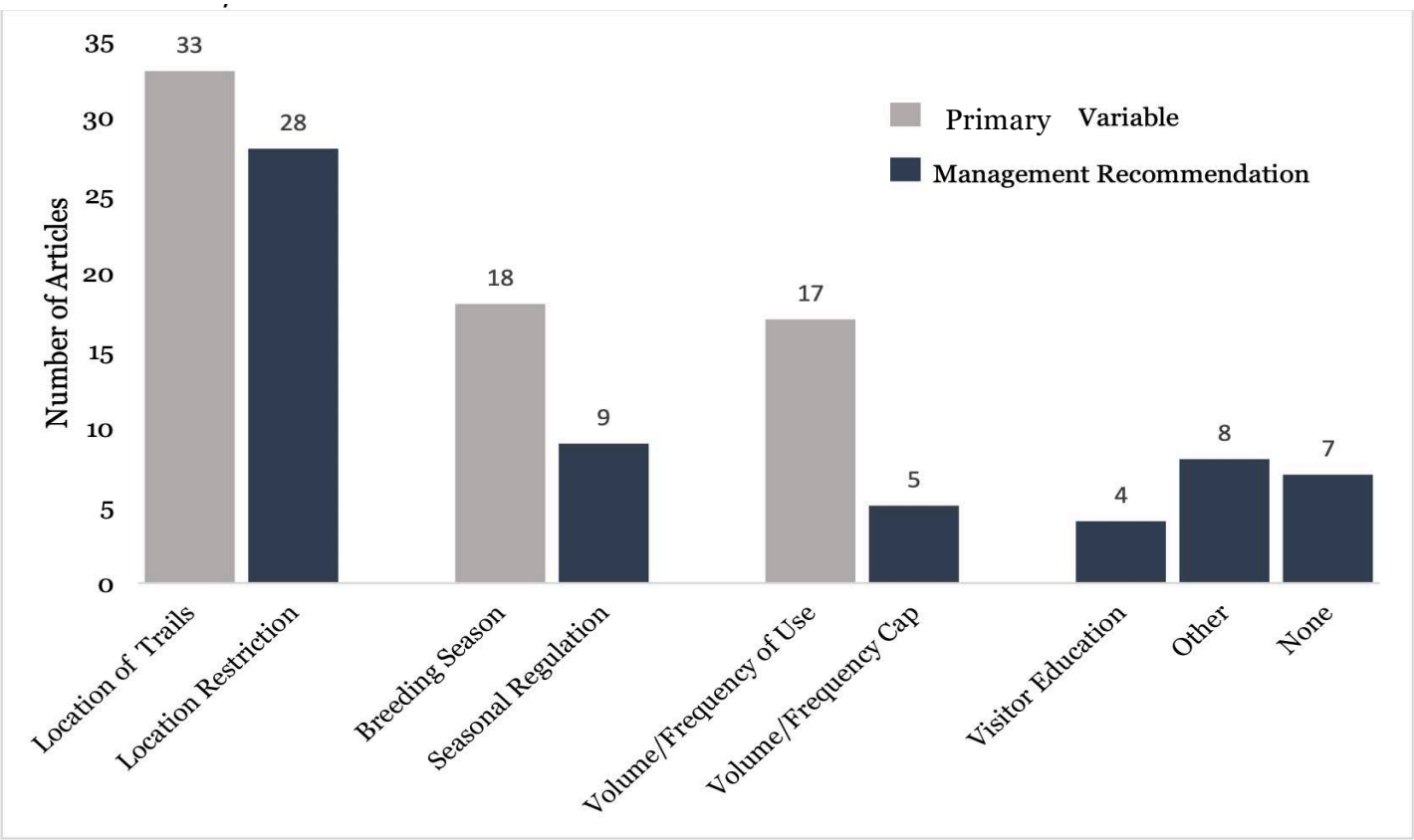


Figure 11 Summary of Studies on Trail and Wildlife Relationship Management Recommendations

Vermont's Resilient Right-of-Ways Project

Karl Honoken[1], Elise Schadler[2]

[1]USDA Forest Service, [2]VT Forest Parks and Recreation

The goal of this project was to develop a collaborative and integrated approach to advance green stormwater infrastructure (GSI) in roadside environments, targeted at communities in the Lake Champlain basin that have the greatest need to manage stormwater runoff from developed urban centers and rural back roads.

Figure 12 Green Street Design example in Shelburne, VT.

Cooperative Forest and Wildlife Habitat Management in Central Wisconsin

Joshua Benes[1], Hannah Butkiewicz[1]

[1]Golden Sands Resource Conservation and Development Council

Fragmentation can make it difficult to apply forest management techniques at a regional scale. Despite parcelization, a Wisconsin regional conservation nonprofit called Golden Sands RC&D has found innovative ways to catalyze regional forest management using the State of Wisconsin's Deer Management Assistance Program (DMAP). Golden Sands RC&D's program, Cooperating For Woods and Wildlife (CFWW), has the goal to assist private landowners with the creation of group cooperatives to collectively and collaboratively enhance forest health, restore wildlife habitat, and control invasive plants across property boundaries. Golden Sands RC&D has so far enrolled more than 125 landowners with more than 13,000 acres into these cooperatives. Working with these landowners and federal partners, Golden Sands RC&D has also restored more than 100 acres of wildlife habitat for the endangered Karner blue butterfly. This presentation will provide information about the State of Wisconsin's DMAP program, the history of Golden Sands RC&D's CFWW program, and how similar programs may be adopted in the northeast.

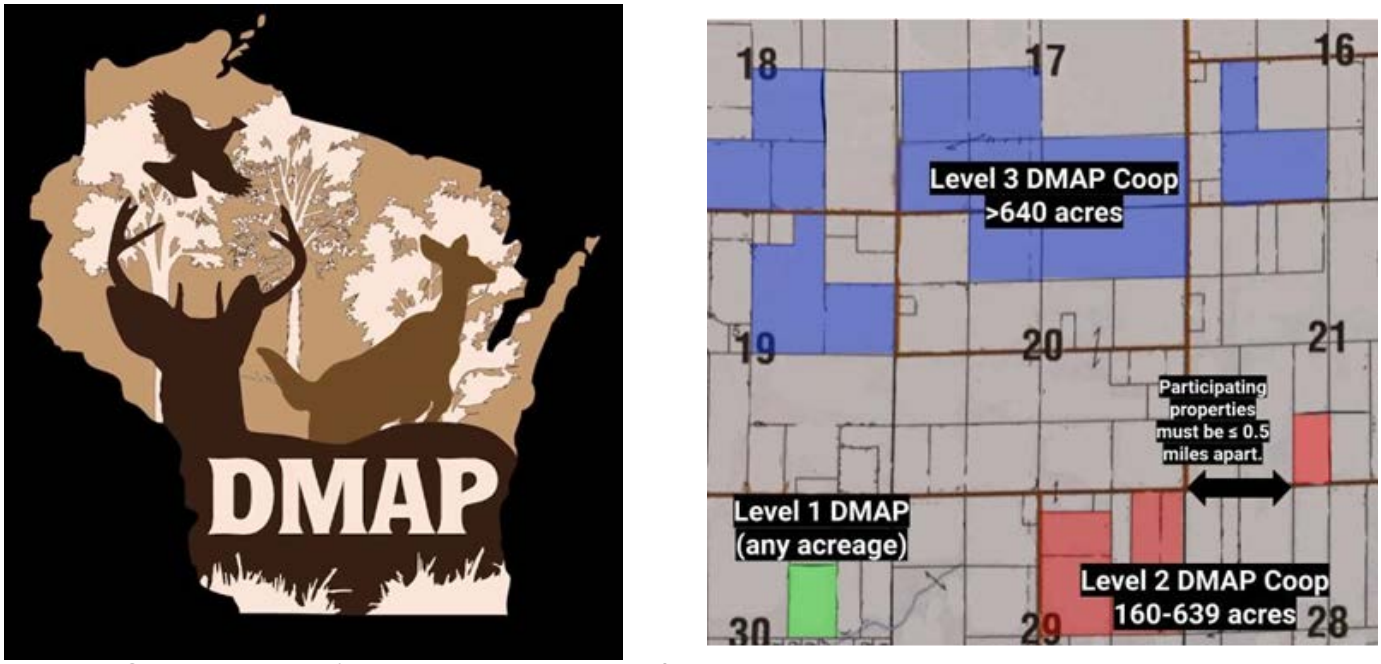


Figure 13 Wisconsin's Deer Management Assistance Program

Bob Popp[1]

[1]VT Dept of Fish & Wildlife

SCIENTIFIC NAME	COMMON NAME	STATE STATUS	GLOBAL STATUS	DISTRIBUTION	Forested
Adiantum viridimontanum	Green Mountain maidenhair-fern	T	G3	Endemic	
Agastache nepetoides	Yellow giant hyssop	T	G5	Peripheral NE	
Agastache scrophulariifolia	Purple giant hyssop	T	G4	Peripheral NE	
Allium canadense	Wild garlic	T	G5	Peripheral NE	Floodplain Forest
Ammophila breviligulata ssp. *champlainensis*	Champlain beach grass	E	G2G3Q	Endemic	
Anemone multifida	Early thimbleweed	E	G5	Peripheral South	
Anthoxanthum monticola	Alpine Sweet-grass	T	G5	Peripheral South	
Anticlea glauca	White Camas	E	G5T4	Peripheral East	
Aplectrum hyemale	Putty-root	T	G5	Peripheral NE	No. Hardwood Forest
Arabidopsis lyrata	Lyre-leaved Rock-cress	T	G5	Peripheral NE	Oak Pine Forest
Arethusa bulbosa	Arethusa	T	G4	Central Common to North	
Arisaema dracontium	Green dragon	T	G5	Peripheral NE	Floodplain Forest
Asclepias amplexicaulis	Blunt-leaved milkweed	T	G5	Peripheral NE	
Asclepias tuberosa	Butterfly-weed	T	G5?	Peripheral NE	
Asclepia verticillata	Whorled milkweed	E	G5	Periheral East	

Figure 14 State Endangered Species List

Climate Change is projected to shift plant hardiness zones both latitudinally and elevational. Winter chilling requirements may no longer be met for some plants or seeds, and extended growing seasons may allow more southern species to move northward and upslope. Changing conditions will likely favor more stress tolerant species and species with spores and/or small wind-blown seeds.

