Proceedings of the December 13, 2019 **Forest Ecosystem Monitoring Cooperative** Conference

Monitoring for Impacts of Climate Change: Tracking and measuring outcomes in northeastern forests

FEMC
Forest Ecosystem Monitoring Cooperative

Davis Center • University of Vermont • Burlington, VT, USA

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 U.S. DEPARTMENT OF AGRICULTURE

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Introduction to the Proceedings

The Forest Ecosystem Monitoring Cooperative (FEMC) held its 29th annual conference on December 13, 2019, in the Davis Center at the University of Vermont. The guiding theme, ***Monitoring for Impacts of Climate Change: Tracking and measuring outcomes in northeastern forests*** was chosen to focus on the importance of monitoring in helping understand and manage for the impacts of climate change throughout northeastern forests.

An opening plenary session moderated by Vermont Commissioner of Forests, Parks and Recreation Michael Snyder, featured remarks from renowned climate change biologist Richard Primack and Massachusetts Fish and Wildlife Habitat Program Supervisor John Scanlon. Both speakers emphasized the importance of using historical records and ongoing monitoring to track the effects of climate change and evaluate the success of our management efforts.

This year's conference included two sessions of concurrent talks where 30 collaborators from across the region presented their most recent research and monitoring efforts. Afternoon working sessions allowed participants to engage directly with regional experts, providing critical input to ongoing efforts ranging from co-designing forest adaptation research to using knowledge co-production minimize invasive pest risks. As always, these sessions provide valuable time for the collaborative network to engage around ongoing projects to further our collective understanding of the region's forests and the threats they face.

These proceedings represent a combination of summaries, abstracts and outcomes collated by FEMC staff as a resource for forest professionals working across the region. Additional details, including videos and downloadable PowerPoints of presentations can be found on the meeting home page at: www.uvm.edu/femc/cooperative/conference/2019/content.

Monitoring for Impacts of Climate Change: Tracking and measuring outcomes in northeastern forests

As our understanding of climate change and its potential negative impacts on forested ecosystems in the Northeast grows, many innovative efforts are being initiated across the region to manage for and adapt to changing climate patterns. Following the theme of the previous Forest Ecosystem Monitoring Cooperative (FEMC) conference, ***Forests and Climate Change: Managing impacts and planning for the future***, this year's conference focused on the ways in which we can track and assess the effectiveness of our management efforts. Because climate is so highly variable in both spatial and temporal realms, quantifying changes requires long-term data to detect gradual shifts, along with future projections informed by robust models. It requires ecologically relevant metrics to capture conditions most likely to impact forested ecosystems and defined objectives to best understand if desired outcomes are achieved. Many professionals across our region have risen to this monitoring challenge and gathered at the 2019 FEMC annual meeting to share their approach, successes and findings to help inform how we can better monitor for climate change impacts moving forward, and how we can evaluate the success of efforts to manage or mitigate these impacts.

The annual conference of the FEMC provides an important opportunity for communication, exchange of ideas, and expanding collaboration around forest ecosystem management and monitoring in the region. These Proceedings serve as an archive of these presentations, conversations and working sessions and provide a framework from which to continue and improve our collective efforts to sustain forested ecosystems across the northeast.

Summaries of Morning Plenary Sessions

Using historical records combined with modern records to track the effects of climate change on the plants and animals of Thoreau's Concord

Richard Primack, Professor of Biology, Boston University
Richard Primack, author of the well-known book, Walden Warming, studies the effects of climate change on the flowering, fruiting, and phenology plants, the migration times of birds, the flight times of insects, and the potential for ecological mismatches among species resulting from climate change
Dr. Primack has been the recipient of the Bullard and Putnam Fellowships from Harvard University, the Alexander von Humbodlt Foundation Award, and a Guggenheim Fellowship.

In 2002, Dr. Richard Primack began to research the effects of climate change in the eastern United States with students from Boston University. They have, over the past 17 years, developed techniques for measuring and documenting the environmental impacts of climate change across the plant and animal kingdom, including comparisons to rich historical data. This work is particularly relevant in New England, where temperatures have been increasing faster than anywhere else in the United States.

Dr. Primack's research addresses three main questions: *How has biodiversity been affected, why should we care and what are we going to do?* Addressing the first question, Dr. Primack identified key indicators for monitoring the biological impacts of climate change such as vegetation phenology, distribution of species, and abundance of species. To this end, Dr. Primack has collected years of data on seasonal phenology, ranging from the timing of pond and lake freeze in the fall and thaw in the spring as a physical manifestation of climate change, to migration patterns of birds and butterflies, and yearly growth of trees. The most efficient way to study these indicators relative to climate change is comparing current patterns to historical or continuous records.

Dr. Primack's efforts include examining records recorded by Henry David Thoreau in the 1850s in unpublished journals. Thoreau recorded information about both cultivated and wild species of plants over an eight-year period in Concord, Massachusetts. Thoreau's observations were repeated by another biologist named Alfred Hosmer from 1878 to 1902.

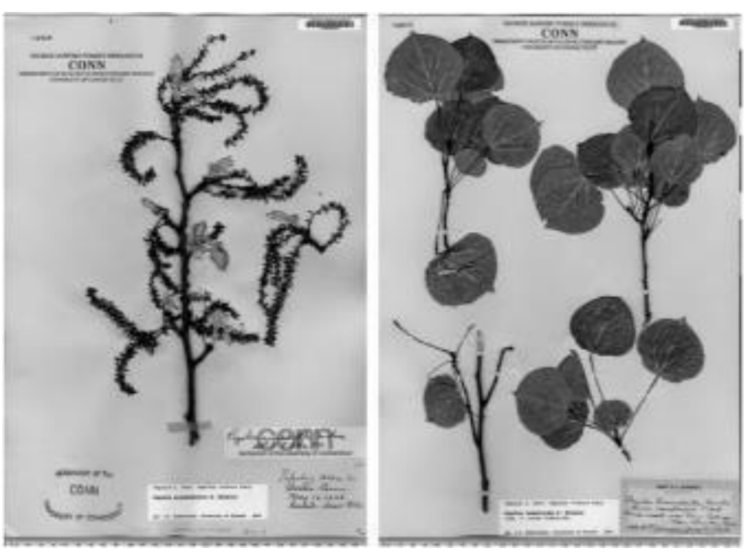
Starting in 2004, students went to Concord to repeat the same observations that Thoreau and Hosmer made. They looked for the first flowering time in the spring for specific wildflowers, and for the timing of tree leaf out. In Thoreau's years, the average flowering time was May 16th, in Hosmer's years it was May 11th and the new data from Dr. Primack and his students put the average flowering date around May 6th.

Compared to historical climate records, these compiled data also show that average flowering time has a direct correlation with the spring temperature.

In addition to direct changes in temperature and plant phenology metrics, Dr. Primack also discovered changes species distribution. The northeastern region is experiencing a significant loss of wildflower species even in well protected landscapes such as Concord where 27% of the wildflower species documented by Thoreau are now locally extinct. Many of these species include cold-climate loving species, providing evidence that this may be related to climate change in the region.

Dr. Primack's data indicates that trees may be more sensitive to rising temperatures then spring flowers, leafing out about two weeks sooner then what Thoreau recorded. Scientists suggest that these changes in trees may be related to changes in understory vegetation as earlier leaf out shades the understory, resulting in a shorter period of full sunlight at critical reproductive times.

This phenomenon where changes in one species may have cascading impacts on another is called an ecological mismatch. There are concerns that similar mismatches between plant flowering and native insects could be contributing to recent decreases in the biomass and species diversity of native insects. A similar mismatch could be occurring between plants and birds.



Another source of information used to track changes in species phenology, biomass and diversity includes herbarium specimens. Historical records of plant collections as well as old photos were found to be a good source of information to track changes in species distribution and abundance as well as differences in phenology.

Models suggest that by the end of the century, the northeast will experience a 3-5°C increase in average temperatures. Considering the changes documented by Dr. Primack and his students over our historical 1-2 °C increase, such a drastic change moving forward could have dire consequences for the regions flora and fauna. Dr. Primack stressed the importance of collaboration among researchers and practitioners, outreach and education of the public, and the potential of citizen science to expand our monitoring efforts. It is only through these collective efforts that we can promote and protect forest health and educate the public on the importance of taking action.

Considering the importance of Thoreau's work in Dr. Primack's ongoing research and monitoring efforts, he closed with three lessons to take from Thoreau:

"***Observe nature carefully, live simply and try to affect society."***

Evaluating success of monitoring for impacts of climate change on state wildlife lands in Massachusetts

John Scanlon, Habitat Programs Supervisor at Massachusetts Division of Fisheries & Wildlife
John Scanlon brings over 30 years of experience in forestry, wildlife management, ecological restoration, wetlands, natural resource management, and environmental awareness. Starting as a forester in the Massachusetts Division of Fisheries and Wildlife, Mr. Scanlon now leads the assessment and prioritization of state wildlife lands for active management, provides technical assistance to private and public landowners, while conducting public outreach for management activities, and monitoring management impacts.

John Scanlon began his presentation by asking three key questions:

> ***What are we managing for?***
>
> ***What are the environmental stressors that are impacting managed forest ecosystems?***
>
> ***How do we assess the impacts of management relative to environmental stressors?***

The answers to these questions are necessary to fully assess the effectiveness of current management strategies, which is critical to guide our efforts moving forward. This is the work that John Scanlon leads in Massachusetts, with the goal of informing restoration and management activities with climate change in mind.

The Massachusetts State Wildlife Action Plan encompasses and monitors a range of habitat types across Massachusetts. These habitat sites that includes grasslands, shrub lands, young forests, full canopy forests and forest reserves. In order to address the first question (What are we managing for?), Scanlon and his colleagues built on the rich archive of peer reviewed scientific papers to identify clear, measureable outcomes for each habitat type. For example, they identified targets for coverage and distribution for each habitat type based on levels necessary to maintain viable populations of native wildlife species. At 81% of the state's wildland habitat types, full canopy forests are well above their target distribution of 60-70%, while grasslands, shrub lands, and young forests are well below their targets.

Before climate change was widely understood to be an environmental stressor, human land use such as deforestation, agricultural conversion, and subsequent abandonment were the primary drivers of habitat type and condition across the landscape. In terms of his second question (What are the environmental stressors that are impacting managed forest ecosystems?), we now have evidence for how strongly climate change has shifted key ecosystem processes.

Several decades ago, a similar stressor was discovered after widespread decline in high elevation spruce fir forests came to the forefront. Acid rain was identified as the primary culprit and represents a tremendous success story of science informing policy, which translated into measurable improvements in ecosystem health and function. Concerns, voiced by scientists and conservationists, successfully led to the 1990 Clean Air Act. This hinged on the resounding evidence of the negative impacts of acid rain on the ecosystem, and how well researchers were able to communicate these impacts to the public. The positive impacts of the Clean Air Act are now evident in the rebound of red spruce ecosystems across the region. This serves as an excellent example of how monitoring was key to both identifying the cause of the problem, but also in demonstrating the impact of the policy solution.

But monitoring ongoing impacts of climate change, as well as the effectiveness of management and policy actions may not be as straightforward as it was for acid rain. Often climate impacts on forested ecosystems are indirect, with feedbacks and interactions that cross species boundaries. In other cases, some species will benefit from climate change shifting competitive dynamics that have dominated successional processes for thousands of years. For example, oak and hickory populations are projected to increase while maple, beech and birch populations are projected to decrease under changing climate. In terms of overall forest "health" understanding our target outcomes and how the current stressors will impact those outcomes is essential to designing the right management strategy.

In Massachusetts, Scanlon and his colleagues are monitoring vegetation, breeding birds, pollinating insects, vernal pools, and carbon in order to provide the data and information necessary to measure progress towards target outcomes and track the impact of management efforts. For example, MassWildlife implements stratified vegetation monitoring at primary monitoring sites and uses the information about species occurrence and abundance to map observed concentrations and distributions of target species. This information is used to make sure that locations of advanced regeneration are protected.

Scanlon also stresses the importance of "thinking outside the box" in terms of identifying monitoring targets. For example, because their abundance corresponds to flowering plant species, pollinating insects may serve as a more easily measurable proxy for vegetation abundance.

In order to monitor for any potential impacts of climate change on our diverse landscapes, we will need to emulate and improve on these efforts demonstrated in Massachusetts' managed areas. This is not an easy charge for the region's land managers, but the conservation and restoration of landscape diversity should prove worth it.

Abstracts from Contributed Talks

There were 28 talks contributed to the conference, presented between two sessions throughout the day. In the morning, there were four concurrent sessions. These sessions included *Climate and Forest Ecosystems* moderated by Cormac Quinn, *Pests and Disease* moderated by Ryan Kincaid, *Technology and Partnerships* moderated by Stephanie Long and *Forest Management* moderated by Meredith Naughton. There were four concurrent sessions in the afternoon session of talks as well. The concurrent sessions included the continuation of *Climate and Forest Ecosystems* moderated by Cormac Quinn, *Forest and Alpine Ecology* moderated by Ryan Kincaid, *Wildlife* moderated by Stephanie Long and *Forested Waters* moderated by Rebecca Harvey. Below are the abstracts submitted for these talks, including author affiliation. The presenting authors name is in bold type.

Climate and Forest Ecosystems

Moderator: Cormac Quinn

Consisted of seven talks, encompassing both the morning and afternoon sessions of the Contributed Talks, related to Climate and Forest Ecosystems.

Assessing ecosystem controls on soil carbon storage across the northeastern United States

Adam Noel[1]

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

Effects of climate change can be seen globally. Mitigation plans to rising atmospheric carbon dioxide (CO2) levels are a top concern among academics and the public alike. Of the major carbon reservoirs, soil pools represent the largest and most stable resevoirs that may be influenced by management decisions. The study of soil carbon sequestration must take into account many interactions among variables. Thus, I have drawn on the state factor framework from ecosystem ecology to integrate diversity with other factors on a landscape scale (climate, topography, parent material). Looking beyond species richness effects, tree species functional traits have been shown to alter aboveground productivity and may also have impacts on belowground carbon stocks. This study will show the current results of a Northeastern region study using forest inventory analysis (FIA) plots analyzing landscape variable effects on soil carbon stocks, and will be the first study to demonstrate results in a temperate forest setting.

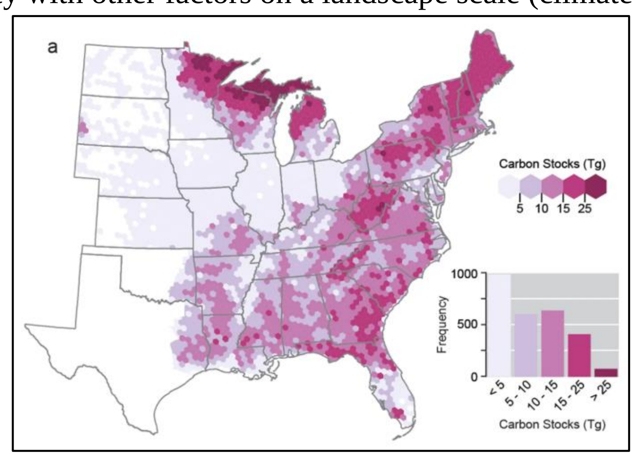


Figure 2. Forest Carbon Stocks (aboveground)

Every picture tells a story aka/ forest photography designed to document, interpret and monitor climate change-forest change

Roger L. Merchant[1]

[1]Associate Extension Professor Emeritus, University of Maine Cooperative Extension, Forestry-Nature Tourism-Community Development

How might we visually monitor forests and landscapes to document and interpret forest changes from climate change in New England? Every Picture Tells a Story illustrates methods and perspectives from forest photography designed to capture essential characteristics of trees, forest stands and landscapes, as well as changes in their character over time, offering light-weight possibilities for visually monitoring long-term forest change.

Two narrow windows of dynamic forest change brighten our windows annually; the intense coloration of autumn and subtle pastels before bud break. Gifford Pinchot planted a European beech on his estate remarking, “too bad I won't live long enough see this to maturity”. His magnificent beech now bears witness to decades of cultural and environmental change. Annual changes to this tree seem barely notable, save for photos displayed in a “now and then window”.

Climate induced forest change is upon us, the trees and the forest. U.S. Department of Agriculture (USDA) Tree Atlas research graphically reveals cold adapted species migrating northwards as things heat southwards. Measuring and monitoring forest change helps our social and environmental understanding, but this is complicated by this eco-relocation that will likely occur in landscapes over the next 100, 200, 400 years. How might we capture data and pictures that tell this evolving story over a longer span of time, over lifetimes?

Every Picture Tells a Story explores “forest photography by design” which minimizes visual chaos in forest scenes, helping clarify forest subject matter for documentation, interpretation and monitoring purposes. We examined interior scenes of forest stands, as well as landscape level details that inform these purposes. As a forester and photographer, I began documenting forest changes in 1980. Recently I opened up a 73-year monitoring window on forest change in the 1943-2016 Forest Project. These and other examples inform how we might visually capture climate-forest change.

Tracking climate-forest change through research and measurement is an important, ongoing conversation. I would add and argue that, in tandem with this, we need a base of visual data that photographically captures forest change at stand and landscape levels. Each mode is distinct, but when integrated and presented in tandem, they form a powerful whole data set, grounded in both the research and the visual landscape, telling and showing our story under the thumb of human induced climate change.

Monitoring long-term forest change is a human act requiring much patience, if not faith, given current events concerning climate change/forest change. Every Picture Tells a Story illustrates photographic perspectives and methods that can capture the essential character of forests and forest landscapes. Visual tools and photographic methods that clarify the character of forests and landscapes today can establish an important baseline for monitoring climate change/forest change.

Forest Carbon: An essential natural solution for climate change

Paul Catanzaro[1], Tony D'Amato[2]

[1]University of Massachusetts Amherst
[2] Rubenstein School of Environment and Natural Resources, University of Vermont

Forests play a critical role in reducing the effects of climate change. There is growing debate about the most appropriate strategy to maximize this benefit. This presentation covered the role carbon plays within forests, the impacts and trade-offs of land-use options on forest carbon, and specific carbon-informed forest management strategies to help maintain carbon storage during a timber harvest.

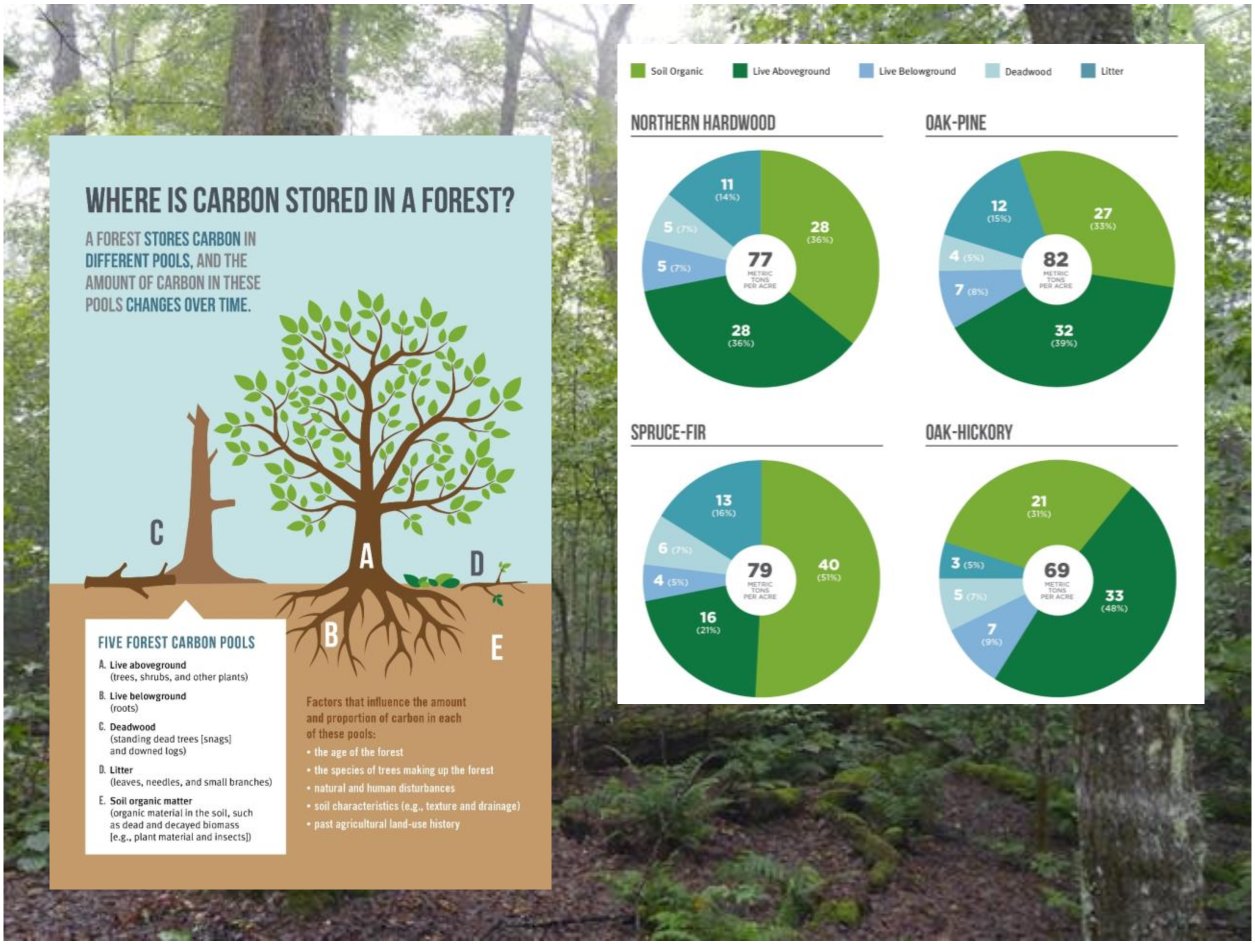


Figure 3. Different types of forest carbon pools and their percentages in different forest types.