There are presently 160 listed (endangered or threatened) vascular plants in Vermont. Vermont is home to few endemics due to its recent glaciation, therefore most of our rare plants are on the periphery of their range and more abundant elsewhere. In fact, about 80% of Vermont's listed plants are on the periphery of their range here and are expected to be affected by climatic shifts. The distribution between plants on the northern periphery versus those on the southern periphery is close but slightly favors those on the northern periphery. A subset of listed species that are known to occur in forested settings, was also analyzed to infer their likely fate based upon climate change scenarios. The ramifications are that Vermont and most of New England will most likely be recipients rather than donors on new species in any potential future range shifts

Living on the edge in a warming world: distributions and thermal refugia of forest insects across the northeastern United States

Michael T. Hallworth[1], Jason Loomis[1], Nathaniel Sharp[1], Julia Pupko[1], Spencer Hardy[1], Ryan Rebozo[1], Kent McFarland[1]

[1]Vermont Center for Ecostudies

Insect populations across the planet are experiencing precipitous declines, are ubiquitous within food webs, and serve as bioindicators of ecosystem health. As such, understanding their response to climate change is drastically needed. We used 1,289,559 insect observations of 16,336 species from museum collections, field studies, and community scientists to better understand 1) how forest insects are distributed across New England and 2) help inform conservation efforts given forecasted climate change scenarios. This work couples species distribution models, remotely sensed data, and climate projection models to identify current & anticipated distributions, and climate refugia of forest insects across the northeast. Our results identify how climate forcing impacts diversity hotspots for forest insects and allows stakeholders to locate and prioritize conservation/restoration efforts.

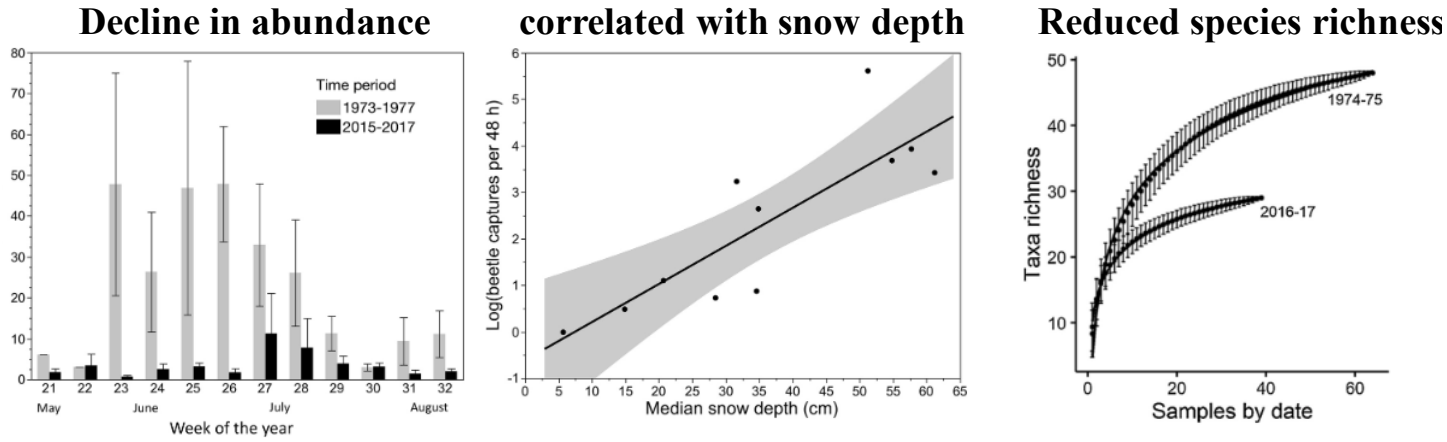


Figure 15 Beetle Decline in New England

Logan Johnson[1], Jim Duncan[2], Pia Ruisi-Besares[2], Amanda Mahaffey[1], Madeline Baroli[3], Maria Janowiak[3], Christopher Riely[4]

[1]Forest Stewards Guild, [2]Forest Ecosystem Monitoring Cooperative, [3]Northern Institute of Applied Climate Science, [4]Sweet Birch Consulting, LLC

Oaks dominate seventy percent of Southern New England forests. Unfortunately, many pressures compromise these forests' long-term outlook, including deer browse, defoliation by insects, seasonal droughts, and other climate change-related stressors. Concurrently, 70% of the region's forests consist of small parcels owned by families and individuals, meaning landscape-scale efforts to increase the resiliency of oak forests depends on effective landowner outreach and education.

The Oak Resiliency Assessment Tool developed by the Forest Ecosystem Monitoring Cooperative in collaboration with the Northern Institute of Applied Climate Science and the Forest Stewards Guild provides foresters, other resource professionals, and landowners with a tool that provides insights into the resiliency of oak forests.

After providing information about themselves and the forest they are assessing, the tool user answers a series of questions on a sliding scale about a variety of different disturbances and climate-related impacts. Following these questions on impacts, the user answers questions about the adaptive capacity of the forest or how well it might tolerate impacts without undergoing significant change, based on a variety of characteristics.

Responses to the questions on impacts and adaptive capacity are fed into a report that provides information on issues of concern for the forest and resistance, resilience, and transition approaches that can inform future management decisions.

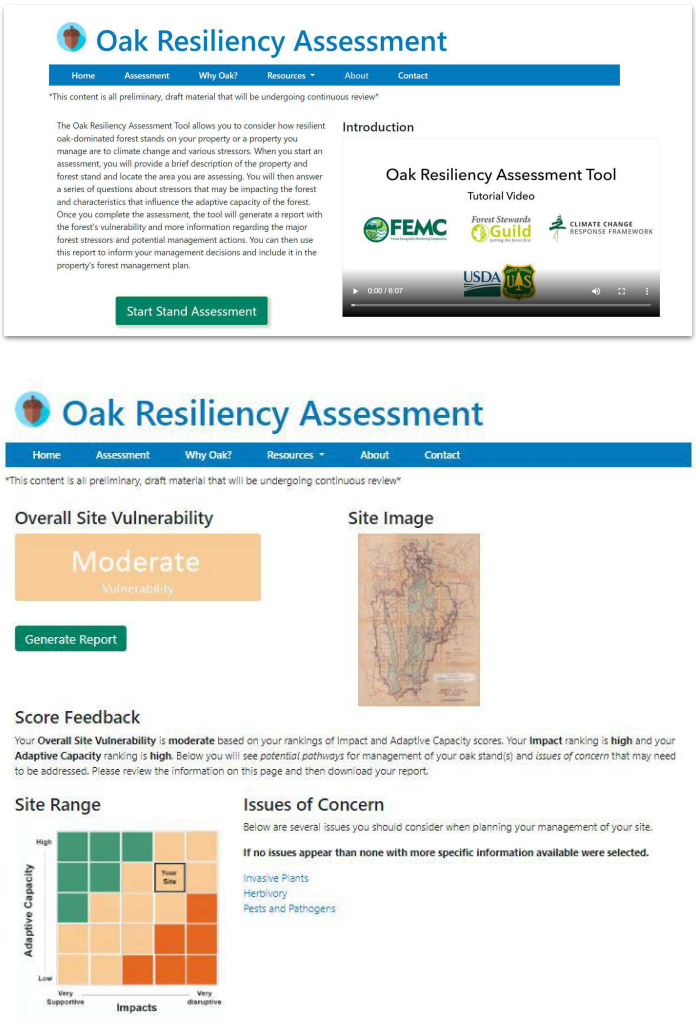


Figure 16 The Oak Resiliency Assessment Tool

Utilizing Climate Change Refugia for Climate Change Adaptation and Management in the Northeast.

Sara Wisner[1], Toni Lyn Morelli[2]

[1]University of Massachusetts Amherst, [2]Northeast Climate Adaptation Science Center

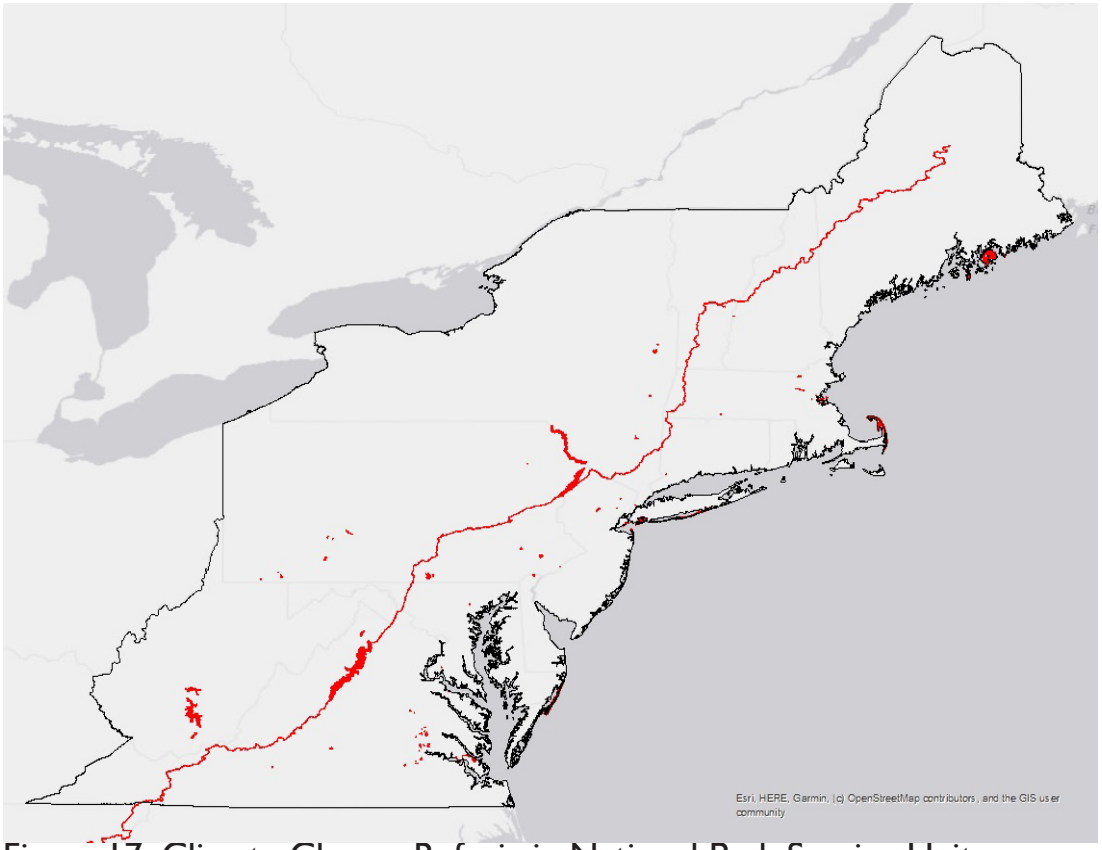


Figure 17 Climate Change Refugia in National Park Service Units

To account for the effects of climate change, management plans in the northeast need to incorporate climate adaptation. Conserving climate change refugia is one adaptation strategy. Climate change refugia are areas buffered by climate change that enable the persistence of valued physical, ecological and cultural resources. Using a translational ecology approach where researchers and managers from the National Park Service (NPS), US Geological Survey (USGS), and the University of Massachusetts worked together, we focused on identifying refugia for tree, herbaceous plant, mammal, and bird species in order to prioritize them for conservation action. Results will predict changes in distribution of habitats and species due to climate change, identify areas for invasive species treatment and other management actions, protect climate-buffered areas from development, highlight priorities for future monitoring and data analysis, and eventually provide a platform that can be replicated in other regions and provide potential future research opportunities.

Red Cedar Woodlands in Vermont: An overlooked form of old growth and potential climatic record.

Matt Peters[1]

[1]Peter's Botanical and Ecological Service

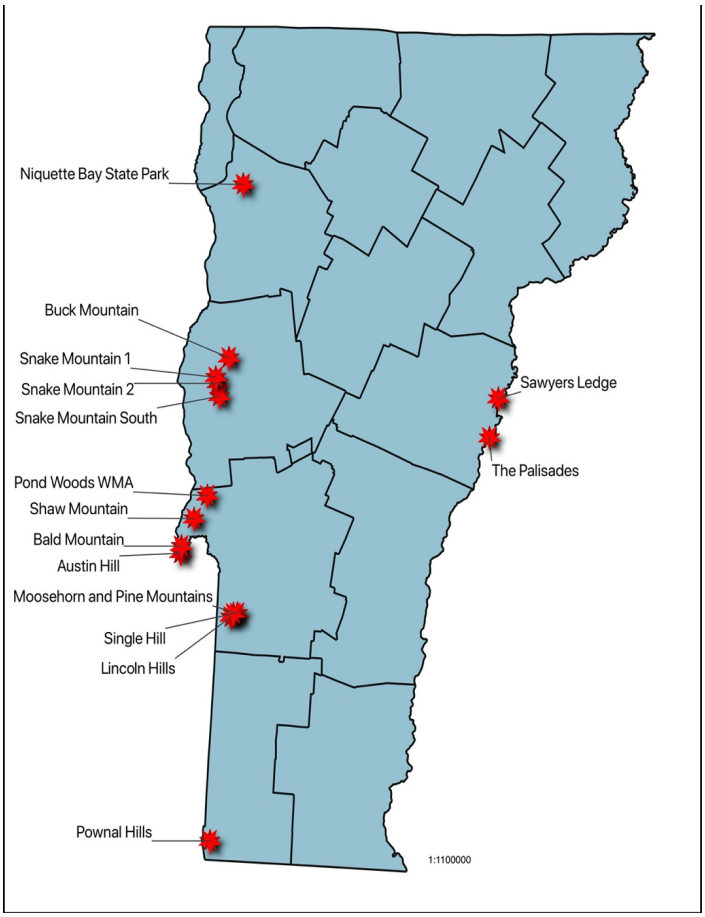


Figure 18 Sites of Red Cedar Woodlands in Vermont

The potential for some conifers living in drought-stressed, challenging environments to reach great age has been well documented, with familiar examples such as the bristlecone pines (Pinus longaeva) of the west and the northern white cedar (Thuja occidentalis) cliff forests of the Niagara escarpment. Such old conifer forests are also known as a source of valuable dendrochronological records with relevance for climate studies. Less well known, however, is the potential for eastern red cedar (Juniperus virginiana) to form very old forest communities in the Northeast. Trees approaching 600 years old have been documented in a Red Cedar Woodland community in New Hampshire and studies of related red cedar cliff communities in the mid-Atlantic region also indicate this potential. Vermont is home to similar Red Cedar Woodland natural communities, but these have been little studied beyond basic ecological description and mapping. Red Cedar Woodlands are a globally imperiled to vulnerable (G2-G3) natural community type that occurs throughout New England (except Maine and Rhode Island) and in New York, Pennsylvania and Ontario. About a dozen small occurrences are currently known in Vermont, and existing accounts of these sites frequently suggest that the the trees appear old; however, there has been almost no data quantifying tree ages. During 2021 this small study focused on coring and aging red cedar trees in six Vermont Red Cedar Woodland study sites. This presentation will introduce this rare natural community type and provide preliminary coring results suggestive of substantial tree ages at these sites. Numerous rare species were also documented at the sites in the course of this study. Drought-prone sites such as those occupied by Red Cedar Woodlands have the potential to show early indications of a changing climate while housing a potentially valuable climatic record of the past several hundred years.

Northern Hardwood Seepage Forest: A Newly Classified VT Natural Community with Implications for Climate Resilience, Wildlife, and Wetland Conservation

Dan Farrell[1]

[1]Vermont Fish and Wildlife Department

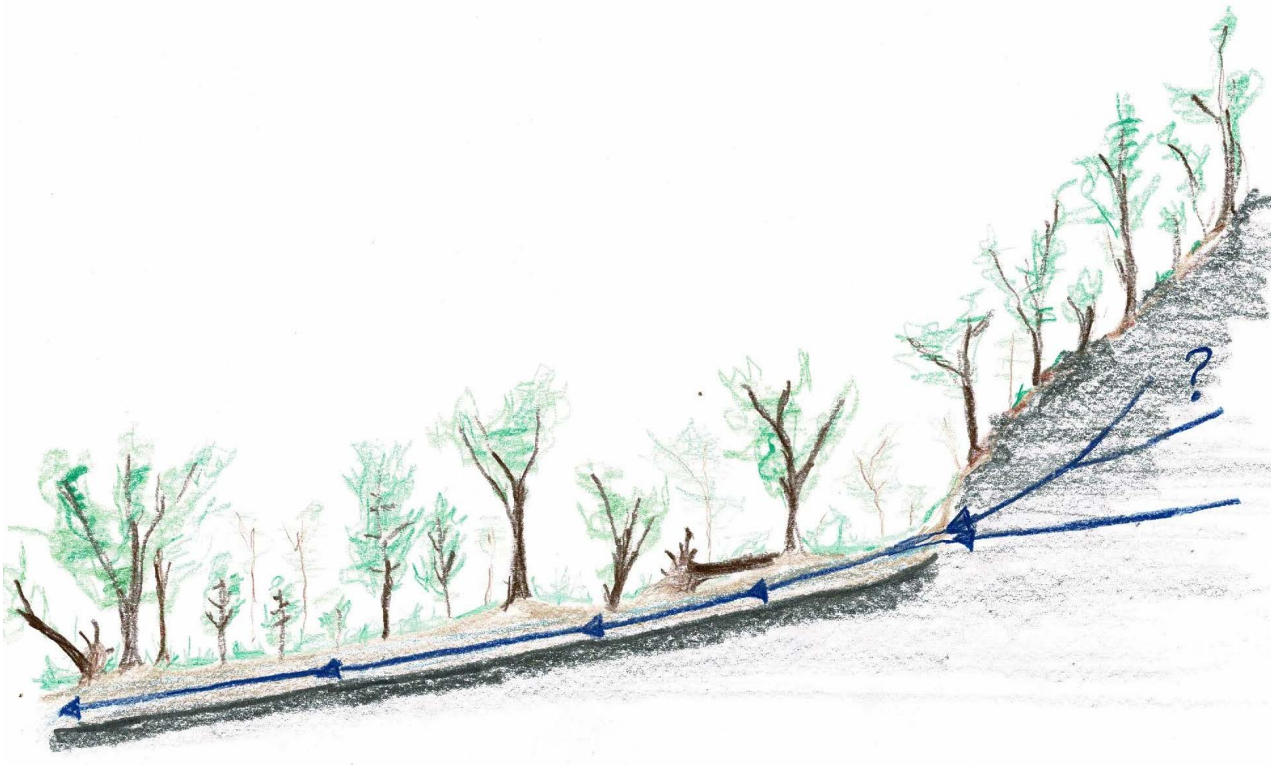


Figure 19 Depiction of the Northern Hardwood Seepage Forest

Northern Hardwood Seepage Forest (NHSF) is a newly classified, under-surveyed, diverse wetland natural community type in Vermont that contributes to freshwater climate resilience and benefits fish and wildlife. Similar communities occur in New Hampshire and Maine. It was introduced to the public in the second edition of Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont (Thompson, Sorenson and Zaino, 2019). Difficult to find using remote sensing data, they are regularly mapped as upland natural community types, though some datasets provide clues. Although predominately wetlands, occurrences of this groundwater-fed community type currently documented by the Vermont Fish and Wildlife Department (VTFWD) are rarely included on national and Vermont wetland maps. Spring thaw occurs earlier than in surrounding areas and provides much needed vegetation to bears and other wildlife. During the heat of the summer, the cool water supplied to streams by NHSFs can create refugia for aquatic species like brook trout. As headwater wetlands, they also increase the flood resilience of rivers downstream. Temporal and micro-topographically related spatial variability of depth to water table produces dynamic and heterogeneous sites with variable canopy cover, conditions that beget high species diversity, especially where there is high soil pH and nutrient availability. Increased awareness and documentation of this important natural community type will foster further understanding. Building on fieldwork by the VTFWD and other ecologists, we will discuss identification, vegetation, natural processes, and implications for conservation, climate resilience, and wildlife.

Carbon benefits of Family Forest Carbon Program practices in the Northeast region

Chris Zimmerman[1], Laura Marx[1], Jim Shallow[1], Richard Campbell[2], Ethel Wilkerson[3] Wilkerson, Sunil Nepal[3]

[1]The Nature Conservancy, [2]American Forest Foundation, [3]Spatial Informatics Group

Developed by the American Forest Foundation (AFF) and The Nature Conservancy (TNC), the Family Forest Carbon Program (FFCP) enables family forest owners to access climate finance from carbon markets and empowers them to help address climate change while earning income from their land. A Northeast pilot of the FFCP is planned to launch in 2022. Landowners enrolled in the FFCP are paid to implement carbon beneficial management practices and carbon stock change is monitored post implementation to generate credits. TNC and AFF worked with the Spatial Informatics Group (SIG) to model the potential forest carbon stock change of three FFCP practices (Grow Older Forests, Retain more carbon in a thinning and Create Gaps to Promote Regeneration) over 20 years in the Lower New England and Green, Taconic, Berkshire Mountains Ecoregional Sections. TNC and SIG developed methods to model practices and develop a composite baseline using the Verra VCS improved forest management methodology. Carbon modeling was conducted using the Forest Vegetation Simulator (FVS) and data from 543 FIA plots that met the following eligibility criteria: private ownership, Maple/beech/birch or Oak/hickory forest type and had >2,000 board feet/acre. The "Grow Older Forests" practice, which is a deferred harvest for 20 years, resulted in largest carbon benefits above baseline across all forest types and ranged from 1.2 to 2.3 MT/acre/year. The "Create Gaps" practice, harvesting 20% of the project area (~ 16% removal of basal area) with an 80% uncut retention zone(s), showed carbon benefits of 1.1 MT/acre/year above baseline for the Maple/Beech/Birch forest type. The "Retain Carbon in Thinning" practice, which thinned the project area to midpoint between the A and B-lines (~ 25%) had small carbon benefits, 0.3 to 0.7 MT/acre/year above baseline. A 50% retention area was subsequently added to the thinning practice to increase projected carbon stock change above baseline. In the Oak/Hickory forest type the high stocking of the baseline limited the ability of harvest practices, even those with small removals of basal area, to exceed carbon stocking of the baseline. These results were used to refine FFCP practices specifications and eligibility requirements and set practice payment rates. Additional modeling is underway in collaboration with the University of Massachusetts-Amherst to further understand the carbon benefits of these practices and others.