Growth of northeastern tree seedlings in response to future precipitation scenarios

Peter Clark[1], Tony D'Amato[1]

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

Seedling germination, growth, and establishment is a sensitive period and a critical bottleneck in the regeneration of forest trees, yet little is known about how this process will be impacted by a shifting climate. Despite projected future shifts in species ranges, the germination and regeneration response of locally adapted (current) tree species compared to those predicted to be better adapted to future conditions is poorly understood. Understanding forest regeneration response under novel future climate scenarios is important as it may lead to compositional or functional shifts in forests with implications on forest health, productivity, and biodiversity.

To examine the regeneration of forest trees under shifting climate, we test the response of fourteen currently-adapted and "future-adapted" species grown from seed and bare-root seedlings under precipitation manipulation located in recently harvested forest gaps. Tree species were selected across a suite of functional traits from species currently common in northeastern US forests as well as from species projected to be better adapted to future climates. Two seedbed treatments (scarified and undisturbed) and four precipitation scenarios (projected shifts in rainfall frequency and magnitude) were used to examine species response in establishment, phenology, allocation, and water use efficiency.

Results indicate a strong germination response to seedbed treatment with a mean increase of 128% (±58) in scarified treatments. Seedlings responded most positively to rainfall frequency while rainfall magnitude had less effect. Precipitation treatment most positively influenced growth and establishment of larger seeded species such as *Pinus strobus*, *Fagus grandifolia*, *Castenea dentata*, and *Quercus rubra* but survival was moderated by an interaction between precipitation and soil treatment. Species life stage and functional traits are most important for seedling growth and survival to treatments, which will have consequences for managing for future adaptability in stand composition (assisted migration) and emphasizes the importance of species functional traits for decision making.

The implications of this research may refine future species distribution models as well as provide tangible information for managers of northern forests seeking to maintain ecosystem function during a time of uncertain future global conditions.

Moving the Needle: Assessing what forest managers need to increase climate adaptation in New England

Amanda Mahaffey[1], **Christopher Riely**[2] Maria Janowiak[3],

[1]Forest Stewards Guild
[2] Sweet Birch Consulting
[3] Northeastern Institute of Applied Climate Science, US Department of Agriculture Forest Service

Forestry and natural resource professionals are increasingly looking for information on the anticipated effects of climate change on ecosystems, as well as potential management options for responding to these changes. At the same time, the inability to know exactly what will happen in the future can create significant barriers for incorporating new information into management planning and project implementation. The field of climate change adaptation has been growing rapidly in the past decade, with multiple organizations providing scientific and technical resources to help advance climate-informed practices across the northeastern United States and beyond.

We conducted a needs assessment to better understand the status of climate change adaptation among forest and land managers in New England in order to characterize existing barriers to implementing climate-informed practices and identify actions that would help overcome the biggest challenges. The needs assessment consisted of an online questionnaire and four in-person listening sessions that engaged dozens of practitioners from across New England. There was widespread agreement among the participants that the climate was changing and that the effects were observable through a variety of changes occurring in forests, including warmer temperatures, more extreme events, and increases in forest pests, diseases, and invasives species. Participants reported that more information was needed related to climate change and its interactions with other ecosystem components, particularly in relation to tree species dynamics, wildlife, altered hydrologic cycles, invasive plants and pests, and human social and economic factors.

Participants pointed to a number of barriers to climate change adaptation, the greatest of which was the perception of greater uncertainty of future conditions as a result of a changing climate and its effects on ecosystems. The challenges that were identified by New England practitioners as part of this assessment are consistent with many surveys that have been conducted regionally and nationally among forest managers and natural resource professionals. A primary purpose of the needs assessment was to identify actions that would help overcome these barriers.

We identified five key themes:

- Manage in the face of uncertainty.
- Expand information resources to inform decisions.
- Prioritize risks and management actions.
- Address barriers to sustainable forest management.
- Learn from each other through communities of practice.

The needs assessment process convened a large number of forest managers who are actively interested in advancing climate change adaptation in their work. By providing a venue for managers to express a desire for action, we have demonstrated that there is a high degree of interest in the topic and that a forest climate adaptation community of practice is beginning to coalesce in the region.

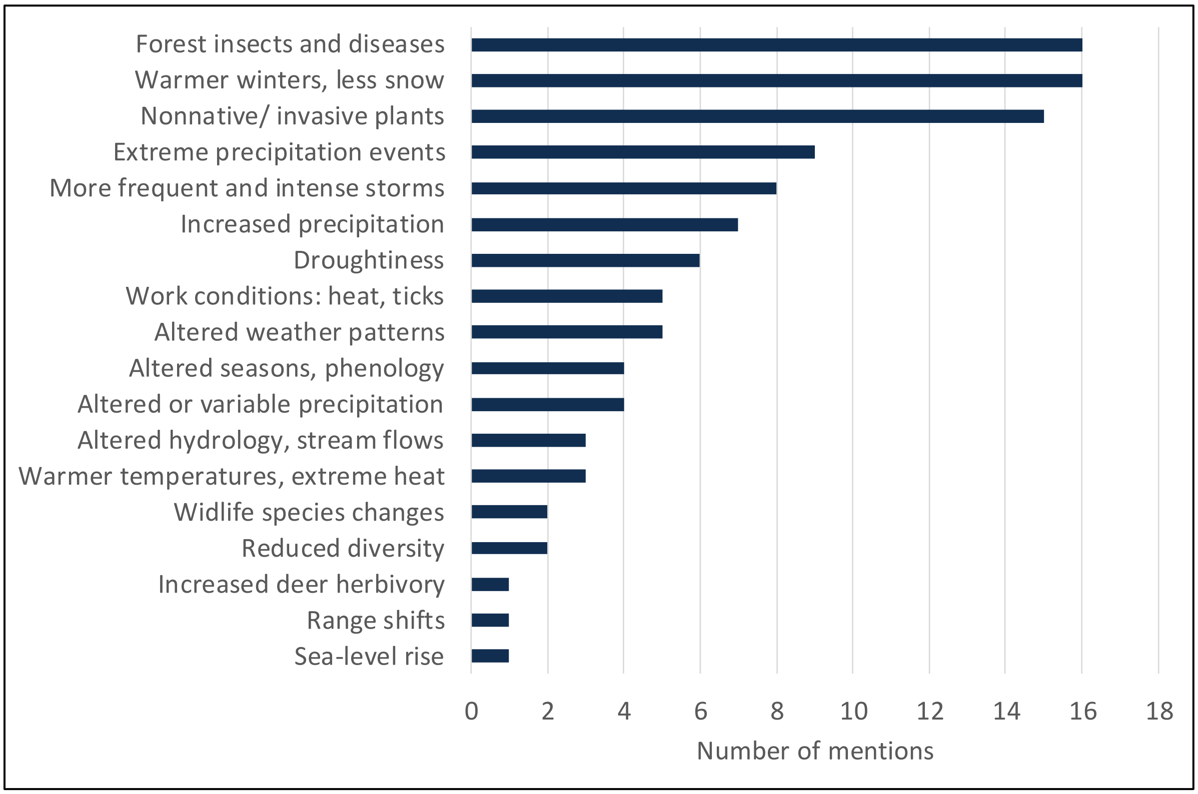


Figure 4. Observed environmental changes due to climate change: Measurement of mentions by participants of online questionnaire and in person listening sessions.

Northern hardwood forest soil respiration response to climate change: Insights from multiple climate manipulation experiments

Andrew B. Reinmann[1,2], Lindsey E. Rustad[3], Heidi Asbjornsen[4], Matthew Vadeboncoeur[4], Pamela H. Templer[5], John L. Campbell[3], Timothy J. Fahey[6]

[1]City University of New York (CUNY) Advanced Science Research Center
[2]Hunter College
[3]US Department of Agriculture Forest Service
[4] University of New Hampshire
[5]Boston University
[6]Cornell University

Mean annual air temperatures for the northeastern U.S. are projected to increase to 3 to 5 °C by the year 2100, which could stimulate ecosystem process like carbon sequestration. Climate models also project that warmer winters will result in reduced snow cover and increased frequency of soil freeze-thaw events, which may offset the positive effects of warming by damaging roots. Furthermore, extreme climate events such as drought and ice storms are expected to become more frequent and severe, which may also have adverse impacts on forest ecosystems.

Ecosystem carbon cycling is heavily mediated by climate conditions and projected changes in climate across the northeastern U.S. are likely to have important implications for northern hardwood forests. At Hubbard Brook Experimental Forest in New Hampshire we leverage three separate climate manipulation experiments to quantify and contrast the response of soil respiration, the second largest carbon flux in northern hardwood forests, to these expected changes in climate.

The Climate Change Across Seasons Experiment (CCASE) was initiated in 2012 to induce both growing season warming and increased freeze-thaw cycles in winter. The DroughtNet experiment was initiated in 2015 to reduce throughfall by 50% (Phase 1) and 90% (Phase 2). The Ice Storm experiment (ISE) was initiated in 2015 to induce forest canopy damage from different levels of ice accumulation on branches.

We found that soil warming increases rates of soil respiration by nearly 40%, but soil freeze-thaw cycles offset this stimulatory effect of warming. In comparison, moderate (50% exclusion) and severe (90% exclusion) drought conditions reduce soil respiration by <25% and ~50%, respectively. Notably, we found large reductions in soil respiration within weeks of initiating the 90% through fall exclusion treatment. Despite creating large amounts of litter and woody debris, the ice storm experiment had a small and negative impact on soil respiration. Collectively, these findings suggest that changes in climate that result in soil warming (in the absence of soil freezing) and/or severe drought conditions (even those of short duration) will have the biggest impacts on rates of soil respiration.

Vermont's Functioning Floodplains Initiative – Reconnections in the riverscape

Mike Kline[1], Gretchen Alexander[2]

[1]Fluvial Matters, LLC
[2]Vermont Department of Environmental Conservation

A partnership of Vermont agencies and organizations is developing and applying data and mapping methodologies to support river research and watershed-scale restoration of stream, wetland, and floodplain function. New fluvial process data and a publicly accessible mapping platform will be used to promote the restoration of natural floodplain functions and optimize the implementation of conservation and restoration practices that address the loss of stream, wetland, and floodplain connectivity.

Fundamental to Vermont's climate adaptation effort will be promoting change at relatable natural and socio-economic scales. Changes in land practice to restore functioning floodplains are largely at the discretion of local communities. Landowners and state/federal technical and funding assistance programs must be geared toward local asset management. The Functioning Floodplains Initiative will seek to garner local community support by publicizing and tracking the accumulation of the natural and socio-economic assets derived from connected and naturally functioning floodplains including: fish and wildlife habitat, water quality, avoided damage from floods and fluvial erosion, and the storage of carbon affecting the earth's climate.

Forest and Alpine Ecology

Moderator: Ryan Kincaid

Consisted of four talks in the afternoon session of the Contributed Talks

Forest structure could mitigate negative impacts of climate change on functional diversity in northeastern North America

Dominik Thom[1], Anthony Taylor[2], Rupert Seidl[1], Wilfred Thuiller[3], Jiejie Wang[2], Marie Robideau[4], William Keeton[4]

[1]Institute of Silviculture, University of Natural Resources and Life Science (BOKU) Vienna
[2]Atlantic Forestry Centre, Natural Resources Canada
[3]Université Grenoble Alpes, Laboratoire d'Ecologie Alpine
[4]Rubenstein School of Environment and Natural Resources, University of Vermont

Evolution has equipped organisms with a diverse set of traits to cope with their environment, selecting for a diversity of functions that determine plants' life history strategies. The functional diversity (FD) of an ecosystem defines its range of possible responses to environmental change. Many are now recommending integration of FD concepts within forest management plans to build greater adaptive capacity to climate change. However, incomplete scientific understanding hinders the implementation of FD-based management approaches. Our study fills some of these knowledge gaps by (i) mapping the current distribution, (ii) analyzing the drivers, and (iii) testing the sensitivity of FD to increases in temperature and precipitation in northeastern North America.

We combined a literature and database review of 44 traits for 43 tree species with terrestrial inventory data of 48,426 plots spanning an environmental gradient from northern boreal to temperate biomes. We assessed the impact of 25 explanatory variables on FD and conducted a climate sensitivity analysis, employing an ensemble approach of combining multiple non-parametric models. Using functional Hill numbers, we tested the effect of rare vs. abundant species on FD.

Temperate forests and the boreal-temperate ecotone east and northeast of the Great Lakes were identified as FD hotspots. FD was most strongly associated with forest stand structure. FD responses differed for increases in temperature and precipitation. Temperature elevated FD in boreal, but lowered FD in temperate forests. Precipitation effects were less distinct, but negative to neutral throughout the region. Weighting species abundance differently changed the results only marginally.

Environmental filtering is only of secondary importance behind forest structure in explaining the FD distribution for tree species in northeastern North America. Forest management can increase FD by fostering structural complexity. These efforts can compensate negative impacts of climate change on temperate forests, and increase the diversity of functionally poor boreal ecosystems. Moreover, mixing species from functionally different groups may improve the adaptive capacity of forests to an uncertain future.

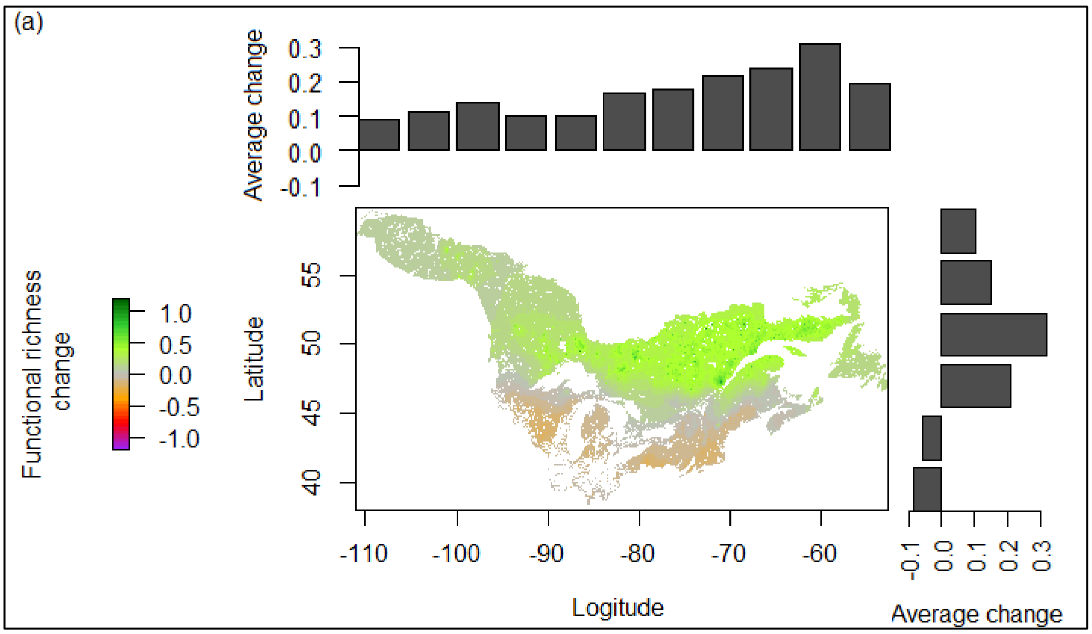


Figure 5. The change in functional richness due to climate sensitivity. Boreal forests: Increasing functional diversity. Temperate forests: Decreasing functional diversity.

Monitoring plant populations in the Adirondack Alpine

Tim Howard[1], Kayla White[2], Julia Goren[3]

[1]New York Natural Heritage Program
[2]Adirondack Mountain Club
[3]Adirondack Council

Our populations of alpine plants in the Adirondack Mountains seem especially sensitive to change because of the small total area of alpine zone both seperately on each Adirondack alpine summit and altogether. Our goal for this project is to monitor plant populations in the alpine zone through repeated, stratified random sampling.

We report on findings from our first three sampling bouts, separated by about six years: 2006-2007, 2013, and 2018-2019. In 2006-07. We sampled 376 plots; in 2013, we sampled 371 plots; and in 2018-2019 we sampled 379 plots. Each sampling effort was conducted on the 17 summits with significant alpine vegetation. Each plot was placed using a spatially-balanced, randomization procedure in GIS. Field crews located these points using GPS. Within each 5m X 5m plot we counted the number of stems or plants. For species where individuals were hard to count, we estimated aerial coverage.

We used generalized linear mixed models to examine the effect of sample bout as an ordered factor while accounting for differences among summits and the effect of terrain differences such as solar radiation, slope, surface curvature, flow accumulation, and flow drop. Models were fitted using a zero-inflated negative binomial distribution. Of the nine species found in at least 4% of the plots, five had a significant positive response over the three time periods, one had a negative response, and three had no significant change in count. We discussed these patterns in vegetative response as they relate to our predictions about vegetation change in the alpine zone.

Northern Hardwoods and Long-Term Change: Assessing old-growth and managed experimental forest in Adirondack Mountains of New York

Stacy McNulty[1], Ravyn Neville[1], Gregory McGee[1], René Germain[1]

[1]State University of New York College of Environmental Science and Forestry (SUNY ESF)

Late-successional forests possess unique biological assemblages due to structural features such as large trees, multi-layered canopies, roost and den sites and wildlife foods. The Sugar Maple (*Acer saccharum*) - Yellow Birch (*Betula allegheniensis*) - American beech (*Fagus grandifolia*) northern hardwood forest type in northeastern North America provides diverse and complex habitats for vascular plants, animals and other species. However, most northern hardwood forests have been compromised by the invasive scale/fungal complex Beech Bark Disease (BBD) which targets beech. Infected trees produce prolific root sprouts which form dense understories of shade-tolerant saplings at the expense of desirable herbs, shrubs and tree seedlings. BBD killed the majority of mature, nut-producing beech decades ago, but many trees are again reaching maturity. The dramatic changes caused by BBD are of concern for long-term forest resilience, biodiversity, habitat quality, and productivity in the face of climate change.

SUNY ESF's 6,000 ha Huntington Wildlife Forest (HWF) is a research and monitoring site centrally located in the 2.4 million ha Adirondack Park; HWF contains over 400 ha of >300-year-old forest. In mature stands on HWF, BBD severity has a strong influence on the probability of beech survival and infected trees can survive for over 25 years, creating both opportunities and challenges. In one second-growth forest with BBD, an experiment provides information on pre- and post-harvest vascular plant, epiphyte, bat, small mammal, and bird responses to forest management. The treatment is designed to retain critical wildlife trees and remove diseased beech and provide opportunities to assess long-term changes to this forest type.

Given millions of hectares of BBD-invaded forests in the region, combined with threats such as climate change, effective understanding of and management to retain habitat features for native communities is critical. Adirondack Park is the largest contiguous wild landscape in the coterminous United States and part of the United Nations Educational, Scientific and Cultural Organization (UNESCO) Champlain-Adirondack Biosphere. As such, it provides an exemplary place to investigate long-term changes to forest resilience, structure and composition, species assemblage and dynamics in old growth and managed forest. We present an eighty-year record of forest dynamics in this northern hardwood system.