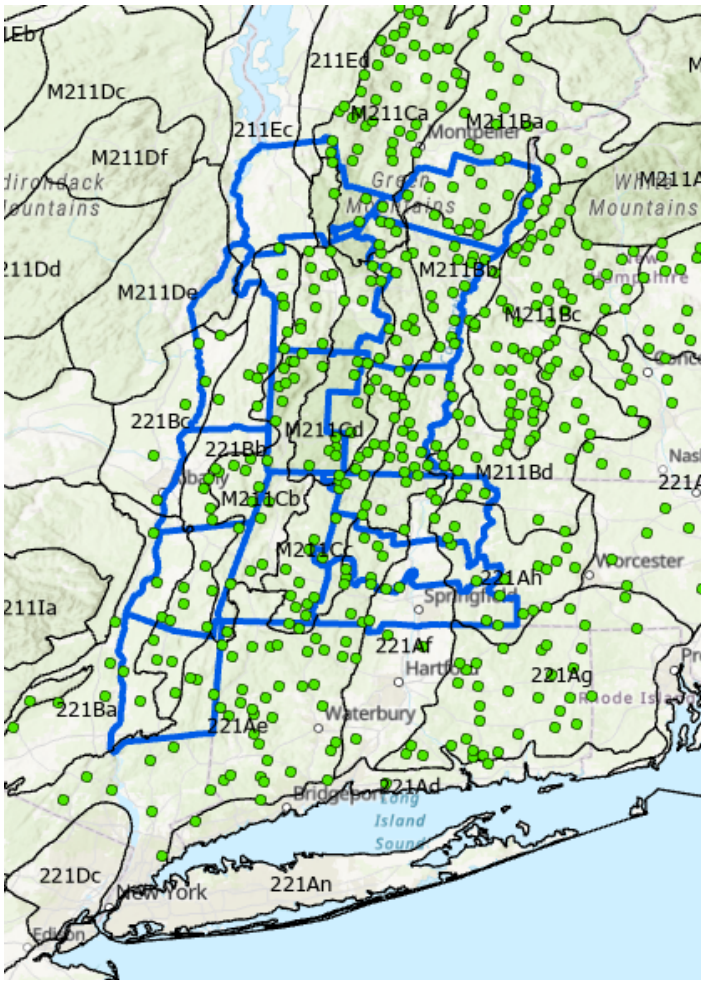


Figure 20 Forest inventory analysis plots to determine annual forest carbon stock change

Conservation planning for the next generation of forest land management at Smokey House Center

Jesse Pyles[1], Blanca Begert[2], Seth Inman[2]

[1]Smokey House Center, [2]Yale School of the Environment

In 2021, Smokey House Center in Danby, VT partnered with Yale School of the Environment to rewrite its forest management plan. Post graduate Fellows aided Smokey House in redefining management units from their timber harvest potential to natural communities through which management (or lack of active management) will help achieve and promote conservation values on Smokey House Center's 5,000-acre protected property -- including water quality, wildlife connectivity, carbon sequestration, and general climate resilience. This presentation explores the Use Value Appraisal (or "Current Use") program as applied to assessing and asserting conservation values on private lands. The new Conservation Plan, once accepted by the State of Vermont, will transfer the property from "Forestry" Current Use tax program to the "Conservation" category. Presenters describe their approach to identifying conservation values and establishing new management areas based on those values, field observations, and the opportunities for research and monitoring into the future.

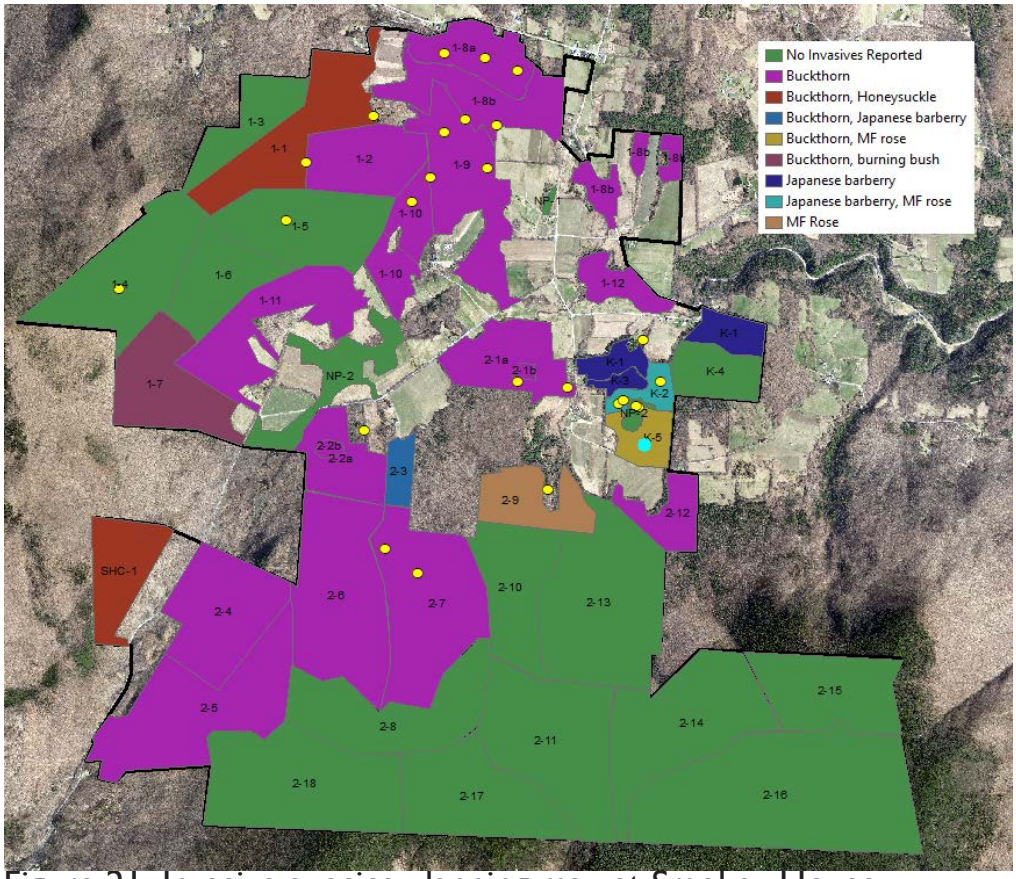


Figure 21 Invasive species planning map at Smokey House Center

Forest Cents: Using Carbon Markets to advance Forest Conservation

Jim Shallow[1]

[1]The Nature Conservancy

Forests ability to remove and store carbon from our atmosphere is widely seen as one of the most efficient and cost-effective ways to address climate change. As Governments and businesses are implementing programs to reduce their carbon footprint carbon markets are growing and along with them opportunities for forest landowners to sell their forest's carbon. The markets are adapting to provide new ways for landowners and businesses to tap into the carbon sequestering power of trees. Using recent examples from Vermont projects, this presentation will give a high-level overview of how these markets work, the emerging opportunities for landowners and they can help protect Vermont's forests.

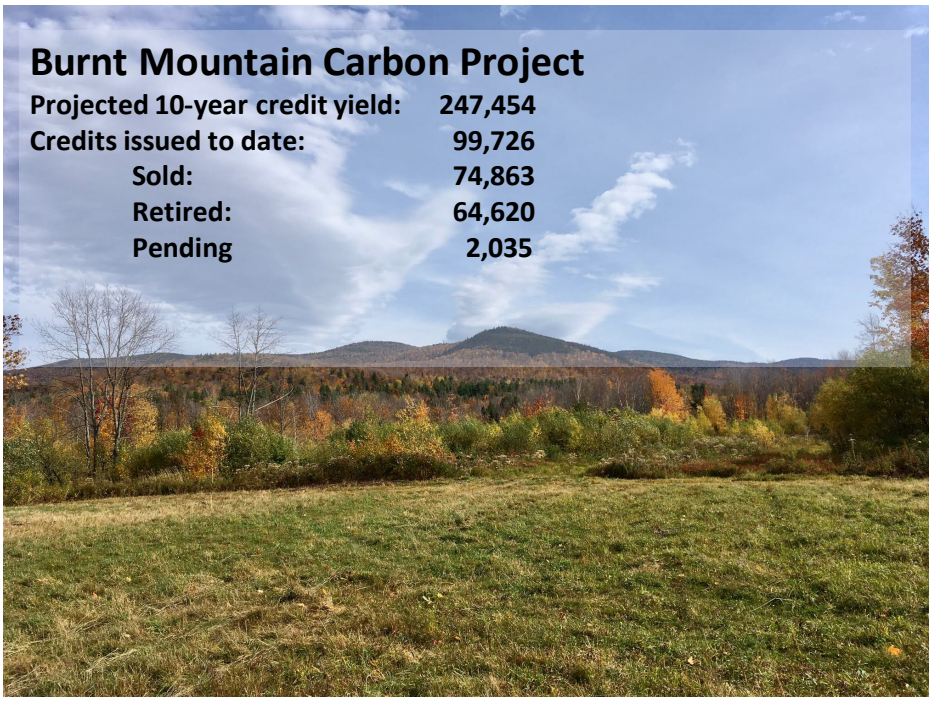


Figure 22 Carbon credits from the Burnt Mountain Carbon Project in Vermont

Monitoring forest health with UAS ("drone") technologies

Adam Zylka[1], Maddy Zimmerman[1], Jarlath O'Neil-Dunne[1], Kelly Schulze[1], Lauren Cresanti[1]

[1]University of Vermont Spatial Analysis Laboratory

Unoccupied Aircraft Systems (UAS) or "drones" have the potential to provide meaningful insights for urban and community forestry. The ability of UAS to collect frequent imagery and elevation datasets with high spatial resolution may allow for improved monitoring of forest conditions, especially when impacted by pests or invasive species. During the summer of 2021, the University of Vermont Spatial Analysis Laboratory collected UAS-based LiDAR and multispectral imagery to monitor the response of a community forest in Addison County, Vermont to the increased activity of Lymantria dispar larvae ("gypsy moth caterpillars"). These data illustrate both the severity of defoliation resulting from these caterpillars and the resiliency of the forest following the transformation of caterpillars into adult moths. Similar techniques using commercially available UAS platforms and sensors may allow for efficient and timely monitoring of the health of small and medium forest plots.

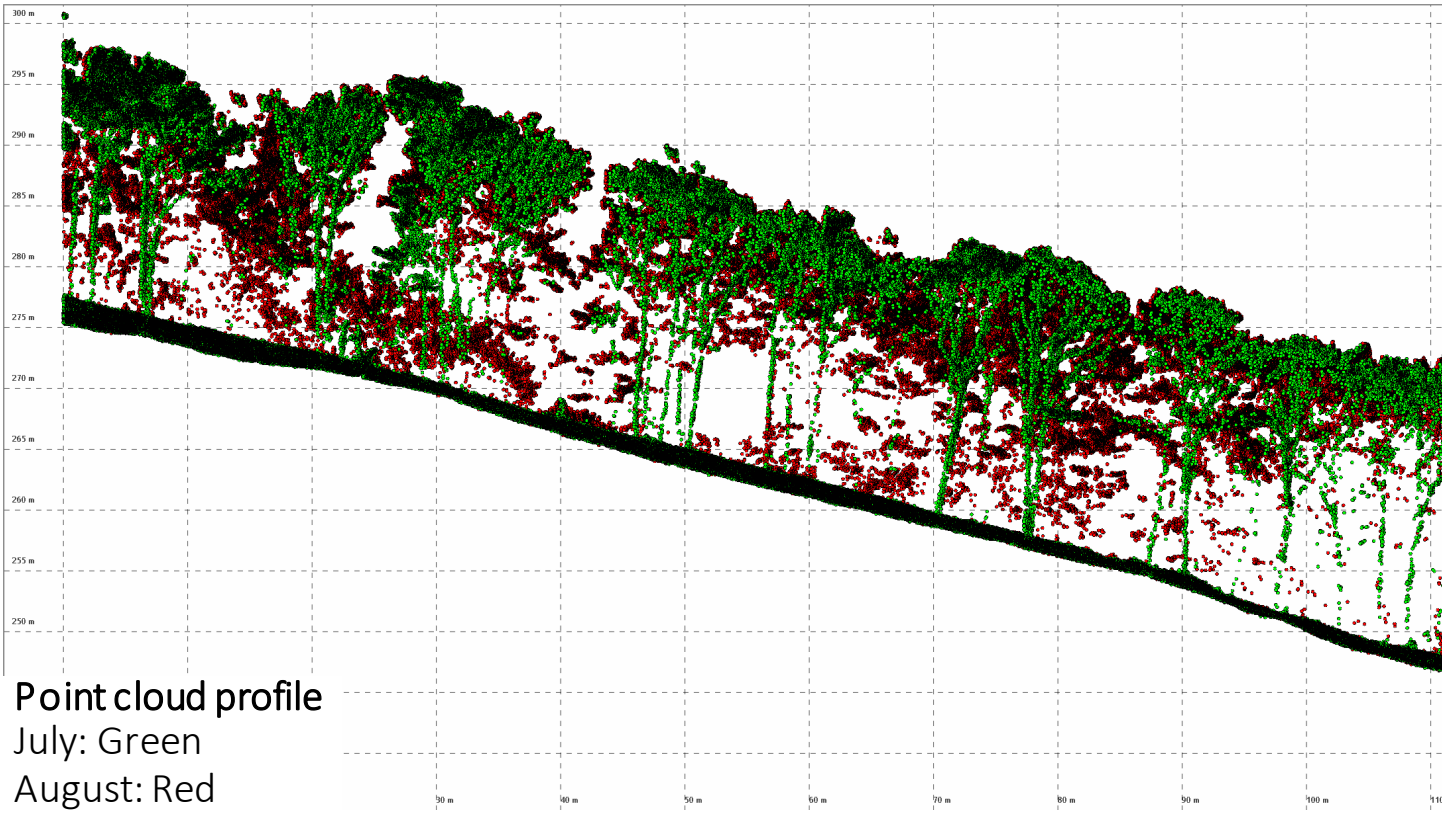


Figure 23 Point cloud profile from LIDAR data of forest section

Forest Farming in the Northeast: Building a Community of Practice

Karam Sheban[1]

[1]Yale School of the Environment

The cultivation of commercially-valuable herbs under a forest canopy--an agroforestry practice called forest farming--represents a strategy for increasing economic and ecological diversity on private forested properties across the Northeast. For the forest landowner, it presents an opportunity to diversify land-based income streams with low additional labor and costs by converting idle forestland into an economic asset without compromising forest health or timbering potential. For the forest manager, it presents an opportunity to implement conservation practice and landscape-scale management across a fragmented landscape. The result is greater product diversity, increased forest resilience, and long-term ecological and economic viability. Led by the landowner, forest farming falls inside various high-level conservation frameworks, from Assisted Species Migration (ASM) to Natural Climate Solutions (NCS).

A major barrier to establishing a forest farming enterprise is access to technical information and assistance on topics such as farming techniques, market strategy, regulations, and forest resource inventory and management. While coordinated technical assistance is being organized in other regions--exemplified by the Appalachian Beginning Forest Farmer Coalition (ABFFC), a group founded by Virginia Tech University in 2015 dedicated to the development of forest farming enterprises--this assistance remains sparse and uncoordinated throughout the Northeast U.S.

The development of a Northeast Forest Farmers Coalition will allow farmers to meet this opportunity by providing the first region-wide forest farming educational campaign in the Northeast. We are building a broad community of practice, centered around small and mid-sized farms and forested properties. In-person trainings, the establishment of a peer-to-peer forest farming mentoring network, and the creation of forest farming demonstration sites at strategic locations throughout the region represent the core of our educational campaign.

Meanwhile, project research will generate baseline data to address understudied ecological, financial, and production questions related to five important forest farmable species with significant profit potential--American ginseng (Panax quinquefolius), goldenseal (Hydrastis canadensis), ramps (Allium triccocum), black cohosh (Actaea racemosa), and bloodroot (Sanguinaria canadensis).

With a national American Forest Farming Council in the early stages of design, the establishment of a Northeast Forest Farmers Coalition is building a foundation of forest farmers and educational resources in the region with an eye to the future. This presentation will describe the fundamentals of forest farming, the development of this new USDA-funded initiative, the structure of the ecological research taking place as part of the project, as well as prior forest farming research conducted by project PI Karam Sheban currently in review in the journal Agroforestry Systems.

Figure 24 American Ginseng, a potential product of forest farming

Using a new tool: Forest Impacts of Climate Change: Monitoring Indicators

Pia Ruisi-Besares[1]

[1]Forest Ecosystem Monitoring Cooperative

This year the Forest Ecosystem Monitoring Cooperative announced the release of the Forest Impacts of Climate Change: Monitoring Indicators Version 1.0 web-tool. This tool allows users to explore where monitoring of important indicators of climate change is occurring throughout forests in the Northeastern U.S. Users can access protocols and visualize where monitoring studies are already being conducted. Landowners, managers, and researchers can then use these protocols to implement their own, comparable monitoring programs that will be added to a larger database. Developing this network of monitoring sites provides critical information to help close spatial gaps in monitoring efforts and provides baseline data for further inquiry into how forest systems are shifting in response to climate change. This talk will show attendees how to use the tool and the results of a preliminary gap assessment of monitoring in New England and New York.

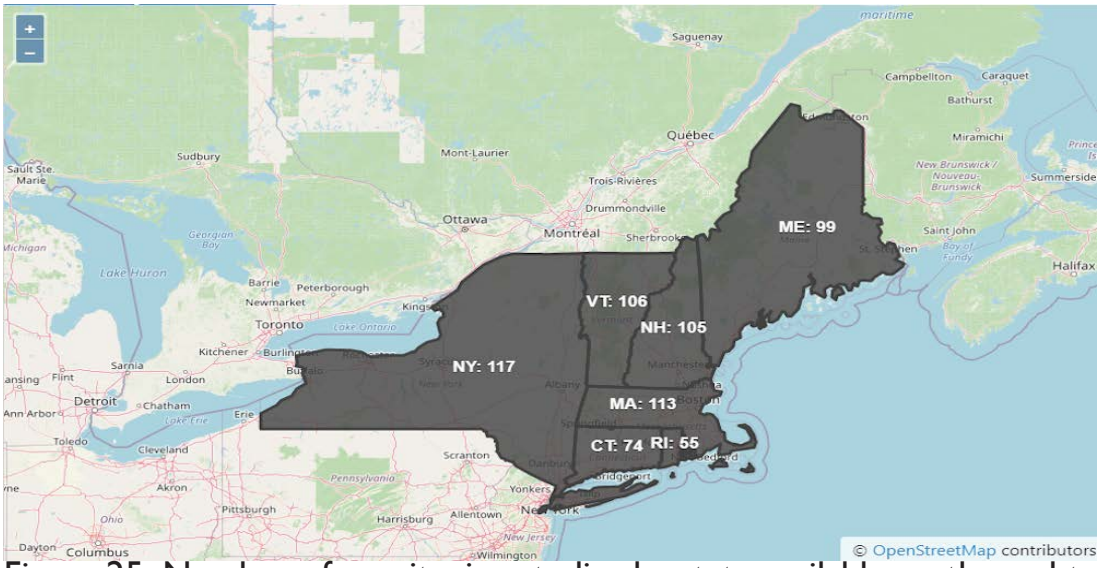


Figure 25 Number of monitoring studies by state available on the webtool

Assessing the efficacy of assisted migration: physiological response of seedlings to moderate severity drought and adaptive silviculture treatments

Al Freeman[1], Cameron McIntire[2], Tony D'Amato[1]

[1]University of Vermont, [2]United States Forest Service

Climate regimes are changing at a faster rate than natural tree migration historically has shown to be able to track. The inability for species to keep pace with climate is expected to generate significant lags in natural migration of tree species, leading to vulnerabilities in climate adaptability. To evaluate the efficacy of transitioning forest composition through the use of assisted migration, this study focuses on determining sensitivity and mechanistic thresholds for species predicted to have population and range expansions under changing climate regimes. We measured seedlings--Betula lenta (Black Birch), Castanea dentata (American Chestnut), and Quercus rubra (Red Oak)--planted in 2016 in one-acre gaps as part of the installation of the Adaptive Silviculture for Climate Change Network. Throughout the 2021 growing season (June-August), we monitored gas exchange, growth, intrinsic water use efficiency, and water potential to determine species limitations and adaptive capacity of these species. We present preliminary findings on the physiological responses of these seedlings during a moderate drought. Given the efficacy of assisted migration for facilitating change in ecosystems relies upon long-term growth, survival, and reproduction of assisted species, quantifying physiological limits to these processes is urgently needed.