Trends and Environmental drivers of tree growth for seven major species in Vermont: future implications in the context of climate change

Rebecca Stern[1], Paul Schaberg[2], Shelly Rayback[3], Chris Hansen[1], Paula Murakami[2], Gary Hawley[1]

[1]Rubenstein School of Environment and Natural Resources, University of Vermont
[2]US Department of Agriculture Forest Service
[3]Department of Geography, University of Vermont

As climate change progresses, tree species and forest types in the Northeast are expected to shift in response to changing temperature and hydrologic regimes. However, an accurate understanding of the future health and productivity of regional forests is likely dependent on information regarding how species have responded to past changes in factors such as climate and pollution inputs.

Using standard dendrochronological techniques, we quantified changes in annual xylem increment growth of dominant and codominant hardwood (sugar maple, yellow birch, American beech, red maple, and red oak) and conifer (Eastern hemlock and Eastern white pine) trees at multiple sites across different latitudes and elevations throughout Vermont. Red oak, Eastern hemlock, and Eastern white pine all exhibited sustained increases in growth over the past 70 years, while the remaining species showed evidence of plateaued growth during the past 40 years.

We also related relative growth trends to local- and elevation-adjusted climate data (e.g., temperature and moisture) and pollution inputs of sulfur and nitrogen to assess their influence on species-specific productivity. Although many associations with environmental parameters were species-dependent, all seven species showed positive associations between growth and summer moisture and negative associations with summer temperature. The classic northern hardwood species, sugar maple, American beech, and yellow birch, all showed positive correlations with moisture at the beginning of winter and negative correlations with warmer winter temperatures. Both eastern white pine and eastern hemlock showed positive associations between growth and spring temperatures. Somewhat surprisingly, all species except American beech exhibited negative associations with pollutant deposition. We described how these findings compare to species ecological niches and may relate to projected changes in suitable habitat with climate change.

Forest Management

Moderator: Meredith Naughton

Consisted of three talks in the morning session of the Contributed Talks.

Climate change and stream crossing practices on Vermont's timber harvests

David Wilcox[1], Karl Honkonen[2]

[1]Vermont Department of Forests, Parks and Recreation
[2]US Department of Agriculture Forest Service

As our climate changes, so do challenges in timber harvesting operations. A stream that may have been a small trickle one day could be a raging torrent the next. If you are planning a timber harvest in Vermont and run into this situation, how do you get your timber from one side of the stand to the other? Stream crossings are the main source of sediment associated with logging operations. Many stream crossing structures are undersized to handle increasingly larger and more frequent flood events. The Vermont Department of Forests, Parks and Recreation (VT FP&R) received a grant from the US Forest Service to improve stream crossing practices on timber harvesting operations to reduce nonpoint source pollution. This project provided technical assistance to loggers participating in the Portable Skidder Bridge Rental Program to ensure that bridges were installed, used and removed correctly, and that Acceptable Management Practice (AMP) compliance was attained, ensuring a higher level of protection for water resources.

Comparison of the resistance of even-aged and uneven-aged stands to environmental stressors in temperate forests as measured by tree mortality

Rebeca Cordero Montoya[1], Philippe Nolet[1], Christian Messier[1], Anthony D'Amato[2]

[1] Institut des Sciences de la Forêt Tempérée, Université du Québec en Outaouais
[2]Rubenstein School of Environment and Natural Resources, University of Vermont

With global change, forest trees will be exposed to more and more stress in the coming decades. However, little is known about how forest management will interact with these stressors and how they will impact the ability of trees to resist disturbances. Resistance is the capacity of an ecosystem to absorb the effect of a disturbance and to remain largely intact; therefore, in our case, tree mortality is assumed to show a lack of resistance. The objective of this study was to compare stress-related tree mortality in the two most common silvicultural systems used in Northern hardwoods: even-aged and uneven-aged silviculture (hereafter EAS and UAS). Our hypothesis is that the forests managed under EAS will show a higher resistance to stressors as measured by density independent mortality than UAS.

Using a novel terrestrial mobile LiDAR technique, we mapped all dead and living trees (>10 cm DBH) within 40 sugar maple dominated stands: 16 even-aged, 16 uneven-aged and 8 old-growth stands. We separated the relative role of forest management on individual tree mortality from other factors such as size, species and neighbour competition by modelling the probability of mortality for each tree. We observed that density-dependent mortality was similar between EAS and UAS stands. Nevertheless, for large trees, density-independent mortality was greater in the UAS than EAS stands. This is assumed to be due to the fact that trees in UAS stands often go through several periods of growth suppression, increasing their vulnerability to various biotic and abiotic stressors compared to trees in EAS stands, which experience a more stable neighbourhood competition during their lifecycle. Our study suggests that the type of silvicultural system used can have important effects on the resistance of forests to global changes.

Local topograpy

		alive	dead
EAS	Flat Area	98.78%	1.22%
	Lower Slope	97.13%	2.87%
	Middle Slope	98.35%	1.65%
	Ridge	98.10%	1.90%
	Upper Slope	98.55%	1.45%
	Valley	98.28%	1.72%
UEAS	Flat Area	95.95%	4.05%
	Lower Slope	95.26%	4.74%
	Middle Slope	94.43%	5.57%
	Ridge	95.10%	4.90%
	Upper Slope	93.48%	6.52%
	Valley	96.80%	3.20%

Silviculture with birds in mind: effects of disturbance-based forester practices on habitat characteristics and carbon storage

William Keeton[1], Dominik Thom[1]

[1]University of Vermont

In many regions, including the Northeast, foresters are testing approaches that emulate natural disturbance effects as a method for broadening the array of ecosystem services and biodiversity provided in managed forests. For example, a National Audubon program called "Silviculture with Birds in Mind" (SBM) was developed to diversify forested bird habitats. While it was not proposed explicitly as disturbance-based forestry, it incorporates many of those concepts. As a relatively new set of practices, the results of SBM treatment on forest dynamics and how they compare to natural disturbances have not been explored. Moreover, researchers have not yet investigated the potential of SBM to produce co-benefits, such as enhanced carbon storage. Thus, the objectives of our study were to (i) analyze SBM treatment effects and compare them with natural disturbances, and (ii) assess the co-benefits of multiple habitat indicators and carbon storage within four years of silvicultural treatment.

We derived 14 indicators of structural and compositional diversity as well as carbon storage from 217 SBM inventory plots, and compared them with intermediate-severity wind disturbance using non-metric multidimensional scaling (NMDS). Subsequently, we applied multi-hierarchical Bayesian models to investigate SBM treatment effects on aboveground carbon storage, as well as on four key habitat indicators. We then employed a Bayesian framework to model the relationships between habitat indicators and carbon storage. SBM treatments enhanced the variation in individual structural elements compared to untreated control plots. While SBM treatments were closer in ordinal space to intermediate-severity wind disturbance than untreated control plots, emulation of wind disturbance effects was incomplete. Carbon storage was positively associated with the H'-Index of structural and compositional diversity.

The results showed that application of SBM promotes diversification of habitat conditions in northern hardwood-conifer forests and we expect those effects to amplify as stands develop post-treatment. However, we propose widening the portfolio of silvicultural approaches in the Northern Forest Region to more fully encapsulate the spectrum of natural disturbance dynamics, viewing this as a key strategy both for biodiversity conservation and climate change mitigation.

Forested Waters

Moderator: Rebecca Harvey

Consisted of four talks in the afternoon session of the Contributed Talks.

Acid rain update Adirondack Mountains (NY) 2019: deposition improvements revitalizing surface waters

Karen Roy[1]

[1]New York State Department of Environmental Conservation, Division of Air Resources

The four short years since the Fall 2015 International Conference on Acid Rain hosted by the US have produced more far reaching events and results. The transfer and evolution of the National Atmospheric Deposition Program to its new quarters in Wisconsin in 2018 and the continuing (three decades) collaboration among the Environmental Protection Agency (EPA) led Long Term Monitoring Program (LTM) network across four ecoregions and several states in the Northeast US sets the stage for my update on 52 Adirondack LTM lake sites. The results of experimental brook trout stocking at Brook Trout Lake (western Adirondacks) in 2005 and the unexpected August 2019 appearance of a naturally spawning population of this species at Lake Colden (eastern High Peaks region) support deposition and water chemistry improvements.

Managing headwater streams for climate resilience: Monitoring the geomorphic impact of large instream wood structures at Burnt Mountain Natural Area

Megan Gordon[1], Shayne Jaquith[1], Gus Goodwin[1]

[1]The Nature Conservancy (TNC)

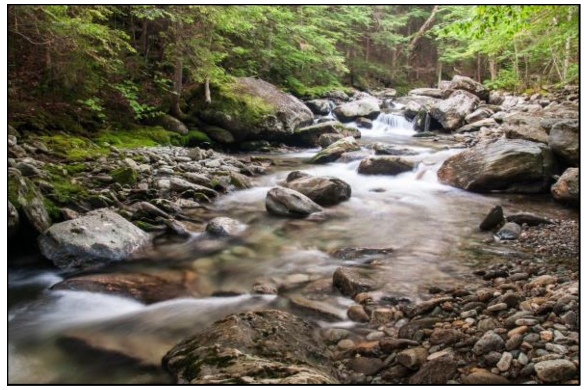
Historically, humans have straightened rivers, cut forests, and cleared wood and debris from our waterways, depriving rivers of their natural tendency to meander and add wood to the system. However, the reality is that a messy river is a healthy river. The absence of large wood in Vermont's headwater streams limits their ability to provide ecosystem services that have become increasingly important as the climate changes such as support diverse habitats, slow floodwaters, and retain sediment and nutrients. The Nature Conservancy's recent acquisition of the Burnt Mountain Natural Area in northern Vermont provides an opportunity to restore 3.5 miles of the upper Calavale Brook, a coldwater tributary to the North Branch of the Lamoille River, using large wood additions.

Initial assessments of the stream indicated that it is in fair geomorphic condition but that the strategic addition of large wood could restore the stream to excellent condition and improve instream habitat, river-floodplain connectivity, and sediment and nutrient retention. In 2017, TNC collaborated with Vermont Fish and Wildlife to install over 50 instream wood structures on a 2-mile stretch of the brook. The impacts of large wood additions on brook trout populations has been documented in Vermont. Therefore, our monitoring focuses on wood structure integrity and the geomorphic response of the stream. In this session, I shared the sampling and monitoring design, as well as the preliminary results and reflections on two years of data collection and observations, justifying that wood is good.

Monitoring Vermont reference streams to understand climate change impacts

Aaron Moore[1], Jen Stamp[2]

[1]Vermont Agency of Agriculture, Food and Markets
[2]Tetra Tech



Climate change is expected to lead to dramatic changes in stream habitat, including higher water temperatures and increases in the frequency and magnitude of extreme flow events. In turn, changes in temperature and flow can have major impacts on biological communities. For over a decade, Vermont biologists have been monitoring macroinvertebrate communities, water temperature, and stream flow throughout a network of reference streams, in addition to measures of water quality and habitat. While long-term data from this effort will be essential to more fully understand climate change impacts, early results have already helped show how communities may be affected. Devastating floods from Tropical Storm Irene in 2011 showed precipitous declines in macroinvertebrate densities, despite resiliency in taxa richness. Twenty years of paired biological and hydrological data at Ranch Brook in Stowe, VT show predictable community shifts and lower assessments of biological condition when high flow events occurred with more frequency. A major landslide recently occurred at a stream near Ranch Brook, wiping out localized macroinvertebrate communities and dramatically altering downstream habitat.

Monitoring recovery at this site will help us understand the potential effects of these types of precipitation driven events. A seasonal monitoring study was carried out at reference streams in 2019. This study could shed light on how climate-driven temperature changes may affect macroinvertebrates during the State's traditional September-October sampling period. These types of studies are necessary for understanding the implications climate change may have on the use of established biological criteria to assess stream health, and distinguishing these effects from more localized stressors.

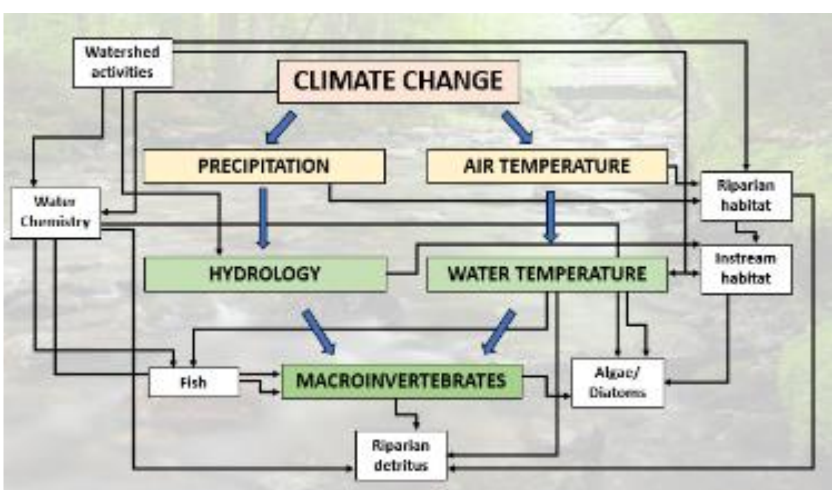


Figure 6. Streams are complex ecosystems: Integrate stressors at multiple spatial scales. Intricate interactions between biological communities and their habitats.

Site preparation and direct seeding trials for riparian forest restoration

Analise Carington[1,2], Pete Emerson[3]

[1]United States Fish and Wildlife Service (USFWS)
[2]Intervale Center
[3]Vermont Fish and Wildlife Department (VFWD)

The agricultural history of many riparian restoration sites in Vermont has posed many challenges for tree and shrub establishment. Old hay fields and pastures often mature into a dense, persistent mix of perennial grasses and herbaceous species that inhibit the natural succession of riparian forest species and create an environment inhospitable to planted trees and shrubs. In contrast to this, when annual cropland in riparian areas is taken out of production for restoration, we have seen the bare soil allow for impressive amounts of natural regeneration of riparian woody species.

This observation has led a team of Vermont Fish and Wildlife Department, Connecticut River Conservancy, and U.S. Fish and Wildlife Service biologists to experiment with different techniques for site preparation at riparian restoration sites. The goal is to control the existing vegetation to (a) expose enough bare soil to allow for successful natural regeneration of riparian woody species and/or (b) prepare a seedbed to allow for the direct seeding of riparian woody species.

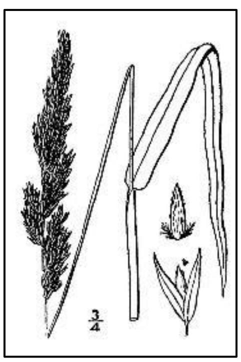


Figure 7. Reed canarygrass (*Phalaris arundinacea)*

Beginning in 2015, 48 plots were established at 2 sites on the Barton River at Willoughby Falls WMA in Orleans County, VT. The sites were abandoned hay field and pasture dominated by reed canarygrass (*Phalaris arundinacea*). Four treatment types were chosen: control (mow only), plow/rototill only, herbicide followed by plow/rototill, and plow/rototill followed by herbicide. The 2019 results show an increase in % cover of forbs, decrease in % cover of grasses, and an increase in total number of seedlings for the plow/rototill followed by herbicide treatment type. Monitoring of these sites is funded through at least 2021.

Encouraged with the results of this pilot project, USFWS and VFWD have partnered to expand and adapt the experiment to other regions of the state. In the summer of 2019, test plots were established at Laplatte Headwaters Town Forest in Hinesburg, Ethan Allen Homestead in Burlington, and Pine Island Community Farm in Colchester. In addition to the original combinations of plowing/rototill and herbicide, different organic site preparation techniques are being tested. We will also be testing different techniques for the direct seeding of riparian woody species after site preparation, including hydroseeding and broadcasting. We see immense potential for this process to enhance riparian restoration efforts across the state.

Our presentation reviewed our work-to-date and preliminary results, outlined our plans for next season, and discussed challenges and opportunities for this work into the future. Annalise Carrington co-presented with her VFWD colleague, Pete Emerson.

Pests and Disease

Moderator: Ryan Kincaid

Consisted of three talks in the morning session of the Contributed Talks.

Trends in invasive plants in eastern National Park forests

Aaron Weed[1], Kate Miller[1], Camilla Seirup[1]

[1] National Park Service, Inventory and Monitoring

The National Park Service's Inventory and Monitoring Program (NPS I&M) monitors forest health in a network of permanent plots in eastern national parks. The 39 parks included in this study vary widely in size, land use history, climate, and designation. However, all parks are impacted by invasive exotic plant species and the threat of further expansion and new invasion. We presented preliminary findings regarding trends in invasive plants in the northeastern national parks over the last 12 years of monitoring. We used mixed effects models to determine how invasive plant abundance is changing over time in each park and assessed multiple scales and metrics of plant invasion, including proportion of plots invaded, frequency of 1m2 quadrats invaded, and average percent cover of invasives. We assessed trends in invasive plants overall, by species, and by the following guilds: trees, shrubs/vines, graminoids, and herbs.

Parks vary considerably in their degree of invasion: Acadia National Park is the least invaded park (4.6% of plots invaded) while the most invaded parks are in the mid-Atlantic states (9 parks with 100% plots invaded). Increasing trends in invasive species abundance far outnumbered decreasing trends, and only one parks in the northeast showed an overall decline in invasive plant abundance over time: Marsh-Billings-Rockefeller National Historic Park (Woodstock, VT).

Where detected, significant declines of invasive herbaceous or graminoid species tended to coincide with roughly equivalent increases in invasive shrub abundance. Japanese stiltgrass (*Microstegium vimineum*) emerged as the most aggressive invasive species and is a high management priority, particularly in northern parks where its range is still limited, possibly by climate. Invasive shrubs also increased over time in many parks across the region and should be a high management priority because of their impacts to natural forest processes, biodiversity, and because their population growth is likely sensitive to climatic change. Our findings suggest that invasive plants continue to be a challenge for many parks in the northeast and climate change may exacerbate those impacts. Reversing the widespread increase of invasive plants we have documented will require a long-term commitment from the NPS and broader understanding of how the abundance of invasive plants will respond to a changing climate.

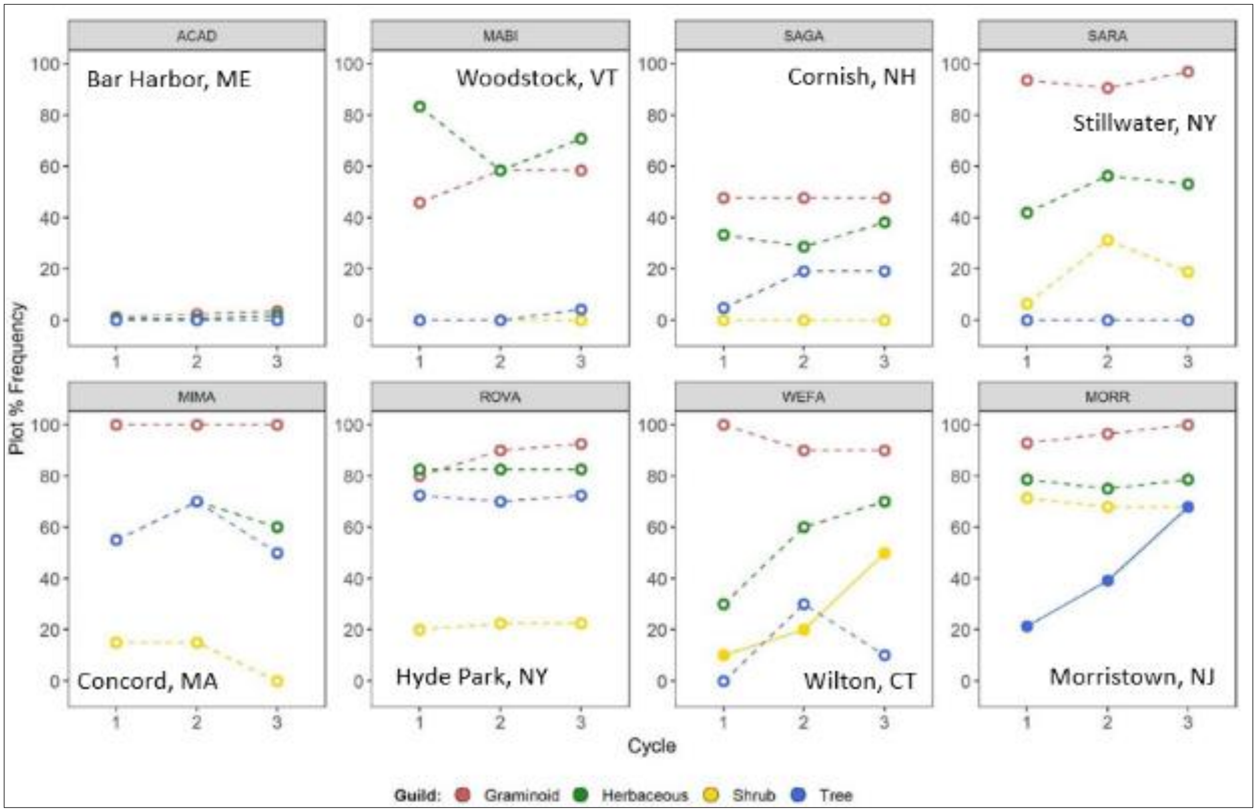


Figure 8. Average percent cover of different types of invasive plants. Patterns are similar within quadrant, shrubs are most abundant and tend to increase.