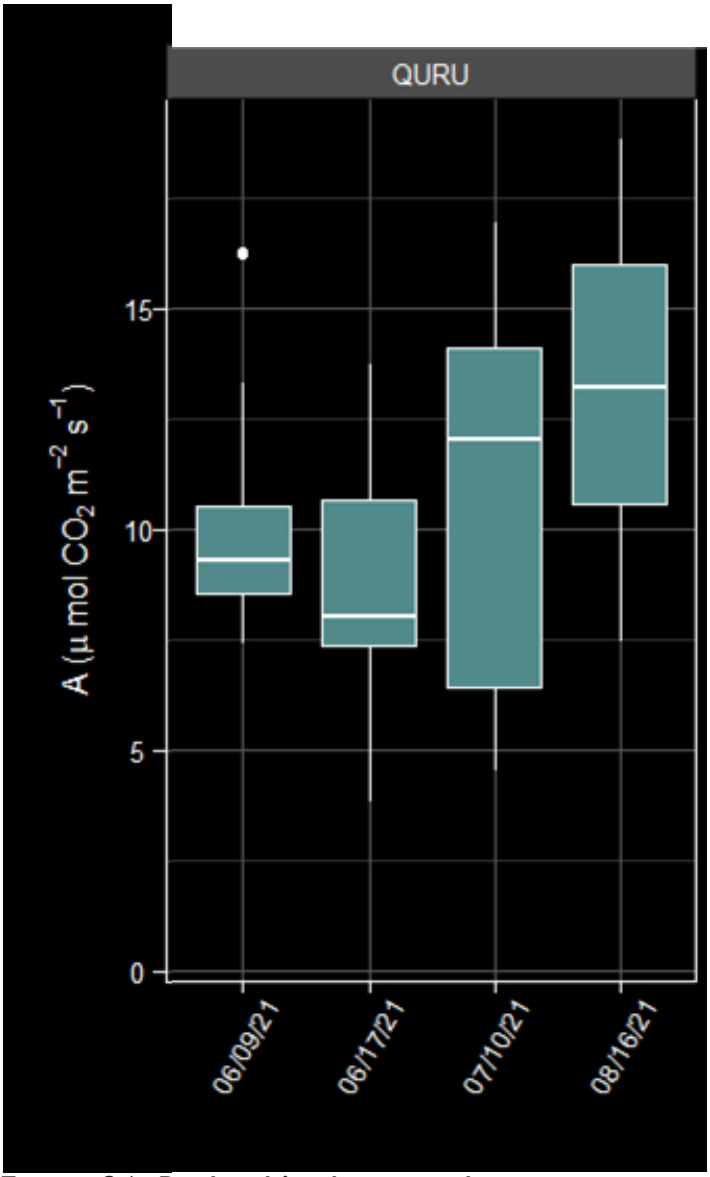


Figure 26 Red oak's photosynthetic capacity, showing anisohydric behavior

Measuring Municipal Land Use Approaches for Maintaining Forests and Wildlife

Jamey Fidel[1], Jens Hilke[2], Andrew Wood[2]

[1]Vermont Natural Resoures Council, [2]Vermont Fish and Wildlife Department

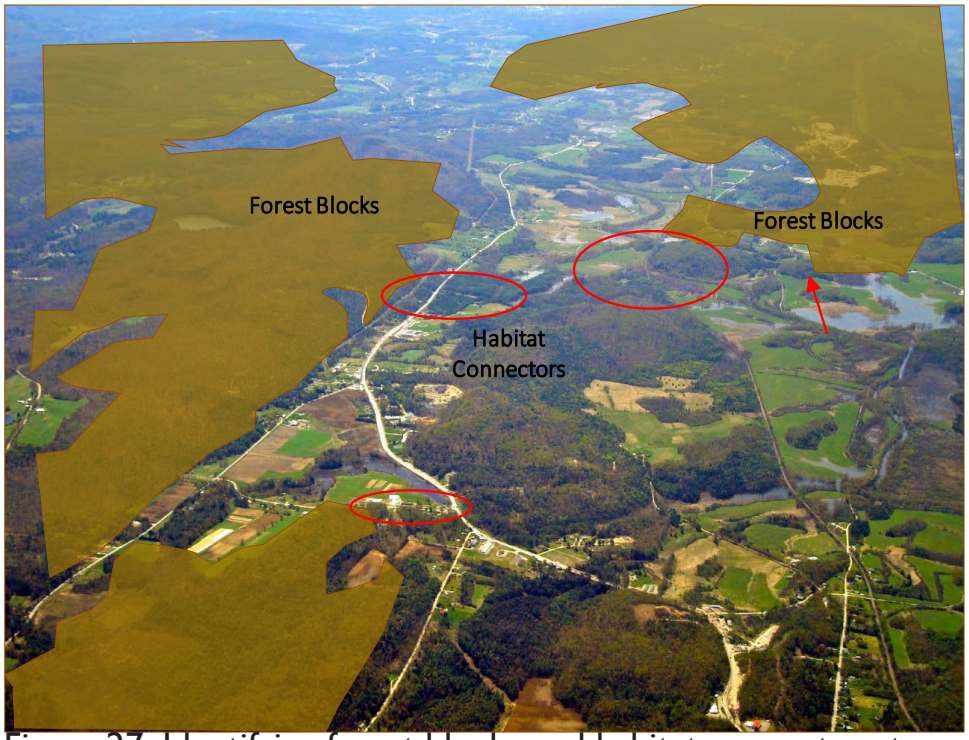


Figure 27 Identifying forest blocks and habitat connectors to look for gaps

Communities play a vital role in maintaining resilient ecosystems, especially in the face of rising challenges. Town plans and land use policies shape how growth and development occurs and how natural resources are maintained; however; with 269 separate municipal governments in Vermont, approaches can be varied and disjointed. A recent study conducted by Vermont Natural Resources Council in partnership with the Vermont Fish and Wildlife Department examined data on municipal land use planning to measure how communities are maintaining ecosystem functions, with a focus on wildlife habitat and intact forests. The study collected comprehensive data from every town plan, zoning bylaw, and subdivision regulation to understand the degree to which policies are being employed to maintain forest and wildlife functions. The presentation will share findings at the local and regional level, including the degree to which land use policies are addressing emerging challenges such as climate change, invasive species, and forest fragmentation. The presentation will also share the results from two similar studies in 2000 and 2010 and highlight where progress is being made, and where gaps remain in land use planning to promote resilient ecosystems. Finally, the presentation will explain the leading regulatory and non-regulatory land use strategies for communities to maintain intact forests and wildlife functions, included in a new version of the publication Community Strategies for Vermont's Forests and Wildlife: A Guide for Local Action.

White-tailed Deer Harvest Success and its Impact on Forest Understory Vegetation:

Ralph Green III [1], Danielle Begley-Miller, PhD [1]

[1]Pace University

In southeastern New York, white-tailed deer (Odocoileus virginianus) populations have increased over the last 50 years from a lack of natural predation, increase in food resources from land use changes, and restrictive hunting regulations. Unmanaged deer populations have severe negative impacts on understory plant communities, a key contributor to forest regeneration and biodiversity, affecting other plant and animal species. Numerous strategies are employed by land managers throughout the Hudson Valley region of New York to manage deer via lethal means. This study aims to better understand the effectiveness of different white-tailed deer removal programs (i.e., culling, archery, and firearms seasons) compared to no management in improving forest understory conditions across 7 nature preserves in the Hudson Valley. An analysis of variance found that deer density estimates decreased or stabilized across all program types in the first 4 years of management ($F(4,18) = 2.3$, $p = 0.098$), and harvest efficiency (number of deer harvested per hour effort) decreased at all sites with time ($F(3,23) = 8.974$, $p < 0.001$). Culling (5.32 deer/per hour) was the most efficient harvest strategy compared to archery (0.22 deer/per hour) and firearms (0.02 deer/per hour) programs. While management programs did reduce deer densities, an analysis of covariance found that those changes did not correlate consistently with seedling density ($F(1,16) = 0.483$, $p = 0.49$), and seedling height ($F(1,13) = 1.131$, $p = 0.75$), but did positively correlate with understory diversity ($F(1,43) = 11.184$, $p = 0.002$). Vegetation responses appear site-specific and driven by additional site limitations beyond deer density, but data analysis was limited by inconsistent data collection strategies across sites. We recommend regional coordination among land managers to establish consistent protocols to assess and monitor the impacts of deer density on local forested ecosystems prior to starting a deer management program.

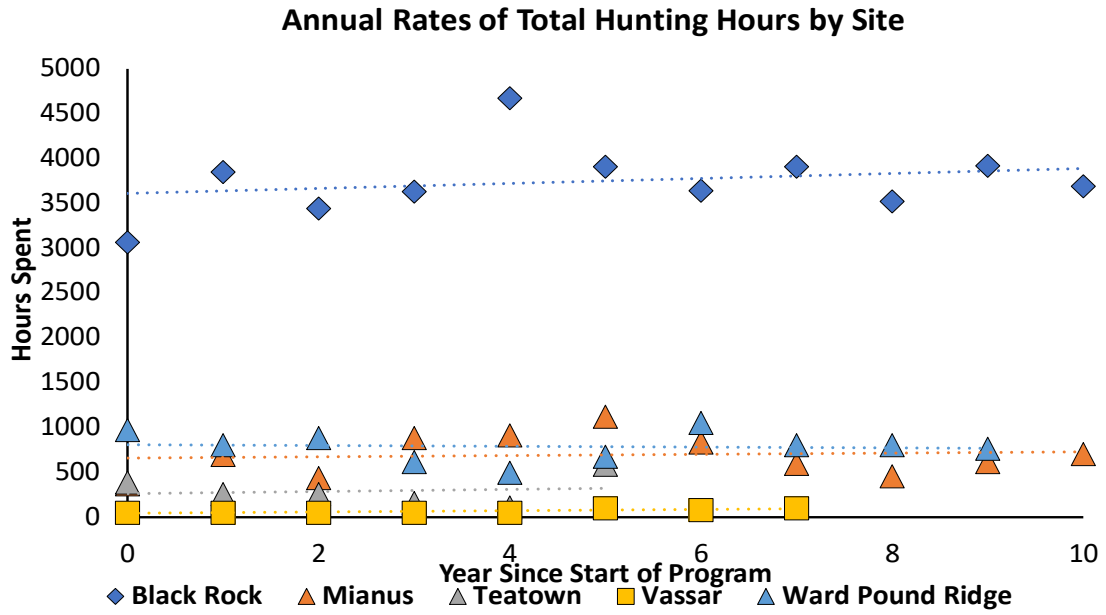


Figure 28 Deer hunting site durations

Where will wildlife cross the road? Using electrical circuit analysis to map wildlife movement and inform transportation management in Vermont

Caitlin Drasher[1], Glenn Gingras[2], Jens Hilke[3], Paul Marangelo[4], James Murdoch[1]

[1]University of Vermont, [2]Vermont Agency of Transportation, [3]Vermont Fish and Wildlife Department, [4]The Nature Conservancy Vermont Chapter

Wildlife populations depend on landscape connectivity for resources, dispersal, and genetic exchange. Roadways fragment the landscape and impede species movements, leading to negative consequences for the genetic and demographic characteristics of populations. Transportation structures, including bridges, culverts, and underpasses, help mitigate these barrier effects by providing areas for wildlife to move beneath roads. However, not all structures are in ideal condition to promote wildlife use, and investments in wildlife-based structure improvements should be prioritized in areas most important for landscape connectivity. We developed the Vermont Terrestrial Passage Screening Tool to rank the connectivity value of state-managed transportation structures for eight species (moose, white-tailed deer, American black bear, eastern coyote, bobcat, red fox, raccoon, striped skunk). The Tool incorporates results of an electrical circuit theory analysis, which mapped the movement of each species at two spatial scales (statewide and structure level) using a combination of occupancy models, expert-derived resistance surfaces, and coarse and fine scale land cover data (NLCD and Lidar-derived, respectively). It also includes data on physical structure attributes, human development influence, and nearby protected lands. The Tool uses a linear programming decision-making framework to rank structures by these metrics and allows agency managers to assess the relative value of a given structure for landscape connectivity. Results of this project will inform decision-making related to mitigating the impacts of roadways on wildlife in Vermont.

Figure 29 Example of structure that is not ideal for wildlife crossing

Figure 30 Example of structure that is ideal for wildlife crossing

Evaluating ONRAB Vaccine Bait Fate and the Use of Bait Stations in the Oral Rabies Vaccination Program in Burlington, Vermont USA

Maggie Batton[1], Richard Chipman[2], Amy Gilbert[2], Fred Pogmore[2], Shylo Johnson[2], James Murdoch[1]

[1]University of Vermont, [2]USDA APHIS

Rabies virus is a fatal zoonotic disease affecting human and animal health globally. The raccoon rabies virus variant is a major source of potential exposure to humans and domestic animals in the United States. The United States Department of Agriculture (USDA) Wildlife Services (WS) National Rabies Management Program (NRMP) has used oral rabies vaccination (ORV) to prevent the spread of and locally eliminate raccoon rabies virus variant from the United States. The ORV strategy targets free-ranging populations of meso-carnivores in Vermont, including raccoons (Procyon lotor), striped skunks (Memphitis memphitis), red and gray foxes (Vulpes vulpes and Urocyon cinereoargenteus), coyotes (Canis latrans), and bobcats (Lynx rufus). Although ORV has been largely successful across rural environments, urban environments have presented greater challenges for less understood reasons. We are monitoring the fate of vaccine baits in developed areas of the Greater Burlington ORV zone using camera traps to model the probability of bait uptake by target species and other sources of bait disappearance. Additionally, we are evaluating supplemental use of bait stations (PVC tubes containing multiple baits) with the current hand baiting strategy with the objective of increasing bait uptake among target species. The results will provide new information to improve the effectiveness of the ORV program in Burlington and potentially other urban suburban areas targeted with ORV. We will be discussing preliminary results and expected outcomes. The project is a collaboration between the USDA APHIS Wildlife Services National Rabies Management Program, National Wildlife Research Center, Vermont Wildlife Services Operational Program, and University of Vermont.

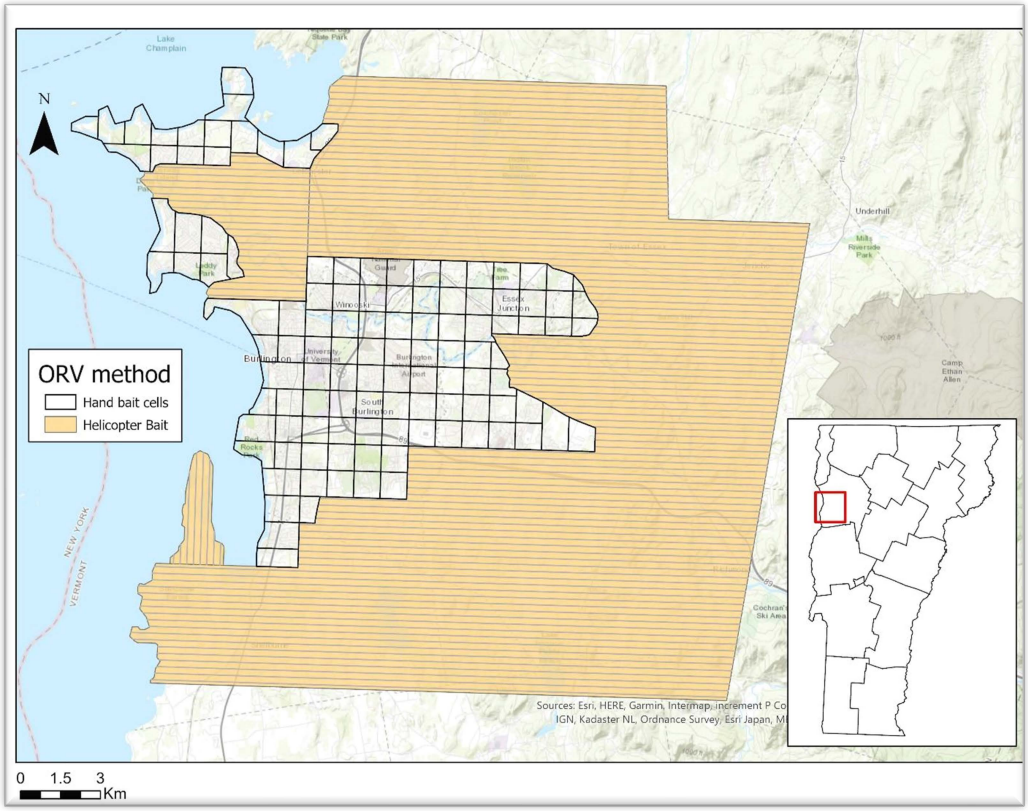


Figure 31 Vaccine distribution type in Chittenden County

Developing Inclusive Field Protocols

Emma Tait[1], Elissa Schuett[1], John Truong[1], Naomi Cutler[1]

[1]Forest Ecosystem Monitoring Cooperative

How do we make fieldwork experiences more inclusive, diverse, equitable, safe and just? Field ecologists often have standard of practice (SOP) documents to capture all of the field methods and protocols to be used when collecting ecological data. However, we often do not have SOPs to guide our field planning and to support field crews in aspects of diversity, equity, and inclusion. This type of SOP is intended to focus on how to manage and support people, from the hiring process, through onboarding, and supporting throughout the field season. We highlighted ways we can recognize, celebrate, and create space for all our different identities, recognize and acknowledge the barriers to joining field programs and environmental organizations, and provide resources and support to cultivate a culture of respecting different experiences, and valuing different voices and perspectives to foster a sense of belonging.

To address the need for more guidance in creating an inclusive and diverse program, FEMC staff hosted a working session at the FEMC Annual Conference with the following goals:

- Understand why developing an inclusive programmatic SOP is important for FEMC and may be valuable for other organizations in the environmental field.
- Identify ways in which an organization can create a more inclusive Field SOP
- Provide resources to learn more and share with colleagues
- Connect with others to continue this conversation and share challenges or successes

The session was used to connect with individuals from other organizations across the region who may also be using or developing these types of documents.

In the session we discussed barriers to inclusion and various ways to address those barriers in different aspects of field program planning, including pre-season planning, hiring and onboarding, field safety, incident reporting and post field season follow-up. This facilitated the building of a collaborative network to continue to discuss and develop programmatic and inclusive field programs.

Session Details

The session was led by four FEMC staff (Emma Tait, John Truong, Naomi Cutler, Elissa Schuett). A total of 31 people attended the session, with 24 fully participating during the break-out sessions and seven people listening to the presentation portion of the session.

Prior to the working session, FEMC staff created a worksheet that groups can use to develop their own Field SOP. The worksheet describes efforts that should be considered in five sections to capture the entire experience for people participating in a field program:

- Pre-Season Planning
- Hiring/Onboarding
- Field Safety
- Incident Reporting
- After the Field Season

Developing Inclusive Field Protocols cont.

Summary from the Working Group Session at the 2021 FEMC Annual Conference

An introductory presentation detailed the need for organizations to develop Field Standard Operating Procedures focused on DEIJ concepts to support people from all identities and backgrounds. The worksheet was used to prompt discussion about other topics that may have been left out or where challenges may arise when others create a similar document. To promote discussion and engagement with attendees, four break-out groups were created to allow for small-group discussion. Several individuals were interested in continuing the discussion and sharing resources with each other as organizations develop their own SOP documents. FEMC will continue to work with this community as needed.

Session Outcomes

The working session was used to engage with individuals who are interested in advancing diversity and inclusion goals in the environmental field. FEMC staff used ideas generated during the session to complete an Inclusive Field SOP for FEMC-led field programs. This document will be shared with attendees of the working session. Additionally, several attendees indicated interest in continuing the discussion and sharing resources in the future. A Padlet board was created to share these resources and provide an easy-to-access site for continued discussion and communication. FEMC staff will continue to engage with this group to learn about challenges and barriers or successes and new resources.

FEMC Working Session: Scoping a Regional Methods Framework for Assessing the Impacts of Browse on Forest Vegetation.

Pia Ruisi-Besares[1]

[1]Forest Ecosystem Monitoring Cooperative

Foresters, land managers, and scientists from across the Northeast have expressed an interest and concern about the health and regeneration of forest ecosystems. The issue is multi-faceted, with separate yet interconnected issues which include but are not limited to invasive species, land-use histories, changing climate, and soil compositions. A key factor and an issue of utmost importance is that of the browse behavior displayed by white-tailed deer. As deer populations have increased historically, forest researchers and managers are concerned about the survivorship of tree seedlings and saplings, including high-value species such as sugar maple, as well as other key plants of the forest understory such as spring ephemerals and other herbaceous layer plants. One barrier to addressing this problem is a lack of regional information about the impacts of deer browse. There are no consistent methodologies for researchers and managers to assess browse impacts and available data is sparse. To date, there is no study that has conducted a regional browse assessment with deer and forest regeneration conditions. Some foresters believe the negative impacts of deer browse on forest health are vastly under-recognized due to this lack of data and studies.

To address this problem, the Forest Ecosystem Monitoring Cooperative (FEMC) is conducting a regional project focusing on identifying the most comprehensive and accurate methods of browse assessment that can be undertaken by researchers, land managers, and forest stewards. The initial steps included interviews with stewards and land managers with expertise in the subject matter, as well as an extensive literature review on browse assessment methodologies. The project also seeks to develop a regional database that forest researchers, practitioners, and decision-makers can use to understand browse impacts across the region. A working goal is also to develop criteria for which methods should be implemented based on numerous site-specific factors.