Using invasive species data and tools to inform management priorities

Jennifer Dean[1], Meg Wilkinson[1]

[1]New York Natural Heritage Program

Invasive species are a constant challenge for forest management, and there is a growing need for data tools to help focus limited resources, particularly as changes in climate intensify invasiveness potentials. In New York, the state invasive species database program has aggregated monitoring information from agencies, NGOs, and citizen scientists for over 10 years. Managed by the New York Natural Heritage Program (NYNHP), the state database provides a centralized spot for stakeholders to report and access standardized location and treatment data through the iMapInvasives system. Recent updates to iMapInvasives make mobile data collection tools, email alerts, data exports, and web map services more accessible to all users across North America.

NYNHP is working with state partners to identify ways to use the invasive species data to prioritize management decisions at many spatial scales. We developed an invasive species tiering process to create standardized, yet locally-specific species lists based on abundance data, invasiveness assessments, and expert input. To help conservation partners decide where to focus their efforts when surveying and managing for invasive species, we also developed a synthesis map layer for New York. This model indicates areas predicted to have high value natural areas prone to new invasive species populations and dispersals by incorporating component models of ecological significance, protected areas, and anthropogenic stressors.

These products are being used by Cornell University in an optimization model to create a decision tool that provides recommended management actions by species and location. As more invasive species information becomes available across the Northeast, there is potential for these tools to be scaled up to help inform regional strategies.

What are we looking for – a review of regional potential incoming invasive species

Judy Rosovsky[1]

[1]Vermont Agency of Agriculture, Food and Markets

There is a large network of Federal and state personnel who work closely together to monitor and detect pests and diseases across the nation. Some of these pests and diseases are locally important, some are of regional concern and some can affect most of the country, like the tree killing emerald ash borer. History suggests that if a pest or disease is established in one New England state, it is likely to move to neighboring states.

The cold winters of New York and New England have traditionally protected us from many pests and diseases. As the climate changes, this protection will diminish. Milder winters will offer pests and diseases, especially those from the south, more opportunities to become established.

An additional concern is that of deliberately introduced pests or diseases. In recent years US Department of Agriculture Veterinarian Service personnel, their state counterparts and FBI members exchanged information concerning possible introduced animal diseases, like African Swine Fever. This year, plant pests and diseases were introduced to the discussion.

Nursery stock is another route of entry for pests and diseases. In 2019, Vermont had trace forwards for two Federally regulated pests and diseases: boxwood blight and Chrysanthemum white rust. Nationally there were 2 trace forwards for Sudden Oak Death Syndrome (SODS) infested plants that had made it to the Midwest.

This review covered pests and diseases that are currently in the New England/New York area and are likely to spread in the region or have shown a capacity to cross large distances rapidly. This includes the diseases mentioned above as well as oak wilt, now found in NY. Likely future incoming pests are the European cherry fruit fly, found in northwestern NY; another fruit fly, the spotted winged Drosophila, present in most states in this area; the brown-tailed moth and its urticating hairs, in eastern Maine; the velvet longhorned beetle, a cousin to the Asian Longhorned beetle; and the infamous spotted lantern fly, well established in Pennsylvania and elsewhere. North of New England are the brown spruce longhorned beetle and the spruce budworm, and from the south we have the southern pine beetle and the elongate hemlock scale, making their way north.

Technology and Partnerships

Moderator: Stephanie Long

Consisted of three talks in the morning session of the Contributed Talks.

The Catskill Science Collaborative: A unique partnership for research, resource management, and outreach

Jamie Deppen[1], Gary Lovett[1]

[1]Cary Institute of Ecosystem Studies

In the Catskill Mountains of New York State, a large number of federal, state and municipal agencies, universities, and research institutes are involved in research, monitoring, and management of natural resources. However, there are few opportunities for scientists and managers to exchange information across agencies and institutions, make data freely available for long-term use, or to communicate research findings to the public.

Hosted by the Cary Institute of Ecosystem Studies and funded through the New York State Environmental Protection Fund, the Catskill Science Collaborative (CSC) was launched in 2018 to fill these gaps in coordination and communication. It facilitates and communicates environmental science in the Catskill Mountains through sharing research with the public, promoting science-informed resource management, and enabling data and idea sharing among scientists working in the Catskills. The CSC has worked with the Forest Ecosystem Monitoring Cooperative to develop a Catskill Mountain regional data archive to provide a "one stop shop" for Catskills data and promote collaboration among scientists.

Catskill Research Fellowships connect resource managers with researchers, provide positive research experiences for students, and help develop the pipeline of researchers working in the Catskills. The CSC also coordinates public events highlighting science in the region and assists with coordinating the Catskill Environmental Research and Monitoring Conference. This presentation provided an overview of this new and unique program and shared lessons learned from its first year.

LiDAR-derived stream mapping stands to drastically improve New Hampshire stream data

Austin Hart[1], Landon Gryczkowski[1], Josh Keeley[2]

[1]White Mountain National Forest
[2]New Hampshire Geological Survey

The White Mountain National Forest and the New Hampshire Geological Survey are using state-wide LiDAR bare earth elevation data to generate more accurate flowlines. This is achieved using a Python script that combines surface morphology and surface flow accumulation. Field validation has shown that this model is promising though not without shortcomings. Factors like substrate, slope, aspect, and forest-type may also affect stream development and are hard to fit cleanly into a model. High resolution LiDAR elevation data also includes man-made features, which pose major issues to modeling water flow, especially under a bridge or through a culvert. Even in their preliminary form, the new flowlines are vast improvements from their predecessors.

Motus for New England

Carol Foss[1]

[1]New Hampshire Audubon

The Motus Wildlife Tracking Network is an international collaboration of researchers that uses coordinated automated radio telemetry receiving stations to study the movements of birds, bats, and even large insects. This network is key to locating areas important to the long-term conservation of species of conservation concern, including forest birds. An effort is currently underway to expand the network of receiving stations in the northeastern United States. This presentation will discuss the history and current status of Motus, applications with northern forest birds, and data from several existing receiving stations.

Wildlife

Moderator: Stephanie Long

Consisted of four talks during the afternoon session of Contributed Talks.

American marten density and habitat associations in New Hampshire

Donovan Drummey[1]

[1]Department of Environmental Conservation, University of Massachusetts Amherst

The historic range of the American marten included much of the northeastern United States, but due to extensive trapping and deforestation, populations have declined or disappeared in several states. Through a combination of natural dispersal from remnant populations and reintroduction efforts, marten have since recolonized parts of their historic range, including the state of New Hampshire. The apparent recovery in New Hampshire can be attributed, at least in part, to the closure of marten trapping and reforestation following field abandonment. Recent signs of recovery in New Hampshire and neighboring states has led to delisting, and the focus is now on population monitoring in order to effectively and sustainably manage the species.

This study seeks to address this need to develop state-wide population estimates of American marten in New Hampshire, and specifically to generate information on habitat requirements and therefore how habitat influences the ways in which population density varies in space. We deployed clusters of camera traps across a large part of the NH marten range using a unique camera station design that allows for individual recognition based on their unique throat patches. The cluster design resulted in individual detections at multiple camera stations which provides information about individual movement patterns. We analyzed this spatial encounter history data using Spatial Capture-Recapture methods to estimate density and space use, and investigates how these aspects of marten spatial ecology are influenced by biotic and abiotic factors.

Assessment of long-term freshwater mussel population trends in the lower Poultney and Lamoille Rivers

Paul Marangelo[1], Michael Lew-Smith[2]

[1]The Nature Conservancy, Vermont Chapter
[2]Arrowood Environmental

Freshwater mussels are widely acknowledged as the most endangered group of animals on Earth. In Vermont, 10 of 18 (55%) are listed by the state as threatened or endangered. While it is generally assumed that Vermont's mussel fauna has been declining over the past few decades, there is little data that substantiates population trajectories. The lower Poultney River has long been acknowledged as having perhaps the most species-rich mussel community in New England, with historical records of 13 species.

We presented long-term quantitative mussel monitoring data of two mussel beds on the lower Poultney River from what is likely the longest ongoing freshwater mussel population monitoring effort in New England. Mean overall densities of freshwater mussels have declined up to 74% between 1998 and 2018 in the Poultney River. Population trends of individual listed species vary, from apparent local extirpation of the black sandshell (*Ligumia recta*) to apparent stability of the pink heelsplitter (*Potamilus alatus*). We have gleaned additional population trend insights by comparing results from extensive qualitative mussel surveys from 1990/91 with qualitative survey data collected in 2019. In addition, we presented 2019 survey data from a 5 mile stretch of the Lamoille River that revisits sites from a 2002 survey. This reach hosts the only occurrence of the elktoe (*Alasmidonta marginata*) in Vermont which is otherwise known from only a small number of other drainages east of the Great Lakes/Mississippi River basins.

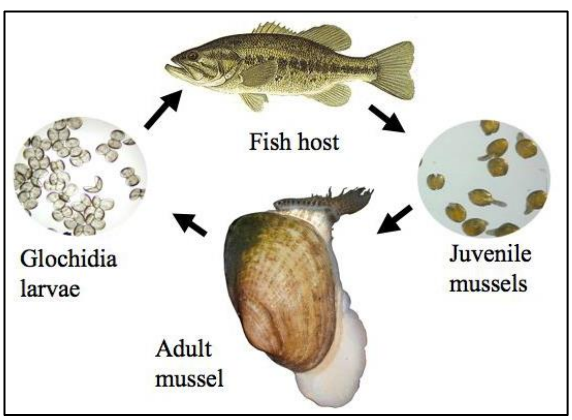


Figure 9. Unique life cycle of mussels in rivers.

Finally, we hypothesize from observations of long-term geomorphic changes at specific mussel beds in the lower Poultney River, that site-scale geomorphic shifts and coarse geomorphic river channel alterations that stem from an extreme avulsion/deposition event in 1783, are interacting with more commonly suspected mussel stressors to exacerbate population declines

Elevational distributions of Montane spruce-fir forest bird communities from 2010-2019

Jason M, Hill[1]

[1]Vermont Center for Ecostudies

There is strong evidence that climate change is occurring more rapidly at higher elevations. This is projected to drive substantial changes in the extent of high-elevation spruce-fir forests in the northeastern U.S. over the next few hundred years. We can reasonably expect more severe consequences for species who exclusively enhabit this shrinking forest biome, than species whose core populations exist at lower elevations and across a wider range of forest types. It is imperative that we formally quantify elevational shifts in the distributions of species occupying spruce-fir forests and understand their elevational tolerance for conservation and management. Notably, Boreal Chickadee (*Poecile hudsonicus*), Blackpoll Warbler (*Setophaga striata*), and Bicknell's Thrush (*Catharus bicknelli*) occur exclusively in the spruce-fir zone in the northeastern U.S.. 95% of the U.S. Bicknell's Thrush population in the US is restricted to elevations above 805 m. Here we utilize the Mountain Birdwatch dataset, where citizen scientists annually conduct repeated 5-minute point counts at >500 high-elevation sampling locations on hiking trails across northern New England and New York. Using a hierarchical Bayesian framework, we examined how the elevational distributions of 10 breeding bird species have changed between 2010 and 2019.

Pulsed resources cause dynamic range changes in the North American Red Squirrel

Michael T. Hallworth[1]

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

Resource availability is a strong driver of animal distributions. In northern hardwood and boreal forests, tree mast events provide an important, large scale, resource pulse that drives population dynamics of the small mammal community. Population-level responses to increased resource availability following tree mast events have been well documented. However, the degree to which pulsed resources such as tree mast events influence species distributions and habitat quality remains unknown.

We tested for density-dependent range expansion of free-ranging North American red squirrels (*Tamiasciurus hudsonicus*) in response to an episodic resource. We combined camera trap and systematic auditory surveys gathered along an elevation gradient throughout Northeastern United States between 2014-2019 to determine how tree masting events influence 1) the elevational distribution of red squirrels through time and 2) habitat quality along the elevation gradient.

We found the elevational distribution of North American red squirrels is highly dependent on tree masting events where the maximum elevation occupied increases in response to tree mast. The elevation minima also decreases in response to tree mast but to a lesser extent. In non-mast years, the elevational maxima and minima contract. In addition to elevation expansions, we found abundance varied considerably at low and high elevations in response to resource availability during and following mast years.

Our results suggest that the elevational band consisting of the upper extent of northern hardwood forest, and the ecotone between northern hardwood and boreal forest, is the highest quality habitat for the North American red squirrel in northeastern United States. Tree mast events provide a critical but episodic resource that leads to changes in the elevational distribution of the North American red squirrel in the northeastern United States.

The dynamic distribution could have profound impacts on other animal populations. As a dominant pre-dispersal seed predator, the presence of red squirrels may have cascading effects on other members of the small mammal community. Furthermore, songbird populations within the region may be impacted as red squirrels are a primary nest predator. High-elevation, ground nesting songbirds such as the Bicknell's thrush (*Catharus bicknelli*), a species of high conservation concern, may be particularly vuln

Descriptions of Working Sessions

Below are the descriptions of the afternoon working sessions provided by contributors. Notes taken by FEMC staff are available in Appendix.

Co-Designing Forestry Studies to Address Adaptation Science Needs

Organizer: Anthony D'Amato, Rubenstein School of Environment and Natural Resources, University of Vermont

The uncertainty around the impacts of climate change, invasive species, and extreme weather events poses a significant challenge to sustaining forest ecosystems in the Northeast. Much of our current management is guided by the outcomes of decades of silviculture research, yet many of the conditions under which those results were generated are rapidly changing. There have been general suggestions for how to approach forest adaptation for uncertain future conditions, but few robust field evaluations exist to inform widespread management applications. This working group session will facilitate discussion among forestry professionals and research scientists to identify what science is most needed to help inform forest adaptation strategies, to address the impacts of climate change and invasive species, and garner input on how to best engage landowners when testing such approaches. The outcomes of this session will inform the design of a series of new silvicultural studies and develop manager-scientist partnerships to enhance the region's capacity for implementing and sharing the outcomes of forest adaptation in practice.

Data Rescue: Archiving 'At Risk' Data from the Catskills to Katahdin

Organizer: Matthias Sirch, Forest Ecosystem Monitoring Cooperative (FEMC)

The FEMC has been working to compile an inventory of at-risk data and rescue high priority material. In this working session we will share insights gained in the rescuing process to inform a broader discussion around defining at-risk data and ways to collectively develop a data rescue framework. What data do you want to see rescued? How do we establish priority? What are the obstacles to rescuing and utilizing at-risk data? These questions were discussed as well as a brainstorm for more efficient methods of connecting rescuers with resources and an exploration of avenues for addressing future data risk. During this working session, the FEMC shared insights gained in the data rescuing process to inform a broader discussion around improving the data rescue framework.

Lye Brook Wilderness Area Subcommittee Working Group

Organizer: Angie Quintana, Green Mountain & Finger Lakes National Forests

Anyone interested in ongoing or future monitoring and research at the Lye Brook Wilderness Area was encouraged to join this discussion, with the goal of making connections and coordinating across organizations and disciplines to support this work. Lye Brook is the only Class I Wilderness Area in Vermont and includes a rich archive of existing data and long-term studies. This workgroup brings together key partners in an ongoing collaboration focused at this Forest Ecosystem Monitoring Cooperative (FEMC) intensive research site. The Lye Brook Wilderness is in the southern Green Mountains of Vermont. It's named after the brook flowing through its western half. Most of it is above 2500 feet on a high plateau with several ponds and bogs. Approximately 80% of the area is forested with northern hardwoods: birch, beech, and maple. Thickets of small spruce dot the area. Several species of neotropical birds, black bear, moose, deer, pine martin and bobcat inhabit these woods. There are many marshy areas off trail and the ecological balance is quite fragile.

Meeting Objectives:

- Provide brief updates on current and near future research and monitoring projects in the Lye Brook Wilderness Area, building on our existing list at: https://www.uvm.edu/femc/cooperative/lye_brook_committee
  - Identify additional research or project needs (to add to existing list)
  - Prioritize and develop strategies to collaborate and accomplish projects and research
  - Choose a date and location for a field trip in summer 2020, and Nov/Dec 2020 meeting

Managing Ash in the Context of EAB – a Regional Discussion

Organizers: Amanda Mahaffey, Forest Stewards Guild

The "little green bug", the emerald ash borer (EAB), is known as a harbinger of death and destruction to ash trees across the continent. Its presence instantly brings to mind the disheartening prospect of every ash tree in a stand, forest, or state, disintegrating into a snag and disappearing from the forest ecosystem. All too often, even the mention of the bug leads managers to harvest every ash tree in reach during a timber harvest. But wait! There are sound, science-based reasons to consider alternative treatments. Ash trees are irreplaceable to Native American cultures in our region. Ash trees - living, dead, or dying - also provide important habitat to wildlife in forest ecosystems. Recent research shows that not all ash trees will die and that cutting them all eliminates our chances of retaining their important ecological and social values.

A series of forums in Vermont this year helped forest managers explore alternative management approaches for ash in the context of EAB. What is your state doing to help foresters manage ash, in spite of the little green bug? In this facilitated working session, participants will share ideas, observations, and strategies for conducting thoughtful silviculture and share learning about ash management across the Northeast region.

Reducing the Risks of Invasive Forest Pests and Climate Change Using Knowledge Co-Production

Organizer: Toni Lyn Morelli, U.S. Geological Survey (USGS)

Building off a recently formed working group focused on understanding of risks associated with pest outbreaks in forests, this working session will refine a structured decision-making framework, with input from new and existing working group members. The goal is to bring the power of ecological forecasts and knowledge coproduction (resource managers and scientists working together) to develop a scalable decision-support system. We are working together to identify information needs for pest species (especially Hemlock Woolly Adelgid). We will further develop our understanding of the role of risk in forest pest man agreement. This working session is a collaboration among the National Phenology Network, USGS, U.S. Forest Service (USFS), and the Regional Invasive Species and Climate Change (RISCC) Management network.

Why Oak? Increasing Resiliency in Southern New England's Oak Forests

Organizer: Christopher Riely, Rhode Island Woodland Partnership

Oak trees are an iconic part of southern New England's forests. Today, they are under pressure from a complex range of stresses including gypsy moth, deer browse, and invasives. Forest managers are struggling to secure regeneration and are further challenged with how to communicate with landowners about options for managing oak woodlands in a changing climate. What makes a resilient forest? What tools can we use to assess how "healthy" a forest is? What are practical management strategies to help increase resiliency in oak forests? What tools can we use to monitor our efforts and find out if we're making a difference? This facilitated working session will explore these and other questions. All participants who work in or care for oak forests are invited to take part.

This discussion is related to a US Department of Agriculture Forest Service-funded project in its early stages with partners in Rhode Island, Connecticut, and Massachusetts. Outputs from the session will help inform our work with professionals and landowners to increase resiliency in southern New England's oak forests.

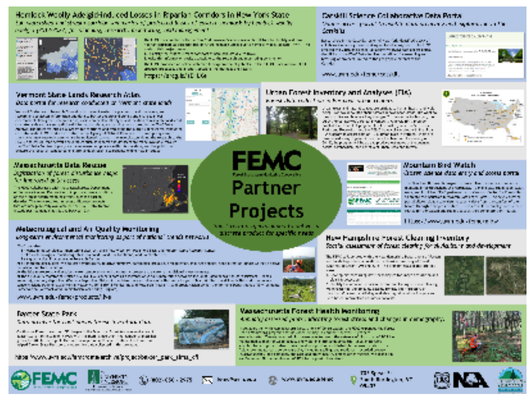
Abstracts from Posters

There were 19 posters contributed to the conferences to be presented during the poster session at the end of the day. Below are the abstracts submitted for these posters, including author affiliation. The presenting authors name is in bold type.