A working session, co-sponsored by Hubbard Brook Research Foundation was held during the annual FEMC Conference on December 16, 2021 with conference attendees and invited guests. The goal of this working session was to discuss the issue of browse impacts on regeneration and how we measure browse impacts across the northeast. The workshop leaders shared insights from a Hubbard Brook Roundtable held in March 2021 to discuss issues related to regeneration with a group of foresters, managers, and scientists. They also gave an overview of FEMC's progress to date on identifying a suite of methods for assessing the impacts of browse on forest vegetation. In two separate break-out sessions, participants discussed either the key criteria for an effective browse impact assessment tool or the most important policies and management decisions to be supported by such a tool. Following the break-out sessions, the conclusion of the workshop summarized each group's key findings and proposed solutions.

Participants in the policy-focused session discussed the need to include foresters and wildlife biologists in discussions to make sure needs are understood by all groups. It was also recognized that forest health is not solely dependent on deer management, but that invasive plants must also be managed.

Participants in the methods-focused session spoke of the need for a method that is not subjective, simple to use, and able to be used at sites across the region. It was recognized that it is unlikely that a single method will be useful across the region due to different habitats. To address this challenge, the assessment method recommended should be based on a larger question that the group aims to answer. Answering a single question will narrow down the criteria that needs to be included in a protocol. Additionally, participants affirmed that a browse impact assessment method should not just focus on plant regeneration; plant community composition, forest health, and other ecological health metrics should be included in any evaluation.

The outcomes of this session is driving the direction of the regional project and informing further monitoring and research. Currently, the FEMC is considering the next steps of the project. The next phase involves reaching out to the appropriate contacts for browse assessment methodologies and implementing field research in the northeast in the summer of 2022.

Introducing the Northeast Silviculture Library

Grace Smith[1], Tony D'Amato[1]

[1]UVM and Northeast Climate Adaptation Science Center

This working group session introduced the beta version of the Northeast Silviculture Library (NESL) to a group of 47 forestry professionals and research scientists working in the Northeast region. During the working session, attendees received a walk-thru of the key features of the website, including how to access case collections, explore and filter cases and how to submit a case. Case study collections are broken up into three categories: Forest Type, Forest Health Issues, and Management Type. Within these collections, subcategories are generated to reflect the most prevalent happenings in the Northeast.

Alternatively, cases can be explored in the "Explore Case Studies" tab, which allows the user to select filters based on forest type, forest health threats, management types, state/province, and/or keywords. This page now includes a map function to display all available case studies by location.

Lastly, attendees were shown the case study submission process in addition to getting access to the case study template. We welcome submissions from anyone with direct experience managing forest lands in the Northeast region and will use any feedback on the NESL website to increase its utility to stakeholders. The outcomes of this session included informing attendees on how to submit their own silvicultural prescriptions and outcomes, reviewing the cases already published, and soliciting submissions from attendees.

Since the working group session, our team has taken into consideration the feedback given to make changes to the library, including the addition of a map function.

As of February 2022, the Northeast Silviculture Library is officially available to the public. Cases can now be submitted for review. We expect to admit accepted cases and build this resource for the forestry professionals and researchers in the Northeast. Updates on new submissions are to come!

New England Forest Inventory Network (NEFIN) Working Session

Jennifer Pontius[1]

[1]UVM and Forest Ecosystem Monitoring Cooperative

The Northeast Forest Inventory (NEFIN) project aggregates continuous forest inventory (CFI) data from across the region into a consolidated online tool. The tool will enable land managers, research foresters, and practitioners to develop a better understanding of forest structure, composition, and condition across the spatial and structural complexities of the region's forests.

NEFIN was developed out of a need to assess trends and patterns of forest metrics using CFI data. While there is a wealth of CFI data collected across the region, the data is collected by state, federal, academic, non-profit, and commercial entities, representing a range of ownerships, management approaches, disturbance history, and site characteristics. Assessing trends and patterns of forest metrics is a challenge from these heterogeneous forests and the dissociated patchwork of effort across the region. Further, the drivers of change in these forest systems have been variable across time, space, and scale. Managing the current forest resource and developing predictions of the future forests requires forest inventories at spatial and temporal intensities that are sufficient to capture the variation across the landscape and from year to year.

The workshop held during the annual FEMC conference shared the current status of CFI data holdings and explored the capabilities of the online NEFIN tool. Workshop participants discussed potential applications of the aggregated NEFIN data, and identified key information, analyses or research questions that should be prioritized applications of the NEFIN tool.

WORKSHOP GOALS

With a large number of CFI datasets currently integrated into the NEFIN database, and the development of the online portal and data exploration tool nearing completion, the specific goals of this workshop were to:

1. Expand the group of potential CFI contributors and end users.
2. Build an engaged collaborative network of forest professionals interested in improving our understanding of forest productivity, composition, structure, and condition, using the NEFIN database.
3. Understand how CFI data is currently used and currently limited, as well as how the NEFIN database can be used to inform current forest management across the region.
4. Identify key information or regional analysis gaps that should be prioritized for NEFIN application or highlighted as use case studies.

Two breakout sessions were held during the workshop to achieve these goals:

Current Use of CFI Data: Breakout 1 focused on identifying the biggest opportunities and barriers to using current continuous forest inventory data to inform the sustainable management of northeastern forests.

What are the sources of forest inventory data you currently use?

Responses fell into several categories, highlighting the wealth of CFI data currently available and the need for intensities from regional to local. This generally included:

- **Regional Inventories:** Most participants indicated a heavy reliance on USFS Forest Inventory and Analysis Data. This is primarily limited to the use of FIA analysis products such as distribution maps, state reports and data output products. The FEMC Forest Health Monitoring Network was also referenced as growing source of region wide data with a yearly resampling interval.

- **State Forest Inventories:** Use of data from a range of state-level organizations such as the Maine Ecological Reserves, Massachusetts DEC Water Supply, State Forest Lands.
- **Local (Forest Specific Inventories):** Several participants report their own CFI data sets, with regular collections used to inform forest prescriptions and management efforts.
- **Limited Use:** Some participants indicated that while inventories are made, this data has not been actively used to inform forest management.

How does forest inventory data currently inform your work?

Most participants reported using CFI data to inform local forest management, to compare and contrast outcomes of different forest management frameworks, to assess relative growth rates and stocking levels on their forests to broader forests across the region, and to compare forest composition and structure at a macro scale.

What specific metrics are most important to be able to extract from inventory?

Key metrics that are considered integral to making use of CFI date included: species composition, stand structure (size, canopy position), growth and yield metrics, and tree condition / mortality.

What are your current data limitations? What information do you need that is not currently available from existing inventory data sets?

Several participants identified key metrics that are not commonly collected as a part of CFI efforts, or not provided by their primary data source. This included a desire for more data on course woody debris, X-Y coordinates for trees, stand age structures, vegetative cover, invasive species, browse activity, as well as a desire for linked ancillary site and climate data to better. Others also indicated a need for plot location information in order to aggregate their own data into existing inventory data. However, emphasis was on the gaps in CFI data collection (either spatial gaps or temporal gaps) that could be filled by expanding NEFIN data sets and identifying key locations to expand current monitoring networks into.

NEFIN Data Application: Breakout 2 focused on specific research question do you want to see the NEFIN project address as a use case study.

How could you use expanded CFI data to inform your work? What information could aggregate CFI information provide that you are not currently getting?

Participants included forest professionals with varied interests across scale (from state-wide assessments to local forest management. As such, their interest in using CFI data included several areas:

- **More representative foundational metrics:** Most participants highlighted the use of broader CFI data as a way to improve and expand representation of forests and provide better foundational data for growth and yield modeling.
- **Change Detection:** The importance of regular, repeated measurements was stressed in order to better detect any changes in forest structure or function that could be mitigated or managed if detected earlier.
- **Forest Comparisons:** Many participants indicated an interest in assessing how their forests compare to other forest across the region and investigate why different patterns may exist in similar forest types across the region.
- **Forest Management Outcomes:** NEFIN may provide a new opportunity for forest managers to connect and compare management outcomes. This collaboration would help inform forest management moving forward, which is particularly important in light of the many stressors forests across the region currently face.

What analyses should be conducted on aggregated CFI data to better inform management of northeastern forests?

Participants also came from a diversity of disciplinary specializations (from forest management, to invasive species and soil science). As such, their interest in aggregated data analysis was varied, but focused on the following topical areas:

- **Species Specific Trends:** Several participants were particularly interested in how various species are faring in light of chronic and novel stresses. Questions such as: "How are specific species faring (growth trends)? Are we having trouble regenerating certain trees?" will become even more important the longer we track this information.
- **Forest Health:** As we begin to see potential "winner vs. loser" species emerge with a changing climate and spread of invasives it will be interesting to see how patterns in forest condition and productivity change across the region. How could this inform management to maintain a resilient forested ecosystem?
- **Forest Carbon:** Informing how management can affect carbon storage capacity in forests may be particularly useful as carbon sequestration becomes a more common management goal.

What are the benefits / uses of this broader examination of CFI data (beyond our individual areas of interest)?

The most common theme was the importance of broader spatial and temporal representation to better understand the patterns and drivers of change in our forests. This aggregation of data will allow better analysis of temporal change, and earlier detection of potential threats. In particular, participants noted the potential impact of climate change on specific species, with the potential to track changes in species distribution across the region in "real time".

Participants also saw the NEFIN effort not only as a new resource, but also as a potential "call to action". How information gaps (as well as information gained) can inform our inventory efforts moving forward may be critical to managing the regions forests at a time of great change.

Next Steps:

To maximize the utility of the NEFIN database, we continue work to expand the collaborative network. There are many ways that joining the NEFIN collaborative can benefit forest professionals across the region:

- **Make your data go further:** Contributing data to this effort will make it easier for researchers to begin answering questions with your data, instead of spending cleaning and merging disparate datasets, while respecting your data sharing limits.
- **Get detailed data documentation (for free!):** As part of the data integration, we will be generating detailed and robust documentation of the methods (and changes in methods) used in each program following best-practices in metadata and information management.
- H**elp and learn from your peers:** By participating, you will join professionals from across the region who are developing and utilizing inventory data for a range of purposes. Learn something new, and help others learn from what you are doing.

Poster Presentations

The poster session was held online. . Each presenter had an opportunity to share the topic of their poster in a pre-recorded flash talk. Following all presentations, break-out rooms were opened for each presenter to have more intimate discussions and answer questions from attendees.

Posters can be viewed at: https://www.uvm.edu/femc/cooperative/conference/2021/content

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

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