2019 Forest Ecosystem Monitoring Cooperative partner projects

James Duncan[1,2], Jennifer Pontius[1,2,3], Alexandra Kosiba[1,2], Nancy Voorhis[1,2], Emma Tait[2], Matthias Sirch[2], Matthias Nevins[2], John Truong[1,2]

[1]University of Vermont, Rubenstein School of Environment and Natural Resources
[2]Forest Ecosystem Monitoring Cooperative (FEMC)
[3]United States Forest Service

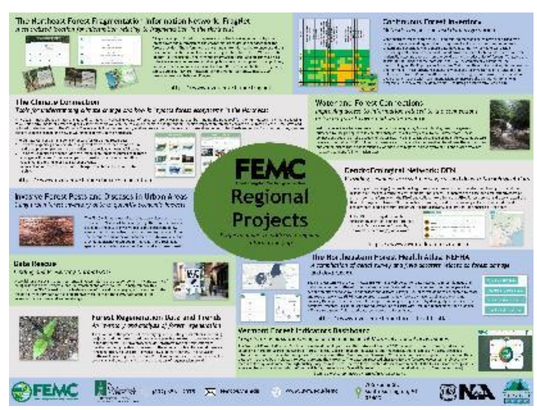


In 2017 FEMC rebranded from the Vermont Monitoring Cooperative (VMC) to the Forest Ecosystem Monitoring Cooperative (FEMC). FEMC was built upon the long-term environmental monitoring initiated by the VMC in 1990. While retaining the role of managing forest ecosystem data in Vermont, FEMC has expanded their reach to organizations and agencies outside of Vermont and built various projects to meet our partner's needs.

2019 Forest Ecosystem Monitoring Cooperative regional projects

James Duncan[1,2], Jennifer Pontius[1,2,3], Alexandra Kosiba[1,2], Nancy Voorhis[1,2], Emma Tait[2], Matthias Sirch[2], Matthias Nevins[2], John Truong[1,2]

[1]University of Vermont, Rubenstein School of Environment and Natural Resources
[2]Forest Ecosystem Monitoring Cooperative (FEMC)
[3]United States Forest Service

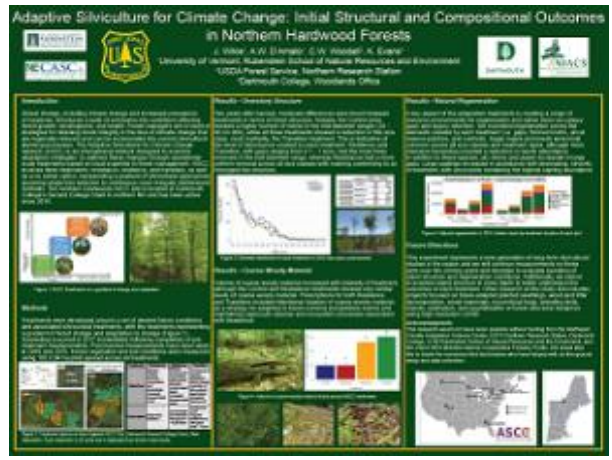


FEMC was built upon the long-term environmental monitoring initiated by the Vermont Monitoring Cooperative (VMC) in 1990. While retaining the role of managing forest ecosystem data in Vermont, FEMC has expanded their reach to organizations and agencies outside of Vermont and built various tools and products that provide answers to questions on a regional scale. These products include, the Northeast Forest Fragmentation Information Network, Continuous Forest Inventory Methods Comparison and Data Aggregation, The Climate Connection, Water and Forest Connections, Invasive Forest Pests and Diseases in Urban Areas, the DendroEcological Network, Data Rescue: Finding and Preserving Data-at-Risk, Forest Regeneration Data and Trends, the Northeastern Forest Health Atlas, and the Forest Indicators Dashboard.

Adaptive Silviculture for Climate Change: Initial structural outcomes in the northern hardwood forest

Jessica Wikle[1], Anthony D'Amato[1], Chris Woodall[2], Kevin Evans[3]

[1]Univerisity of Vermont, Rubenstein School of Environment and Natural Resources
[2]USDA Forest Service
[3]Dartmouth College

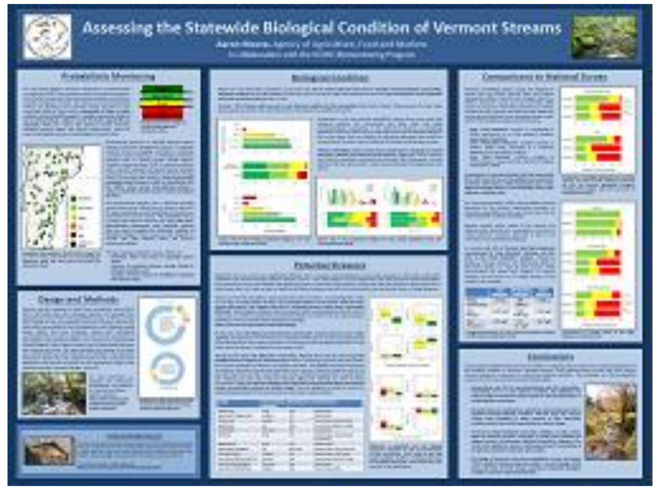


Climate change introduces a suite of unknowns into conditions affecting forest growth, development, and health. Forest managers are in need of strategies for retaining forest integrity in the face of climate change that are regionally relevant and can be incorporated into current silvicultural planning processes. The Adaptive Silviculture for Climate Change network (ASCC) is an international network designed to examine adaptation strategies to address these changes through operational-scale treatments based on local expertise in forest management. ASCC involves three treatments, resistance, resilience, and transition, as well as a no action option, representing a gradient of silvicultural approaches spanning single-tree selection to continuous cover irregular shelterwood methods. The northern hardwoods ASCC site is located at Dartmouth College's Second College Grant in northern NH and has been active since 2017. We present here initial structural outcomes in each of the treatments at the northern hardwoods site.

Assessing the statewide condition of macroinvertebrate and fish communities in Vermont streams

Aaron Moore[1], Jim Deshler[2]

[1]Vermont Agency of Agriculture, Food and Markets
[2]Vermont Department of Environmental Conservation



State aquatic biologists recently completed a five-year assessment of Vermont's streams and rivers. Randomly selected wadeable stream reaches were surveyed for water chemistry, habitat quality, and macroinvertebrate and fish communities. Biological community health was assessed on a scale from Poor to Excellent based on thresholds in the State's biological criteria. Results were used to estimate the biological condition of wadeable streams statewide, and to better understand what factors may be affecting these communities.

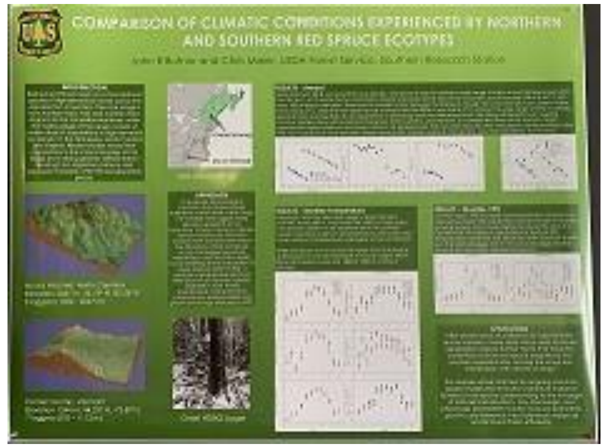
The survey found that a majority of stream miles in Vermont meet criteria for healthy macroinvertebrate and fish communities, with most streams meeting higher thresholds indicative of exceptional water quality. Among sites that did not meet these higher thresholds, the results suggest that land use activities impact macroinvertebrate communities, which are susceptible to changes in water chemistry. Fish communities in the survey were more affected by channel erosion and increased temperature, stressors which are expected to be exacerbated by climate change. These results are consistent with two previous statewide surveys dating back to 2002.

National and regional results from the Environmental Protection Agency's (EPA) National Rivers and Streams Assessment suggest that Vermont is in comparatively better condition for chemical stressors, though fewer Vermont streams were in "least disturbed" condition for phosphorus compared to other water quality measures. The overall condition of macroinvertebrate and fish communities was also higher in Vermont compared to regional and national results. These findings highlight the unique quality of Vermont's streams and the importance of protecting and maintaining the State's aquatic resources.

Comparison of climatic conditions experienced by northern and southern red spruce ecotypes

John R Butnor[1], Christopher Maier[1]

[1]Southern Research Station, USDA Forest Service



Red spruce (*Picea rubens*) is a foundational species of high elevations forests across the Appalachian Mountains. The core range is from northern New York and New England to the Canadian Maritimes, while the trailing edge of the range consists of smaller disjunct populations in high elevation 'sky islands' in Tennessee, North Carolina and Virginia. Recent studies reveal that populations in the core and edge of the range show strong genetic differentiation resulting from migration patterns and subsequent isolation after the last glaciation period.

To evaluate environmental conditions that shape climatic adaptions at both ends of the range, we installed data loggers along elevation gradients at two mountains: Camel's Hump in northern Vermont and Mount Mitchell in western North Carolina. The loggers record air temperature and relative humidity hourly enabling diurnal calculation of vapor pressure deficit (VPD), a measure of evaporative demand. Red spruce is adapted to cool, humid environments, making VPD an indicator of environmental stress. Using data from 2018, we found that red spruce can tolerate a wide range of mean annual temperatures (MAT) from 2.0 to 11.6 °C across the two mountains.

Air MAT was lowest at the tops of the mountains and increased approximately 0.65 °C with every 100 m drop in elevation. There was no overlap in MAT between the transects, though the lowest elevation at Camel's Hump, 570 m was 5.6 °C, while the MAT near the top of Mount Mitchell 2026 m was only 0.4 °C warmer. This wide range of MAT is a strong selective force and has likely led to adaptations in phenology and cold tolerance which will be addressed by an ongoing common garden study with locations in Maryland, North Carolina, and Vermont. The mountain tops are often shrouded in clouds resulting in low VPD that increased at lower elevation (Mean annual VPD: Camel's Hump 0.1 to 0.21 kPa, Mountain Mitchell 0.1 to 0.31 kPa).

Monthly mean VPD is a more nuanced situation, where Mount Mitchell has lower VPD values than Camel's Hump in the peak growing season but is much higher the rest of the year. After several years of data collection to capture inter-annual variation, these data will be used to model geographic regions (further north) that have the potential to sustain red spruce adapted to the southern Appalachians, slowing the range loss anticipated with climate change.

Does soil moisture and soil texture predict the fine-scale community organization of sugar maple and beech in a 1ha old growth forest in Middlebury, Vermont?

Morgan Forest Perlman[1]

[1]Middlebury College

The goal of this research was to understand how sugar maple (*Acer saccharum*) and American beech (*Fagus grandifolia*) segment themselves across slight soil microsites on a small 1ha scale. Understanding soil properties as they relate the ecological niches of these two species allows us to better model the dynamics of northern hardwood forests and adds to our basic knowledge of their natural history.

Data on soil moisture and soil texture were collected in 25 subplots within a 1ha plot. Sugar maple generally dominates in wetter environments than beech. Meanwhile beech dominates where soils are courser and drier. Soil moisture and soil texture were both very strong predictors of the segmentation of two species, sugar maple and American beech, which are generally thought of as co-occurring in hardwood communities.

Microtopography may further influence soil moisture, as there was a positive trend between slope and moisture. Findings suggest we reevaluate the assumptions in some forest dynamics models that single abiotic variables, like light availability, are adequate for explaining and predicating forest dynamics in hardwood forests, even on small spatial scales.

Forest land use activities and fragmentation as a threat to northeastern forest cover and water quality

Elizabeth Doran[1], Mikayla Haefele[2]

[1]University of Vermont - VT EPSCoR BREE Project
[2]Middlebury College

Phosphorus loading in the Lake Champlain Basin is a contributing cause of algal blooms in Lake Champlain during the late summer months. All land cover types contribute to the phosphorus loading, but less attention has been given to phosphorus exported from forested areas because the amount of phosphorus exported per unit area is small and is not measured directly (Lake Champlain Basin Program, 2018). Forests, however, comprise 78% of the landcover in Vermont and are used for timber harvesting, maple sugaring, and recreation, which could each contribute to phosphorus beyond additional background levels being released into streams that lead to the lake.

Earlier in Vermont's history, the land was denuded of most of its trees to provide room for agriculture, and though it does not seem reasonable that the land might be converted to agricultural fields on such a large scale again, there is a definite threat of deforestation due to the development of forested lands into commercial and residential lots. With the subdivision and parcellation of land comes fragmentation of forests, which has been shown to decrease the ability of the forest to provide ecosystem services, such as appropriate wildlife habitat, climate regulation, and water quality control (VTFPR, 2015). The variety of land uses in forested areas and the threat of increased development in the future present good reasons to understand how these changes to the forests of Vermont could possibly lead to decreased forest cover and greater damage to water quality.

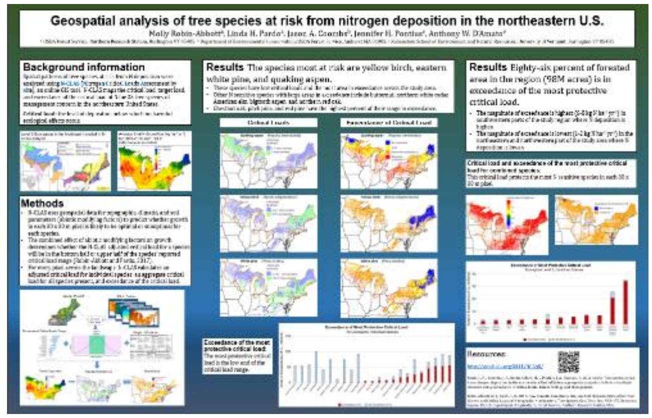
Some 80% of forested land in Vermont is privately held, and of these, 62% are held by individuals and families, which represent a heterogeneous group of decision-making land holders (Butler and Butler, 2016). The goal of this project was to create an agent-based model that can simulate land use decisions made by private family forest landowners, with the distinct purpose of investigating how land use decisions in forested areas affect downstream water quality and how forest land cover might change over time. The decisions that the forest landowner agents can make in the model ultimately lead to a total phosphorus output for the watersheds of interest, specifically the Mississquoi Bay. By investigating how landowners make decisions and what their priorities are for their land, we can better understand what activities are leading to phosphorus exports from forested areas and make suggestions for mitigating water quality damage.

Results obtained from multiple scenarios tested demonstrate the potential fluxes in phosphorus output from forested land that might occur if UVA enrollment increases or if Vermont forest landowners begin to harvest timber more frequently and at a larger scale. The results indicate that it is timber harvesting that contributes most heavily to phosphorus output from forested land, which is consistent with findings from the literature and conversations with forestry professionals.

Geospatial analysis of tree species at risk from nitrogen deposition in the northeastern U.S.

Linda Pardo[1], Molly Robbin-Abbot[1], Jason Coombs[2,3], Jennifer Pontius[4], Anthony D'Amato[4]

[1]U.S. Forest Service, Northern Research Station
[2]Department of Environmental Conservation
[3]U.S. Forest Service
[4] University of Vermont, Rubenstein School of Environment and Natural Resources



Forest health is affected by multiple stress agents (e.g. pests and pathogens, climate extremes and deposition) and further influenced by site and stand characteristics. The critical load, the level of deposition below which no harmful ecological effects are expected to occur, can be used to quantify risk to forest health. In this study, Nitrogen Critical Loads Assessment by Site (N-CLAS), an online GIS analysis and visualization tool, was used to examine spatial patterns of critical loads and exceedance of N deposition for 23 tree species of management concern across 12 level III ecoregions in the northeastern United States.

This novel, high resolution (30m) landscape-scale assessment maps critical loads, target loads, and exceedances for each species present through a series of calculations that incorporate the influence of climate, topographic and soil factors that modify tree response to N deposition. For every pixel across the landscape, N-CLAS calculates an adjusted critical load for individual species and an aggregate critical load for all species present.

Our analysis indicates that eighty-six percent of the forested area in the region (98M acres) is in exceedance of the most protective critical load. The magnitude of this exceedance is highest (6-8 kg N ha-1 yr-1) in the southwestern part of the study region where N deposition is highest. The magnitude of exceedance is lowest (1-2 kg N ha-1 yr-1) in the northeastern and northwestern part of the study area where N deposition is lowest.

For forests in the northeastern U.S., N-CLAS indicates that the most N-sensitive species, those with the lowest critical loads across large portions of the study area, include yellow birch (*Betula alleghaniensis*), butternut (*Juglans cinerea*), Eastern white pine (*Pinus strobus*), Bigtooth aspen (*Populus grandidentata*), Quaking aspen (*Populus tremuloides*), Northern red oak (*Quercus rubra*), and American elm (*Ulmus americana*). While the extent and magnitude of the risk varies spatially, these species consistently determine the most protective critical load thresholds in the mixed stands they occupy.

This analysis indicates that N deposition continues to be a risk factor for forests across the northeast, with a high degree of spatial variability that should be used to inform management plans. Because temperature and precipitation values outside of the optimum range were common drivers of low adjusted critical loads for sensitive species, such analyses will become more important as the effects of climate change continue to impact the ability of the regions forests to respond to stressors.

Lake Champlain Wetland Vegetation monitoring

Josephine Robertson[1], Everett Marshall[1], Aaron Marcus[1], Bob Popp[1]

[1]Vermont Fish and Wildlife Department

The potential for damage and future changes in plant communities bordering the shores of Lake Champlain became exceedingly apparent in 2011 after record setting floods occurred in the Champlain basin. These floods inspired action on the part of the governing bodies of both the United States and Canada to increase understanding of how future flooding events might impact the plant communities lining Lake Champlain's shores.

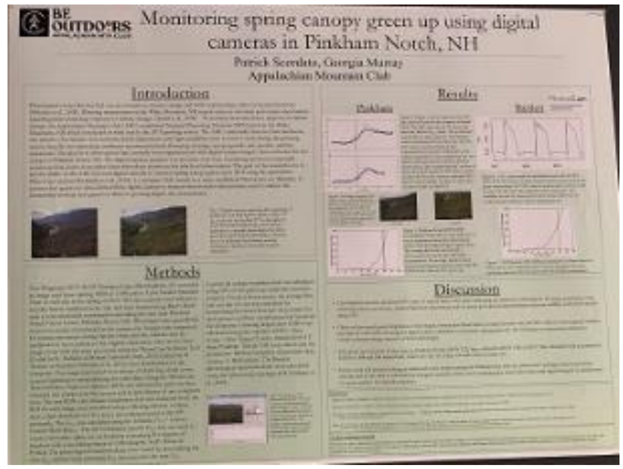
An international joint commission composed of the U.S. and Canadian governments submitted a plan in July 2013 to survey the composition of these lakeside ecosystems with a final work plan completed in 2017. The field work was conducted by the Vermont Fish and Wildlife Department's Natural Heritage Inventory, with assistance from the Vermont Wetlands Program in September and October of 2019. Surveys took place along 75 to 250 meters transects, designed to capture the changes in floral composition along elevation/water level gradients, ranging from aquatic plant communities to lakeshore grasslands to lakeside floodplain forests. The sampling points were evenly spaced along transects with a quadrat size of 1 meter by 0.5 meter. 19 sites were visited in Vermont and New York with generally 3 to 4 transects per site. The sampling design provided representations of vegetation types by elevation gradient and was facilitated using the Collector for ArcGIS App and a R2 Trimble GPS receiver with vertical and horizontal accuracy of less than 5 cm in open habitats.

These data collected will enable accurate modelling of vegetation types for the consequences of future changes to Lake Champlain's water level. Forthcoming modelling will be conducted by Modeling Ecosystem Program of the Hydrology and Ecohydraulic Section of Environment and Climate Change of Canada. During the study, the scientists documented over 70 previously unknown rare and uncommon plant populations in the Vermont wetlands with several new county and state records. All these data will be cataloged in the Vermont Natural Heritage Database.

Monitoring spring canopy green up Pinkham Notch, New Hampshire using digital cameras

Patrick Scordato[1], Georgia Murray[1]

[1] Appalachian Mountain Club



The Appalachian Mountain Club (AMC) monitors White Mountain, NH tree canopy phenology using human-observed plot observations a part of the National Phenology Network (NPN), and more recently, started to monitor tree canopy phenology using digital cameras. The purpose of this study is to test digital cameras ability to track Pinkham Notch, NH spring canopy green up in 2018 and 2019. The results are compared to NPN plot observations, growing degree days (GDD), and a more well-established camera in Bartlett, NH. The AMC digital cameras overlook Pinkham Notch, NH on a bluff, and snapped a photo each hour near midday. Green chromatic coordinate (GCC) values were calculated based on red, green, and blue (RGB) data extracted from a "region of interest" on daily images using the PhenoCam software tool and the equation GCC = Green/(Red+Green+Blue).

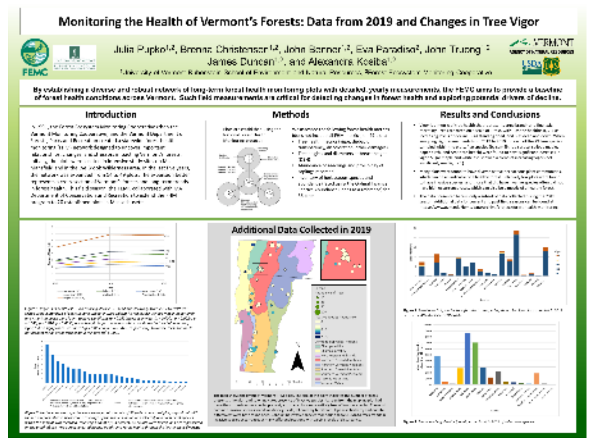
Preliminary methods using a univariate spline containing five degrees of freedom with a smoothing factor of 0.08 in the SciPy library of Python smoothed the raw GCC data. Dates for 10, 25, 50, 75, and 90% of green-up were calculated based on the percentages of GCC amplitude (maxima- local minima). Bud burst and leaf out dates were calculated for individual species and combined across the four tree species based on the NPN plot observations.

Results using the preliminary method show the 2018 and 2019 average first day of year bud burst and leaf out for the individual species observed at plots around Pinkham Notch all fell within the green up start (0%) and 50% amplitude boundaries derived from the digital cameras indicating agreement between the datasets. The research aims to implement more established methods from past PhenoCam studies using the Akaike information criterion to find the best fitted green up curve and phenological transition dates. Combining plot observations with the PhenoCam method demonstrates a way the AMC can evaluate and monitor the impacts of climate change on tree canopy phenology in the White Mountains.

Monitoring the health of Vermont's forests: Data from 2019 and changes in tree health

Julia Pupko[1,2], Brenna Christensen[1,2], John Benner[1,2], Eva Paradiso[2], John Truong[1,2], James Duncan[1,2], Alexandra Kosiba[1,2],

[1]University of Vermont, Rubenstein School of Environment and Natural Resources
[2]Forest Ecosystem Monitoring Cooperative (FEMC)



In 1991, the Forest Ecosystem Monitoring Cooperative, formerly the Vermont Monitoring Cooperative, and the Vermont Department of Forests, Parks and Recreation created a statewide forest health monitoring (FHM) network, designed to uncover important relationships, changes, and stressors impacting Vermont's forested landscape. The plots were initially located in intensive study sites on Mt. Mansfield and in the Lye Brook Wilderness area and were surveyed annually. In the last five years, the network was expanded from 14 to 49 plots by co-locating with other forest health monitoring efforts such as the US Forest Service Forest Inventory and Analysis, the North American Maple Project, and others. The expansion better represents a cross-section of Vermont's forests and long-term trends in forest health. This field season, FEMC collaborated with MA Department of Conservation and Recreation to extend the FHM program to 20 established plots in Massachusetts.

New low-cost stream gauging stations on headwater streams of the White Mountain National Forest

Austin Hart[1]

[1]White Mountain National Forest

Flood events in the mountainous Northeast are inherently difficult to predict and monitor. With the steep, flash flood-prone drainages, small variations in precipitation totals and intensity can make the difference between a modest high-water event and a catastrophic flood. Most often, the magnitude of a flood event is not understood until road work crews and residents venture out to assess the impacts. The existing stream gauging stations near towns are generally lower in the watershed and offer a blurred view of what is coming out of the headwaters. With increases in development, cost of infrastructure repair, recreation traffic, climate variability, and other factors, it will prove worthwhile to gather more detailed flow information in mountainous areas.

With that goal in mind, the White Mountain National Forest Watershed team is deploying a series of remote gauging stations on several headwater streams throughout the National Forest. With EnviroDIY Mayfly data loggers and ultra-sonic range-finding sensors attached to bridges, the setup is low-cost and minimally invasive. These stations will provide a continuous record of flow data high up in the watershed where a gauging station would have previously been cost-prohibitive or low priority. Combined with the downstream data from US Geological Survey or state gauging stations, this project aims to paint a more detailed picture of how the mountain landscape and the entire stream network responds to precipitation.

Sliding down Cotton Brook, Waterbury, Vermont

Marjorie Gale[1], George Springston[2], Colin Dowey[3]

[1]Vermont Geological Survey, DEC
[2]Norwich University
[3]Vermont Agency of Digital Services

A major landslide occurred on the south side of Cotton Brook in the Mt. Mansfield State Forest in May 2019. The immediate goals of the Vermont Geological Survey were to:

1) Document threats in the area,
2) Characterize the site,
3) Propose approximate "exclusion areas" for trails, and
4) Collect baseline data so we can evaluate impacts and change.

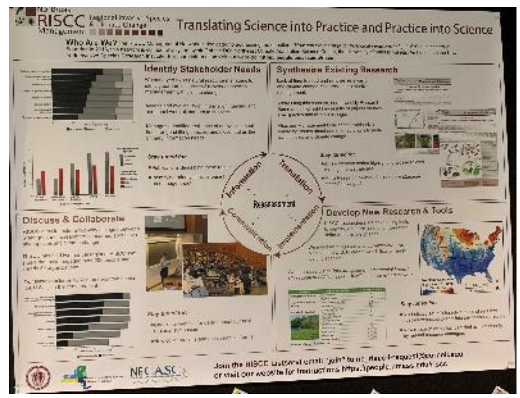
The area of the landslide is approximately 12 acres. The landslide resulted in massive sedimentation in Cotton Brook and a large delta in the Waterbury Reservoir. A comparison of elevation data from the Vermont Agency of Transportation (VTRANS) drone flights on June 12 with the pre-landslide Lidar data shows approximately 200,000 cubic meters of material was excavated, 100,000 cubic meters was deposited at the base, 25,000 cubic meters are estimated in the delta, and 75,000 cubic meters remain unaccounted for (deposited along the brook, in the reservoir, or transported down the Little River). The landslide blocked Cotton Brook, leading to an impoundment upstream. Fractures formed on the wooded hillsides adjacent to the landslide scar and these are areas of potential failure. The slope, roughly 25 degrees, is composed of fine silt and sand lake bottom sediments deposited in Glacial Lake Winooski (Wright, 2019). A slide surface of very fine silt to clay is visible and has been grooved and striated by the overriding material. Mud flows on the surface, fallen trees and boulders, new cracks on the Fosters Trail, and undercutting of the landslide material by the brook along its new channel all contribute to the site remaining hazardous and impacting water quality nearly 5 months later.

Saturation of unconsolidated material above the impermeable clay-silt layer(s), dipping slide surface, type of material (sand over clay), height (109 m), load balance, gravity, and steepness of slope are all likely factors influencing the mass failure; the causes are under investigation. Although changes in frequency of landslides can be an indicator of climate change, we do not have many accurate historical records for landslides in Vermont. However, the Vermont Geological Survey's landslide inventory contains nearly 2000 points and will serve as a baseline going forward.

Translating science into practice and practice into science – Northeast RISCC Management Network

Audrey Barker Plotkin[1], Jenica Allen[2], Evelyn Beaury[1], Emily Fusco[1], Michelle Jackson[1], Brittany Laginhas[1], Carrie Brown-Lima[3], Toni Lyn Morelli[4], Bethany Bradley[1]

[1]University of Massachusetts, Amherst
[2]Mount Holyoke College, Miller Worley Center for the Environment
[3]New York Invasive Species Research Institute
[4]USGS, Amherst, Massachusetts



Translational invasion ecology is a new term for an old idea that managers and scientists need to work together to solve pressing problems about invasive species. Because the combined topics of invasive species and climate change represent a critical emerging challenge, the Northeast Regional Invasive Species and Climate Change (RISCC) Management Network addresses the question "How can we manage for upcoming biological invasions in the light of climate change?". The RISCC Management Network implements translational invasion ecology by identifying stakeholder needs, synthesizing existing research, developing new research and tools, and supporting increased collaboration among scientists and managers.

To identify stakeholder needs, we surveyed over 200 national invasive species managers to assess barriers to management in the context of climate change. We have synthesized existing information through summaries of recent literature targeted at a general audience and by crafting two-page 'management challenge' documents that translate the state of the science, which are distributed to a listserv of 350 members. We are developing new research to prioritize range-shifting invasive species based on their impact, and new online tools to create state-level watch lists of range-shifting species. The RISCC Management Network hosts symposia and workshops to bring together scientists and managers to learn about these combined topics. Finally, we will use the information gleaned from these conversations with managers to inform future research translation, implementation, and communication efforts. Join the RISCC Management Network by emailing "ne_riscc-l-request@cornell.edu" with the subject 'join'.

Travels of a Rusty Blackbird

Carol Foss[1]

[1]New Hampshire Audubon

A pinpoint geolocator (GPS tag) was deployed on a male Rusty Blackbird at its breeding site in northern New Hampshire in June 2018 and retrieved from the bird in the same area in June 2019. Data downloaded from this device documented the bird's travels from August 2018 to April 2019. One key discovery was that it initially traveled north from its nesting area and remained in the Northern Forest until mid-October before migrating south. This poster presents the bird's overall travel route and the New England locations and habitats in which it spent time.

Tree-SMART Trade: Policy recommendations to reduce the importation of forest pests

Gary Lovett[1], Marissa Weiss[2], Kathy Lambert[3]

[1]Cary Institute of Ecosystem Studies
[2]Harvard Forest, Harvard University
[3]The Center for Climate, Health and the Global Environment, Harvard University

Imported forests pests (both insects and diseases) are one of the most serious and under-appreciated threats to forests and urban trees in North America. We led a team of scientists and policy advisors that produced a comprehensive study of the ecological and economic impacts of these pests in the US, and policy options for reducing the importation and establishment of new pests. As a follow-up to that study, we have identified a set of key policy actions that we call "Tree-SMART Trade" (TST). We focus these recommendations on preventing forest pests from becoming established in the country because that is more cost-effective than trying to manage already-established pest populations. We also focus on the two main pathways for introduction of pests into North America: solid wood packaging (e.g., pallets, crates) and live plants imported for landscaping. Since the publication of the TST recommendations, important progress has been made, such as eliminating the practice of allowing five violations of wood packaging standards before levying a penalty and a provision in the 2018 Farm Bill that requires US Department of Agriculture to do a comprehensive report on this issue. More detail can be found at www.caryinstitute.org/tree-smart-trade.

Understanding forest landowner management and decision making in the context of water quality, land use and climate change in the Lake Champlain Basin

Sarah Haedrich[1], Meagan Tan[1], Harrison Rohrer[1], Elizabeth Doran[2]

[1]Middlebury College Environmental Studies
[2]University of Vermont - EPSCoR Post Doc BREE Integrated Assessment

Management of forested lands in the Champlain basin plays an important role in nutrient flows into Lake Champlain, a North American freshwater inland lake. Forest land comprises two-thirds of the basin's surface area, and prior research by the Lake Champlain Basin Program has found this land may contribute up to 21% of the total phosphorus entering the lake each year, a key driver of the increasing incidence and intensity of potentially harmful algal blooms.

The aim of our research is to understand the relationship between the management decisions of private landowners, who own as much as 80% of the basin's forested lands, and the resiliency of Lake Champlain to nutrient loading from extreme weather events. To achieve this, we are conducting interviews with forest landowners in and around Addison County to determine:

1) Their engagement with conservation programs
2) Whether water quality concerns inform their management plans and practices
3) Whether these decisions are likely to change in the coming decades as more extreme weather events hit the area due to climate change.

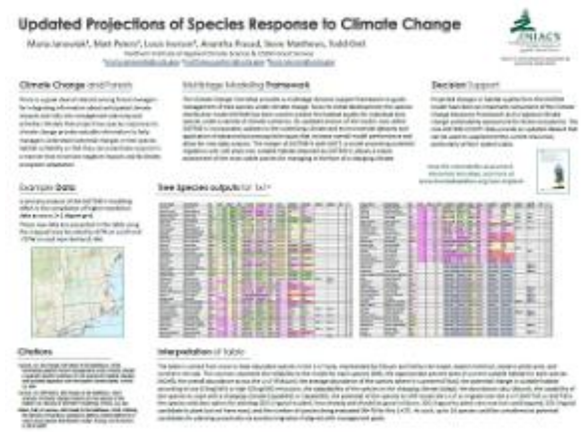
The data gathered from these interviews will be used as part of a larger agent-based model to better understand the role of individual decision making on algal bloom events in Lake Champlain from land use and climate trends in concert with hydrology data.

This poster presents the analysis of quantitative and qualitative data gathered from semi-structured landowner interviews. Themes identified around management practices and the language used in describing these practices in the context of water quality, climate change, and succession was presented along with regional comparison with other areas of the Lake Champlain Basin. A link to a digital online platform that pairs both the gathered data and stories as a public engagement tool was also shared.

Updated projections of species response to climate change

Maria Janowiak[1], Matt Peters[1,2], Louis Iverson[1,2], Anantha Prasad[1,2], Stephen Matthews[1,3], Todd Ontl[1,2]

[1]Northern Institute of Applied Climate Science
[2]US Forest Service
[3]The Ohio State University



There is a great deal of interest among forest managers for integrating information about anticipated climate impacts and risks into management planning and activities. Models that project tree species responses to climate change provide valuable information to help managers understand potential changes in tree species habitat suitability so that they can proactively respond in a manner that minimizes negative impacts and facilitates ecosystem adaptation.

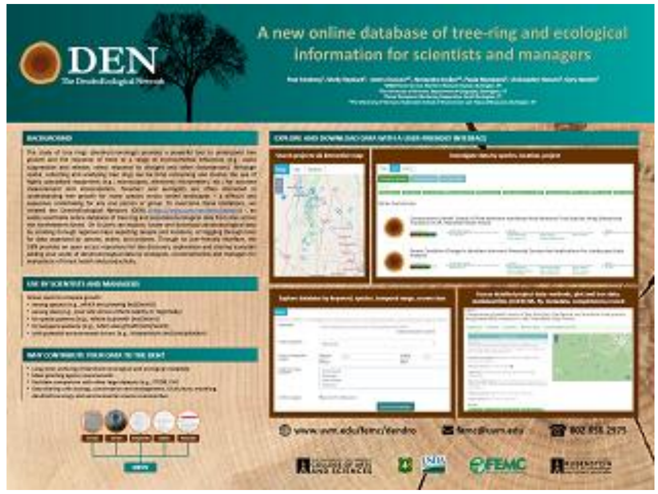
The Climate Change Tree Atlas provides a multistage decision support framework to guide management of tree species under climate change. Since its initial development, the species distribution model DISTRIB has been used to predict the habitat quality for individual tree species under a variety of climate scenarios. An updated version of the model, now called DISTRIB-II, incorporates updates to the underlying climate and environmental datasets and application of advanced processing techniques that increase overall model performance and allow for new data outputs. A primary product is the compilation of higher-resolution data across a 1x1 degree grid, as well as summarized for National Forests, National Parks, and HUC6 watersheds.

Projected changes in habitat quality from the DISTRIB model have been an important component of the Climate Change Response Framework and a regional climate change vulnerability assessment for forest ecosystems. The new DISTRIB-II data provide an updated dataset that can be used to supplement the current resources, particularly at finer spatial scales. Here we described how the model has improved and provided applications of its use.

What is the DEN? A new online database of tree-ring and ecological information for scientists and managers

Paul Schaberg[1], Shelly Rayback[2], James Duncan[3,4], Alexandra Kosiba[3,4], Paula Murakami[1], Christopher Hansen[4], Gary Hawley[4]

[1]USDA Forest Service Northern Research Station
[2]University of Vermont Geography Department
[3]Forest Ecosystem Monitoring Cooperative (FEMC)
[4]University of Vermont, Rubenstein School of Environment and Natural Resources



The study of tree rings (dendrochronology) provides a powerful tool to understand tree growth and the response of trees to a range of environmental influences (e.g., stand suppression and release, stress response to drought and other disturbances). Although useful, collecting and analyzing tree rings can be time consuming and involve the use of highly specialized equipment (e.g., microscopes, electronic micrometers, etc.) for accurate measurement and interpretation. Furthermore, foresters and ecologists are often interested in understanding tree growth for many species across varied landscapes, a difficult and expensive undertaking for any one person or group.

To overcome these limitations, we created the DendroEcological Network (DEN) (https://www.uvm.edu/femc/dendro), an easily searchable online database of tree ring and associated ecological data from sites across the northeastern forest. On it, users can explore, locate and download dendroecological data by scrolling through regional maps depicting sample plot locations, or toggling through links for data organized by species, states, and projects. Through its user-friendly interface, the DEN provides an open access repository for the discovery, exploration and sharing (consider adding your work) of dendroecological data by ecologists, conservationists and managers for evaluations of forest health and productivity. The DEN provides data that allows users to compare growth among species (e.g., which are growing best/worst), among sites (e.g., your site versus others nearby or regionally), assess spatial patterns (e.g., where is growth best/worst), evaluate temporal patterns (e.g., when was growth best/worst), compare relationships with potential environmental drivers of growth (e.g., temperature and precipitation) and much more.

Images and Photo Credits

Cover Photo

Flooded Birch. 2019. Accessed from pixfuel (https://www.pxfuel.com/en/free-photo-xiacm) and licensed under CC0 1.0 Universal license (https://creativecommons.org/publicdomain/zero/1.0/deed.en).

Introduction

Attendees, conference introductions. 2019. Photo by Alyx Belisle, FEMC.

Abstracts from Plenary Speakers

Using historical records combined with modern records to track the effects of climate change on the plants and animals of Thoreau's Concord.

IMG_4704. August 25, 2013. Photo by John Truong. Accessed from Flickr https://www.flickr.com/photos/125618836@N03/14746710642/in/album-72157679358418265/ and licensed under Attribution BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).

Evaluating success of monitoring for impacts of climate change on state wildlife lands in Massachusetts

IMG_3797. June 15, 2013. Photo by John Truong. Accessed from Flickr https://www.flickr.com/photos/125618836@N03/14385789548/in/album-72157679358418265/ and licensed under Attribution BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).

Plenary Sessions

Using historical records combined with modern records to track the effects of climate change on the plants and animals of Thoreau's Concord

Primack Autumn. 2019. Photo by Richard Primack. Accessed from https://www.bu.edu/biology/people/profiles/richard-b-primack/.

Acer Japonicum. 2017. Photo by Richard Primack. Accessed from http://primacklab.blogspot.com/2017/.

Killer Bees. 2018. Photo by Jose Manuel. Accessed from http://primacklab.blogspot.com/2018/.

Populus grandidentata. 2004. Photo by G.S. Torrey Herbarium, University of Connecticut. Accessed from http://primacklab.blogspot.com/2014/.

Walden Pond. 2013. Photo by Richard Primack. Accessed from http://primacklab.blogspot.com/2013/.

Rhododendron fargesii Leaf Out. 2014. Photo by Richard Primack. Accessed from http://primacklab.blogspot.com/2014/.

Evaluating success of monitoring for impacts of climate change on state wildlife lands in Massachusetts

John Scanlon. 2019. Photo by John Scanlon. Accessed from https://www.linkedin.com/in/john-scanlon-b298a26b.

Grassy Hill. 2019. Photo by Massachusetts Government Division of Fisheries and Wildlife. Accessed from https://www.mass.gov/news/achieving-climate-mitigation-and-wildlife-conservation-goals-on-wmas

Grasslands. 2019. Photo by Massachusetts Government Division of Fisheries and Wildlife. Accessed from https://www.mass.gov/service-details/why-is-habitat-management-needed

Carbon storage. 2019. Photo by Massachusetts Government Division of Fisheries and Wildlife. Accessed from https://www.mass.gov/news/achieving-climate-mitigation-and-wildlife-conservation-goals-on-wmas

Deer. 2019. Photo by Massachusetts Government Division of Fisheries and Wildlife. Accessed from https://www.mass.gov/service-details/learn-about-deer

Woodpeckers. 2019. Photo by Massachusetts Government Division of Fisheries and Wildlife. Accessed from https://www.mass.gov/service-details/learn-about-woodpeckers

Abstracts of Contributed Talks

All photos from speaker presentations with the following exceptions:

Vermont's functioning floodplains initiative – reconnections in the riverscape:

Fall Foliage. October 14, 2010. Photo by Kimberly Vardeman. Accessed from Flickr (https://www.flickr.com/photos/kimberlykv/5134878354/) and licensed under Attribution BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).

Climate change and stream crossing practices on Vermont's timber harvests:

IMG_0764. 2019. Photo by Vermont Department of Forests, Parks and Recreation. Accessed from https://fpr.vermont.gov/

Silviculture with birds in mind: Effects of disturbance-based forestry practices on habitat characteristics and carbon storage:

Black Capped Chickadee. 2019. Photo by Audubon Vermont. Accessed From https://vt.audubon.org/news/

Scarlet Tanager. 2019. Photo by Audubon Vermont. Accessed From https://vt.audubon.org/birds

Acid rain update Adirondack Mountains (NY) 2019: Deposition improvements revitalizing surface waters:

Mt. Jo. October 10, 2015. Photo by Vaibhav Bhosale. Accessed from Flickr (https://www.flickr.com/photos/vaibhavpbhosale/22192188714/) and licensed under Attribution BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).

Site preparation and direct seeding trials for riparian forest restoration:

Reed canarygrass (*Phalaris arundinacea*). 1913. USDA-NRCS PLANTS Database / Britton, N.L., and A. Brown, *An illustrated flora of the northern United States, Canada and the British Possessions. 3 vols.* Charles Scribner's Sons, New York. Vol. 1: 170. Accessed From https://plants.usda.gov/core/profile?symbol=PHAR3#

Vermont grassland. 2019. Vermont conservation design, Vermont Fish and Wildlife Department. Accessed from https://vtfishandwildlife.com/node/201

Pulsed resources cause dynamic range changes in the North American Red Squirrel:

American Red Squirrel. 2015. Steve Faccio, Vermont Center for Ecostudies. Accessed from https://necsc.umass.edu/news/climate-change-refugia-research-white-mountains-new-hampshire

Bicknell's Thrush. June 29, 2014. Photo by Aaron Maizlish. Accessed from Flickr (https://www.flickr.com/photos/amaizlish/14554573694) and licensed under Attribution BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).

Summary of Working Sessions

All photos from speaker presentations with the following exceptions:

Co-Designing forestry studies to address adaptation science needs:
Anthony D'Amato. 2019. Photo by Rubenstein School of Environment and Natural Resources. Accessed from https://www.uvm.edu/rsenr/profiles/anthony_damato_tony.

Data Rescue: Archiving 'At-Risk' data from the Catskills to Katahdin:
Matthias Sirch. 2019. Photo by Forest Ecosystem Monitoring Cooperative. Accessed from https://www.uvm.edu/femc/about/staff.

Managing Ash in the context of EAB – a regional discussion
Amanda Mahaffey. 2019. Photo by Forest Stewards Guild. Accessed from https://foreststewardsguild.org/meet-the-team/

Reducing the risks of invasive forest pests and climate change using knowledge co-production
Toni Lyn Morelli. 2016. Photo by Northeast Climate Adaptation Science Center. Accessed from https://necsc.umass.edu/people/toni-lyn-morelli .

Why Oak? Increasing Resiliency in Southern New England's Oak Forests
Christopher Riely. 2018. Photo by Sweet Birch Consulting. Accessed from https://sweetbirchconsulting.com/services/

Abstracts from Posters

All photos of poster thumbnail with following exceptions:

Does soil moisture and soil texture predict the fine-scale community organization of sugar maple and beech in a 1ha old growth forest in Middlebury, Vermont?
Autumn Curve. 2013. Photo by Jay Parker. Accessed from Flickr (https://www.flickr.com/photos/9171182@N02/10102796894) and licensed under Attribution BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).

Forest land use activities and fragmentation as a threat to northeastern forest cover and water quality
Summer afternoon on the Saco River. August 11, 2019. Photo by FotoFloridian. Accessed from Flickr (https://www.flickr.com/photos/fotofloridian/48557807041/in/photolist-2gYTsiF-2gsjX8f-23nAHMs) and licensed under Attribution BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).
Lake Champlain Bridge. August 23, 2018. Photo by Nicholas Erwin. Accessed from Flickr (https://www.flickr.com/photos/nickerwin/30376913588) and licensed under Attribution BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).

Geospatial analysis of tree species at risk from nitrogen deposition in the northeastern U.S.
Bigtooth Aspen Leaf After Rainstorm. July 21, 2015. Photo by Andrew Reding. Accessed from Flickr (https://www.flickr.com/photos/seaotter/19741085740/in/photolist-w5se2f) and licensed under Attribution BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).

Lake Champlain Wetland Vegetation monitoring

Sunlit Wetland. 2019. Accessed from pixfuel (https://www.pxfuel.com/en/free-photo-ogyke) and licensed under CC0 1.0 Universal license (https://creativecommons.org/publicdomain/zero/1.0/deed.en).

New low-cost stream gauging stations on headwater streams of the White Mountain National Forest

Franconia Notch State Park. October 1, 2014. Photo by Mattia Panciroroli. Accessed from Flickr (https://www.flickr.com/photos/dtpancio/16835422977/) and licensed under Attribution BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).

Understanding forest landowner management and decision making in the context of water quality, land use and climate change in the Lake Champlain Basin

Lake Champlain 8. May 26, 2008. Photo by Yuan2003. Accessed from Flickr (https://www.flickr.com/photos/yuan2003/2752597496/) and licensed under Attribution BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).

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

Appendix 1: Plenary session notes from note takers

Speaker in bold. Notes taken by FEMC staff.

Using historical records combined with modern records to track the effects of climate change on the plants and animals of Thoreau's Concord

***Dr. Richard Primack**, Professor of Biology, Boston University*

Notes recorded by Julia Pupko

Conference importance: exploration of interesting intersections between ecology, climate, biology and forestry.

2002: found no studies on the impact of climate in eastern US around that time.

- Many changes recorded in northern latitudes
- Must be changes here too
- NE region has had the largest temperature increase of the United States: includes increased temperature, rainfall, periods of drought, rising sea level and CO_2 which impact tree growth.
- Primack has seen the effects in a 150 year record of ice thaw in small bodies of water. This physical manifestation of climate change.

How does climate change affect biodiversity and ecosystem processes?

Key questions of our time:

1. How has environment been impacted?
2. Why should we care?
3. What should we do?

Key indicators:

1. Phenology (timing)
2. Distribution of species
3. Abundance of species

Best way to assess these questions: find old records and compare to our current conditions.

- Most detailed historical records: Thoreau in the 1850s. Discovered in 2003. Observations can be a "realometer".
- Focused on spring flowering wildflowers (very sensitive to climate). Shown to have a strong linear response to spring temperatures. Warmer = earlier bloom time.
- Same trends noticed at Arnold arboretum using plant specimens from history and comparing them to the exact same plant.

So important to bring these stories to the public. Visuals make a difference.

Trees have strongest response in phenology to climate change.

- Tree leaves responding with earlier leaf out more strongly than wildflowers and bloom time

- Can lead to ecological mismatch between plants/insects/birds.
- Results so far indicate: insects also responding strongly to climate change.
    - Insects are under severe decline in terms of biomass and species diversity with dire consequences for the ecosystem.
- Dr. Primack and students performed experiments to determine triggers of leaf out (temperature, photoperiod). Trees need winter chilling environment and exposure to a certain amount of warmth. Some need longer days (photoperiods).
- Photographs can be used to compare phenology. Used comparisons of cemeteries on Memorial Day to see differences in leaf out time.

Bird data:

- Vast amount of data out there
- Birds are not responding the same way
- Not as responsive because they migrate and don't "feel" the differences here.

Seen a loss in wildflower species:

- Local extinction, even in protected locations
- Particularly in cold loving species, those whose phenology cannot respond as dynamically to climate change.

Many stressors and interactions among the stressors converging on these systems.

- Systems are going to continue to change.
- We will have a southern climate.
- Many trees and animals currently here will not be able to survive.
- Assisted migration may protect endangered species.
- If we don't actively manage these species, they will go extinct.

Future directions/emerging science: fall phenology, interactions among species phenology (birds/plants), larger geographic patterns.

Lessons to live by: Observe nature, live simply, try to affect society.

Evaluating success of monitoring for impacts of climate change on state wildlife lands in Massachusetts

***John Scanlon**, Habitat Program Supervisor*

Notes recorded by Julia Pupko

Environmental Stressors:

- 23 years ago: climate change was not in mainstream conversation
- Human land change is important to look at as an environmental stressor
- Measure organisms and deer herbivory
- Cogbill Paper: Changes in forests: Massachusetts did not have beech pre-colonization
- Transition between "Eastern Broadleaf forests" and "New England Adirondack Province": Northern hardwood forests disrupted by European settlement
- Pitch pine occurs on the cape
    - Used to occur in localized regions throughout Massachusetts
    - Now much less
- Discrete ecoregional provinces disrupted by agriculture and reforestation
- Ranges of trees are changing and predicted to seriously change with climate change
- Sugar maples vulnerable to earthworms and climate change: What stressor leads to decline?
- Acid rain:
    - 1990 Clean air act: researchers made public aware of acid rain effects, led to legislative changes
    - Acid rain is coming back a bit
    - Red spruce may be very vulnerable to changes such as acid rain
- Deer:
    - Density: could find over 50 per mile squared in May
    - 12 – 18 deer per mile squared is the target
    - Deer eat everything
    - Public is disbelieving of deer impact
    - Over population stresses regeneration in forest plants
    - How will climate change exacerbate the impact of over browsing?

Monitoring:

- Monitoring on Massachusetts wildlife lands
    - Pollinating insects
    - Vegetation
    - Breeding birds
    - Vernal pools
    - Carbon
- Use intensive regeneration monitoring
- Think about monitoring insects
- Carbon stored – Carbon released: all based on land management

What are we managing for? What are the stressors to consider? How do we monitor for these impacts?

Management goals have changed over time:

- Know what we have and what we want in terms of cover types and match these to the habitat types.
- How do we adapt to climate change?
- How do you manage with a moving baseline?
- How do management activities release carbon?

What are we managing for?

- Step 1: What natural communities do you have now?
- Step 2: Determine your desired future condition (Where do you want to go?)
- Step 3: Determine priorities for restoration and management (locations to implement management)
- Step 4: Conduct initial biological information!
    - Need baseline data prior to management to know if management activities are working
- Step 5: Prepare for management (planning)
- Step 6: Environmental Permitting and contracts to implement

What are the stressors of concern?

- Historical land use … legacy of land use
- Acid deposition
- Invasive species and deer herbivory (earthworms)
- Climate change

The "discrete tension zone" (Cogbills): in place for centuries between central hardwoods and northern hardwoods pre-settlement (agricultural conversion and abandonment).

- Human clearing disrupted that tension zone.
- Has been settling out over the last 2 centuries as forests return to the landscape.
- Discrete transition zone has been obliterated.
- What will the new transition look like?
- Will be altered by novel stress agents listed above and complicated by how stressors interact

What should we monitor? (crowd sourced responses)

- Focus more on the invertebrates (pollinating insects)
- The forests depend on pollinator services they provide

Need baseline vegetation information before and after any treatments

- Species occurrence and abundance
- Must include boots on the ground
- Mapping is critical, not just averages or totals: include advanced regeneration in surveys
- Plan carefully considering spatial distribution of species and where management techniques should be applied
- Think about adding monitoring for pollinator insects

- Think about adding monitoring for carbon: storage, release, sequestration.
    - Should be able to create carbon budget for any management activities including what we release from these activities
    - Focus on how we can use forest management to sequester carbon

Take home message: John asks "at what point did we lose control?" Think about taking part in the 50th anniversary of earth day this April and what you can do to really make it count.

Appendix 2: Working session notes from note takers

Organizer in bold. Notes taken by FEMC staff

Co-Designing Forestry Studies to Address Adaptation Science Needs

Tony D'Amato, *Rubenstein School of Environment and Natural Resources, University of Vermont*

Notes recorded by Jennifer Pontius,

Overview:

- This is an opportunity to listen to what stakeholder needs are around adaptation science
- How do we understand the impact and manage for those impacts?
- What informs our management now:we use a lot from experimental forests but we need studies that address new stressors and their interactions (climate change/invasive species), including long term studies to develop new silvicultural strategies

Goals:

- Identify key science needs on the ground around forest adaptation strategies
- Develop and expand partnerships to determine how to DO this across the landscape. Can we co-develop adaptive strategies for silviculture?
- Have stakeholders help us design and implement studies to address climate and invasive issues in forest management.
    - Need to replicate across landscapes rather than one-off demonstration projects and have a commitment to follow up long-term (10-years).
    - Opportunity to provide funding for people to measure and summarize impacts on collaborator lands.

Research questions and experiment ideas raised by the group:

Group 1:

- How to manage beech?
- Why are we seeing oak seedlings showing up in new places?
- Social evaluation of perceptions, implementation and public opinions around different silvicultural techniques.
    - How to engage with large landowners around these issues
    - What social information is needed to keep forestry relevant and acceptable to general public?
    - Can we get in front of the curve in terms of forestry perceptions?

Group 2:

- How do we measure and ensure the outcomes of demonstration projects?
    - Can we find success stories and communicate those stories?
- Management implications of water stress (changing precipitation).
- How does climate change affect forest carbon?
    - How does pro-carbon silviculture work?
    - How do we communicate this to landowners?
    - What are the tradeoffs?
- Assisted migration best management practices.
- Regeneration (big picture) deer browse: are there other options beyond just hunting?
- Are we picking the right adaptation strategies (refugia vs. adaptation)?
    - What is the spatial component of what we should do (where should we do what)?
    - How to manager high vs. low risk stands?

Group 3:

- Original water quality work is outdated so our ANP's are outdated.
    - Can we link back to Coweta and Fernow to see how guidelines may need to be changed to manage for water quality?
- Looking at how we access forests and harvesting practices related to water quality.
    - How to access stands to minimize impacts.
- What do we take and what do we leave?
    - What are the benefits of leaving more (ecological and economic)?
    - How do gradients of management intensity fit in?
- What are the triggers for treatment?
- How do you decide among silvicultural options?

Group 4:

- Quantifying what extraction results/impacts are for various adaptive management strategies?
- Carbon budgets and balance for different treatment types.
    - Can we manage for carbon sequestration?
    - Could this be used as a message for management?
- Do our current ANPs account for changing intensity of harvesting?
    - Incorporate new climate regimes?
    - How will climate impact our harvesting operations (e.g. no frozen soil or snow cover to minimize impacts to soil?)
- How do we enhance or retain certain species? Which species should we manage for? Where? How can assisted migration be used? (Which species to use and where to plant them?)

Other comments from the whole group:

Forestry as a PR problem:

- How do we communicate tradeoffs between forestry and carbon with public and landowners (social question)?

- How do we communicate with landowners to get them to adopt these practices?
- Explore and combat perceived barriers to management for climate adaptation.

Chestnut is not on the forefront of people's minds as an option. But many may be open to that.

- Where can we find restoration opportunities?
- Could this be a species that could increase sequestration in our forests?

How do we manage for species that may be lost from the landscape? What other species could be managed to functionally replace those species?

TNC: elm restoration in clayplain forests in Westhaven.

- Deer browse is a big problem.
- Could elm replace ash as a resilience strategy?
- How do we do this, considering deer pressure?

Can we use a partnership to help with forest inventory across existing plot networks?

- Many partners can't staff those inventories.
- How can we include these existing plots in the experimental network?

Potential partners for management experiments (managed lands):
Mike Snyder: VT public lands
Publicover: manages 75000 acres in ME

Data Rescue: Archiving 'At Risk' Data from the Catskills to Katahdin

Matthias Sirch, *Forest Ecosystem Monitoring Cooperative*

Notes taken by Emma Tait

FEMC's Data Rescue project worked to:

1. Create an inventory of all at-risk data, and
2. Rescue as much of the high priority material as possible.

Discussion centered around the index used to select high priority projects to be rescued.

- Consensus that more weight should be given to the temporal coverage of a dataset as well as the number of institutions that might benefit from the data.
- Immediacy score could be added based on physical condition of the source material or how pressing a forest issue might be.
- Spatially, we do not want to lose deep knowledge about a single site when prioritizing datasets over a broader area. May be more appropriately considered on a case-by-case basis.
- Discussed outreach improvement:
  - How to help others rescue their own material
  - Directions that the Data Rescue project could take going forward

A handful of potential rescue projects were suggested.

- FEMC will follow up with each suggestion and include suggestions on Data Rescue inventory.
- Suggestions and comments will be useful in planning for Round 2 of the Data Rescue project.

FEMC recognizes the need to reach out to more non-profit organizations. FEMC archiving workshops lower barriers for folks to manage their data proactively.

Fostering a culture of archiving:

- Is there a better way to reach out to organizations and improve on the 1/3 response rate?
    - The FEMC can contact organizations again during the winter
- When contacting large organizations, how can we be sure not to miss anyone?
    - FEMC will contact several personnel and ask if there is a better channel to reach others
- More weight to temporal coverage for the high priority index
- Regional data is important but shouldn't lose deep knowledge from a single site
- In the index:
    - Account for how many institutions might care about the dataset
    - Add an immediacy score to consider condition of the data source or immediacy of a particular forest issue
- Develop more of a technical manual/management plan for how to rescue certain kinds of items.
    - Might include the chain of technologies needed to rescue items.
- Allow partner to be a part of rescue process
- How do we provide structure for making decisions about what to keep and what to pitch?
    - Should be determined within the organization
    - FEMC can provide feedback on what data is most useful for the FEMC mission
- What is the bar for archiving?
    - Data is worth including on the Data Rescue inventory if an organization reaches out with an expressed rescuing need.
    - FEMC can then use the high priority index to determine if it should be rescued.
- What do we do about ownership and inheritance? *Example*: possessing a box of papers but not the authority to give them away or make public.
    - An internal discussion within the organization would be appropriate to determine what would be done with the material.
- What attribution is most useful for discovery and utilization of rescued data?
    - Keywords, creator, location, topic, sites, short description of material
- When converting paper to digital, are we losing data in the process or creating new types of risk?
- Opportunity to reprocess older raw data with better methods.
- Perhaps we should be rescuing historical data from books.
- Interest in archiving old methods.
- Interest in reviving old studies not completed because land was private, now public.
- Interest in old growth and carbon data
- Connect with other institutions who are also archiving.
    - The Maine State Museum
    - Mass Audubon
    - Digital Preservation Coalition (https://www.dpconline.org/our-work/bit-list/endangered), an international data rescue effort
    - Research Data Alliance (https://www.rd-alliance.org/groups/data-conservation-ig), a data conservation interest group
    - Ecological Society of America (https://www.esa.org/)

- What to do with identified data outside the scope of the Data Rescue project:
    - Bird data from the 1950's onward from NH Audubon, Missisquoi Wildlife Refuge, and Dead Creek Wildlife Area. Hard copies of banding and nest box occupancy data.
- Soil cores in need of a home.
- How should we coordinate with larger efforts? Should we be putting things into ESA supported content?
    - *Example*: Phenology, genetic, geolocator data

Data Rescue, Round 2: Continue the Data Rescue effort during the winter when researchers and land managers may be less preoccupied with field work. This will incorporate RI and CT partners who were not solicited during Round1.

Managing Ash in the Context of EAB – a Regional Discussion

***Amanda Mahaffey**, Forest Stewards Guild*

Notes recorded by Matthias Nevins

Participant take-away:

- Management objectives will/should differ based on site location and context.
    - For example, white ash management, in a working forest context, is different than street tree management/mitigation. White ash management has large implication in the forest management context, but green and black ash are significant in other contexts and other site conditions. Flood plain forest management will likely focus on green and black ash species, which has minimal commercial value.
- Important to retain ash on the landscape.
    - Forest management: harvesting of ash should not be complete.
    - Harvesting of ash should be done in a way that is silviculturally sound.
- "Don't panic": sentiment shared by one of the oldest participants (experienced similar challenges)
    - Not all ash will be lost
    - Should focus on retaining and recruiting ash in our forests
    - Don't intensively harvest all ash
- Maintain biodiversity: When managing for ash in the context of EAB, promote biodiversity. Linked to greater resiliency in the face of changing conditions. Diversity of species, age classes, etc.
- Special focus/re-focus may need to be directed towards black ash species and the potential impacts to wetland habitats as a result EAB.

What do you know? Important information:

- Ash trees are dioecious: male and female flowers are born on separate individuals. When looking to retain on Ash on the landscape, one should look to maintain a good ratio of male: females to promote reproduction of the species.
- Retain vigorous trees which are likely more resistant to infestation.

What more would you like to know?

- Seed saving efforts and approaches? Is this being done? If so, what are the methods?

- Interest in learning more about study out of lake states, showing up to 70% of white ash trees still living following an EAB outbreak.
    - Looking to place the study in context and understand what this might mean for our ash trees.
    - Mortality will likely not be complete.
    - Compounding long-term impacts of an infestation remain uncertain.
- Management of green and black ash
    - Need for additional guidance and information.
    - Focus has been on commercial white ash and street tree management.
    - Recent black ash conference focused on indigenous relationships with ash and is an example of needed focus on this side of the issue.
- Discussed potential ecological impacts of EAB outbreak. Also, what are the positives of (silver lining) this impact? Increased CWD or snags.

What is needed to move the needle?

- Positive messaging. Folks were tired of the doom and gloom
- Strategic, targeted messaging.
- Spreading the word – 4H, cub scouts, local conservation commissions.
- Slow the spread

What can we do regionally?

- Have kids measure trees: Engage the youth, early education.
- Connect with the Association of Vermont Conservation Commissions and other groups outside of forestry circles
- Promote uses of ash (basket making): Get people engaged with the tree through craft.
- Aggregate the important information about ash, EAB, and what we can do.
    - Someone suggested VTinvasives was a good resource.
- Increase face to face exchange
- VT Ash contest: Best Ash. Idea to engage people in identifying ash and getting to know the tree.
- Identify urban street trees and town forest trees that are likely to die/be impacted by EAB
- Collect and save seeds
- Engage the baseball league as Ash is the primary species used to make baseball bats.

Why Oak? Increasing Resiliency in Southern New England's Oak Forests

Christopher Riely, *Rhode Island Woodland Partnership*

Notes recorded by Julia Pupko

High rates of oak mortality (2017-2019) from invasive pests (gypsy moth), drought, herbivory, and climate change. Up to 30% of oak trees in Massachusetts have died. Concerns due to high mortality rates:

1. Safety: high numbers of dead trees may fall on roads, houses, etc.
2. Increased fuel for fires
3. Loss of protection for thin soils
4. Reduced recruitment in areas that already have low rates of regeneration

Purpose of working session: brainstorm and collaborate on approaches to increasing oak resiliency in Southern New England. Christopher Riely has grant partners from Rhode Island, Connecticut, and Massachusetts and is in the planning stages of a project that will address the oak mortality crisis in southern New England. Project has four broad goals:

1. Examine the factors causing oak mortality and determine what methods will best address these issues
2. Address long-term resiliency in oak forests
3. Explore public outreach options to include family forest owners in the conversation
4. Synthesize and analyze data

Working session was run as a group conversation using four prompts:

1. What makes a resilient forest?

   Group responses:

   - Diversity: Oak forests that are primarily one or two species of oak with no other trees are hit hard by gypsy moth and other pests, as there are no natural barriers.
   - Northern red oak forests in moist, mesic valley soils seem to be hit the hardest by gypsy moths. Oaks in dry, cliff communities seem to have higher survival rates.

2. What tools can we use to assess forest health?

   Group responses:

   - Regeneration
   - Basal area and canopy assessments
   - Use the Nature Conservancy Score card
   - Incentivize family forest owners and community members to become involved and assess their oak forests.

3. What are practical strategies that can be implemented to increase oak resiliency?

   Group responses:

   - Oak regeneration seems to have a positive response to controlled burns. In many cases, controlled burns do not kill established saplings and these burns promote seedling growth.
   - Deer exclusions through slash fencing or low fences placed close together (Shroud Institute research) seem to be effective.

4. What tools can be implemented to determine how successful this project is?

   Group responses: Our oak forests may never be the same, so it is hard to say. (Ran out of time)

Appendix 3: Agenda for 2019 Conference

For informational purposes, the agenda from the conference is reproduced on the following page. Also available online at https://www.uvm.edu/femc/cooperative/conference/2019/agenda

2019 Forest Ecosystem Monitoring Cooperative Conference

Monitoring for Impacts of Climate Change: Tracking and measuring outcomes in northeastern forests

December 13, 2019 – Davis Center – University of Vermont

About the Forest Ecosystem Monitoring Cooperative

For over 25 years, the Forest Ecosystem Monitoring Cooperative (formerly the Vermont Monitoring Cooperative) has brought together practitioners from a range of disciplines and institutions to work together on monitoring and assessing forested ecosystems. The result is one of the largest and longest consistent records of forest ecosystem health in the country.

The primary mission of the FEMC is to "**serve the northeast temperate forest region through improved understanding of long-term trends, annual conditions, and interdisciplinary relationships of the physical, chemical, and biological components of forested ecosystems.**"

The History of the Forest Ecosystem Monitoring Cooperative

Established in 1990 as a partnership among the USDA Forest Service, the State of Vermont Agency of Natural Resources and The University of Vermont (UVM), the mission of the Forest Ecosystem Monitoring Cooperative (FEMC) mirrors and builds upon the priorities of these partners and their counterparts in the larger region. The FEMC serves as a hub to facilitate collaboration among federal, state, non-profit, professional and academic institutions towards ongoing monitoring of forested ecosystems across the region and an improved understanding of forested ecosystems in light of the many threats they face. In May 2017, the Cooperative changed its name from the Vermont Monitoring Cooperative as new state partners began participating in the FEMC. The cooperative now includes significant partnerships in Maine, Massachusetts, New Hampshire and New York.

The Services of the Forest Ecosystem Monitoring Cooperative

The FEMC staff supports the activities of a much larger network of actively engaged collaborators across governmental, academic, research and non-profit organizations. FEMC staff work with these collaborators to provide:

- Coordination and facilitation of monitoring and research activities across organizations, disciplines and state boundaries;
- Data support including: retrieval, archive, management, sharing, analysis and synthesis;
- Coordination and support of long-term ecosystem monitoring;
- Yearly syntheses of key ecosystem components, providing up-to-date assessments of current forest condition as well as long-term trends;
- An annual conference where ecosystem professionals come together for a day of sharing, learning and networking across disciplinary and organizational boundaries.

Getting Involved with the Forest Ecosystem Monitoring Cooperative

Interested in getting involved? The FEMC has numerous committees and activities that could use your support, and we would love to hear from you! Contact Jim Duncan (james.duncan@uvm.edu) if you would like to learn more.

Cover Photo – 'Mount Mansfield Summit' by Diana Gurvich

Monitoring for Impacts of Climate Change: Tracking and measuring outcomes in northeastern forests

9:00 to 5:30, December 13, 2019

Davis Center -- University of Vermont -- Burlington, VT

Agenda

8:15 – 9:00 **Registration and Coffee** *(Livak Fireplace Lounge. Coffee in Sugar/Silver Maple)*

8:30 – 8:45 **What is the FEMC?** *(Williams Family Room)*

First time at the FEMC conference? Want to learn more about what the FEMC does and how it works? Grab some coffee and join us for a quick pre-conference intro session to kick off your day.

9:00 – 9:15 **Introduction and Welcome** *(Sugar/Silver Maple)*

9:15 – 11:00

Plenary: Monitoring Effects and Effectiveness *(Sugar/Silver Maple)*

Michael Snyder, Commissioner, Vermont Department of Forests, Parks and Recreation, will be delivering the opening remarks and moderating the morning plenary session.

Using historical records combined with modern records to track the effects of climate change on the plants and animals of Thoreau's Concord

Richard Primack, Professor of Biology, Boston University

Evaluating success of monitoring for impacts of climate change on state wildlife lands in Massachusetts

John Scanlon, Habitat Programs Supervisor at Massachusetts Division of Fisheries & Wildlife

11:00 – 11:20 **Coffee Break** *(Sugar/Silver Maple)*

11:20 – 12:20 Contributed Talks 1 *(Rooms listed below)*

Contributed Talks 1 (11:20 AM – 12:20 PM)			
Climate and Forest Ecosystems *Moderator: Ellie Schiappa* *Room: Silver Maple*	**Pests and Disease** *Moderator: Ryan Kincaid* *Room: Mildred Livak*	**Technology and Partnerships** *Moderator: Stephanie Long* *Room: Jost Foundation*	**Forest Management** *Moderator: Meredith Naughton* *Room: Frank Livak*
Forest Carbon: An essential natural solution for climate change *Paul Catanzaro*	Using Invasive Species Data and Tools to Inform Management Priorities *Jennifer Dean*	Motus for New England *Carol Foss*	Climate Change and stream crossing practices on Vermont's timber harvests *David Wilcox*
Norther hardwood forest soil respiration response to climate change: Insights from multiple climate manipulation experiments *Andrew Reinmann*	What are we looking for - a review of regional potential incoming invasive species *Judy Rosovsky*	LiDAR-derived stream mapping stands to drastically improve NH stream data *Austin Hart*	Comparison of the resistance of even-aged and uneven-aged stands to environmental stressors in temperate forests as measure by tree mortality. *Rebeca Cordero Montoya*
Vermont's Functioning Floodplains Initiative--Reconnections in the Riverscape *Mike Kline*	Trends in invasive plants in eastern National Park forests *Aaron Weed*	The Catskill Science Collaborative: A unique partnership for research, resource management, and outreach. *Jamie Deppen*	Silviculture with birds in mind: effects of disturbance-based forestry practices on habitat characteristics and carbon storage *William Keeton*

12:20 – 1:30 Lunch *(Sugar/Silver Maple)*

1:30 – 2:50 Contributed Talks 2

Contributed Talks 2 (1:30 PM – 2:50 PM)			
Climate and Forest Ecosystems *Moderator: Eliza Letourneau* *Room: Frank Livak*	**Forest and Alpine Ecology** *Moderator: Ryan Kincaid* *Room: Mildred Livak*	**Wildlife** *Moderator: Stephanie Long* *Room: Jost Foundation*	**Forested Waters** *Moderator: Rebecca Harvey* *Room: Chittenden Bank*
Moving the Needle: Assessing What Forest Managers Need to Increase Climate Adaptation in New England *Amanda Mahaffey* *Christopher Riely*	Northern Hardwoods and Long-Term Change: Assessing Old-Growth and Managed Experimental Forest in the Adirondack Mountains of New York *Stacy McNulty*	Elevational Distributions of Montane Spruce-Fir Forest Bird Communities from 2010-2019 *Jason M. Hill*	Acid rain update Adirondack Mountains (NY) 2019: deposition improvements revitalizing surface waters *Karen Roy*
Growth of Northeastern Tree Seedlings in Response to Future Precipitation Scenarios *Peter Clark*	Trends and environmental drivers of tree growth for seven major species in Vermont: future implications in the context of climate change *Rebecca Stern*	Assessment of long-term freshwater mussel population trends in the lower Poultney and Lamoille Rivers. *Paul Marangelo*	Managing headwater streams for climate resilience: Monitoring the geomorphic impact of large instream wood structures at Burnt Mountain Natural Area *Megan Gordon*
Every Picture Tells a Story aka/ Forest Photography Designed to Document, Interpret and Monitor Climate Change-Forest Change *Roger L. Merchant*	Monitoring plant populations in the Adirondack Alpine *Tim Howard*	American marten density and habitat associations in New Hampshire *Donovan Drummey*	Monitoring Vermont reference streams to understand climate change impacts *Aaron Moore*

Assessing Ecosystem Controls on Soil Carbon Storage Across the Northeastern United States *Adam Noel*	Forest structure could mitigate negative impacts of climate change on functional diversity in northeastern North America *Dominik Thom*	Pulsed resources cause dynamic range changes in the North American Red Squirrel *Michael T. Hallworth*	Site Preparation and Direct Seeding Trials for Riparian Forest Restoration *Annalise Carington*

2:50 – 3:00 Coffee Break *(Sugar/Silver Maple)*

3:00 – 4:30 Working Groups

3:00 – 4:30 Working Groups

Proposed and organized by cooperators, these working group sessions provide opportunities to focus on key issues and priorities of members of the Cooperative

Confirmed working sessions include:

Reducing the Risks of Invasive Forest Pests and Climate Change Using Knowledge Co-Production
Organizer: Toni Lyn Morelli, U.S. Geological Survey

Co-Designing Forestry Studies to Address Adaptation Science Needs
Organizer: Tony D'Amato, Rubenstein School of Environment and Natural Resources, University of Vermont

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Why oak? Increasing Resiliency in Southern New England's Oak Forests
Organizer: Christopher Riely, Rhode Island Woodland Partnership

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Data Rescue: Archiving 'At-Risk' Data from the Catskills To Katahdin
Organizer: Matthias Sirch, Forest Ecosystem Monitoring Cooperative

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Managing Ash in the Context of EAB - a Regional Discussion
Organizer: Amanda Mahaffey, Forest Stewards Guild

Lye Brook Wilderness Area Subcommittee Working Group
Organizer: Angie Quintana, Green Mountain & Finger Lakes National Forests

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4:30 – 5:30 Poster Session and Social Hour *(Silver Maple)*

Working Group Descriptions

Reducing the risks of invasive forest pests and climate change using knowledge co-production
Organizer: Toni Lyn Morelli, U.S. Geological Survey
Room: Chittenden Bank Room

Building off a recently formed working group focused on understanding of risks associated with pest outbreaks in forests, this working session will refine a structured decision-making framework, with input from new and existing working group members. The goal is to bring the power of ecological forecasts and knowledge coproduction (resource managers and scientists working together) to develop a scalable decision-support system. We are working together to identify information needs for pest species (especially Hemlock Woolly Adelgid). We will further develop our understanding of the role of risk in forest pest management. This working session is a collaboration among the National Phenology Network, USGS, USFS, and the Regional Invasive Species and Climate Change (RISCC) Management network.

Co-Designing Forestry Studies to Address Adaptation Science Needs
Organizer: Tony D'Amato, Rubenstein School of Environment and Natural Resources, University of Vermont
Room: Mildred Livak

The uncertainty around the impacts of climate change, invasive species, and extreme weather events poses a significant challenge to sustaining forest ecosystems in the northeast. Much of our current management is guided by the outcomes of decades of silviculture research, yet many of the conditions under which those results were generated are rapidly changing. General suggestions for how to approach forest adaptation for uncertain future conditions have been suggested, but few, robust field evaluations exist to inform widespread management applications. This working group session will facilitate discussion among forestry professionals and research scientists to identify what science is most needed to help inform forest adaptation strategies to address the impacts of climate change and invasive species, and garner input on how to best engage landowners when testing such approaches. The outcomes of this session will inform the design of a series of new silvicultural studies and develop manager-scientist partnerships to enhance the region's capacity for implementing and sharing the outcomes of forest adaptation in practice.

Why oak? Increasing Resiliency in Southern New England's Oak Forests
Organizer: Christopher Riely, Rhode Island Woodland Partnership
Room: Frank Livak

Oak trees are an iconic part of southern New England's forests. Today, they are under pressure from a complex range of stresses including gypsy moth, deer browse, and invasives. Forest managers are struggling to secure regeneration and are further challenged with how to communicate with landowners about options for managing oak woodlands in a changing climate. What makes a resilient forest? What tools can we use to assess how "healthy" a forest is? What are practical management strategies to help increase resiliency in oak forests? What tools can we use to monitor our efforts and find out if we're making a difference? This facilitated working session will explore these and other questions. All participants who work in or care for oak forests are invited to take part.

This discussion is related to a USDA Forest Service-funded project in its early stages with partners in Rhode Island, Connecticut, and Massachusetts. Outputs from the session will help inform our work with professionals and landowners to increase resiliency in southern New England's oak forests.

Working Group Descriptions Continued

Data Rescue: Archiving 'At-Risk' Data from the Catskills to Katahdin
Organizer: Matthias Sirch and Emma Tait, Forest Ecosystem Monitoring Cooperative
Room: Sugar Maple

FEMC has been working to compile an inventory of at-risk data and rescue high priority material. In this working session we will share insights gained in the rescuing process to inform a broader discussion around defining at-risk data and ways to collectively develop a data rescue framework. What data do you want to see rescued? How do we establish priority? What are the obstacles to rescuing and utilizing at-risk data? Together we will discuss these questions as well as brainstorm more efficient methods for connecting rescues with resources and explore avenues for addressing future data risk.

Managing Ash in the Context of EAB - a Regional Discussion
Organizer: Amanda Mahaffey, Forest Stewards Guild
Room: Jost Foundation Room

The "little green bug", the emerald ash borer, is known as a harbinger of death and destruction to ash trees across the continent. Its presence instantly brings to mind the disheartening prospect of every ash tree in a stand, forest, or state disintegrating into a snag and disappearing from the forest ecosystem. All too often, even the mention of the bug leads managers to harvest every ash tree in reach during a timber harvest. But wait! There are sound, science-based reasons to consider alternative treatments. Ash trees are irreplaceable to Native American cultures in our region. Ash trees - living, dead, or dying - also provide important habitat to wildlife in forest ecosystems. Recent research shows that not all ash trees will die and that cutting them all eliminates our chances of retaining their important ecological and social values.

A series of forums in Vermont this year helped forest managers explore alternative management approaches for ash in the context of EAB. What is your state doing to help foresters manage ash in spite of the little green bug? In this facilitated working session, participants will share ideas, observations, and strategies for conducting thoughtful silviculture and share learning about ash management across the Northeast region.

Working Group Descriptions Continued

Lye Brook Wilderness Area Subcommittee Working Group
Organizer: Angie Quintana, Green Mountain & Finger Lakes National Forests
Room: Williams Family Room

Anyone interested in ongoing or future monitoring and research at the Lye Brook Wilderness Area is encouraged to join, with the goal of making connections and coordinating across organizations and disciplines to support this work. Lye Brook is the only Class I Wilderness Area in Vermont and includes a rich archive of existing data and long-term studies. This workgroup brings together key partners in an ongoing collaboration focused at this FEMC intensive research site. The Lye Brook Wilderness is in the southern Green Mountains of Vermont. It's named after the brook flowing through its western half. Most of it is above 2500 feet, on a high plateau with several ponds and bogs. Approximately 80% of the area is forested with northern hardwoods: birch, beech, and maple. Thickets of small spruce dot the area. Several species of neotropical birds, black bear, moose, deer, pine martin and bobcat inhabit these woods. There are many marshy areas off trail and the ecological balance is quite fragile.

Meeting Objectives:

- Provide brief updates on current and near future research and monitoring projects in the Lye Brook Wilderness Area, building on our existing list at https://www.uvm.edu/femc/cooperative/lye_brook_committee
- Identify additional research or project needs (to add to existing list)
- Prioritize and develop strategies to collaborate and accomplish projects and research
- Choose a date and location for a field trip in summer 2020, and Nov/Dec 2020 meeting

Poster Titles and Presenters

Abstracts available online - https://www.uvm.edu/femc/cooperative/conference/2019/agenda

Travels of a Rusty Blackbird
Presenter: Carol Foss, *New Hampshire Audubon*

What is the DEN? A new online database of tree-ring and ecological information for scientists and managers.
Presenter: Paul Schaberg, *USDA Forest Service Northern Research Station*

Assessing the statewide condition of macroinvertebrate and fish communities in Vermont streams
Presenter: Aaron Moore, *Vermont Agency of Agriculture, Food and Markets*

Comparison of climatic conditions experienced by northern and southern red spruce ecotypes
Presenter: John R. Butnor, *Southern Research Station, USDA Forest Service*

Monitoring spring canopy green up in Pinkham Notch, NH using digital cameras
Presenter: Patrick Scordato, Appalachian Mountain Club

Translating Science into Practice and Practice into Science - Northeast RISCC Management Network
Presenter: Audrey Barker Plotkin, *University of Massachusetts, Amherst, Amherst, MA*

Adaptive Silviculture for Climate Change: Initial Structural Outcomes in the Northern Hardwood Forest
Presenter: Jessica Wikle, *University of Vermont, Rubenstein School of Environment and Natural Resources*

Understanding forest landowner management and decision making in the context of water quality, land use and climate change in the Lake Champlain Basin
Presenters: Sarah Haedrich, Meagan Tan, Harrison Rohrer, *Middlebury College Environmental Studies*

Forest Land Use Activities and Fragmentation as a Threat to Northeastern Forest Cover and Water Quality
Presenter: Elizabeth Doran, *UVM VT EPSCoR BREE Project*

Does soil moisture and soil texture predict the fine-scale community organization of sugar maple and beech in a 1ha old growth forest in Middlebury, Vermont?
Presenter: Morgan Forest Perlman, *Middlebury College*

Updated Projections of Species Response to Climate Change
Presenter: Maria Janowiak, *Northern Institute of Applied Climate Science & US Forest Service*

Sliding down Cotton Brook, Waterbury, VT
Presenter: Marjorie Gale, *Vermont Geological Survey, DEC*

Lake Champlain wetland vegetation monitoring
Presenter: Jo Robertson, *Vermont Fish and Wildlife Department & Eco AmeriCorps*

New low-cost stream gauging stations on headwater streams of the White Mountain National Forest
Presenter: Austin Hart, *White Mountain National Forest*

Poster Titles and Presenters Continued

Tree-SMART Trade: Policy Recommendations to Reduce the Importation of Forest Pests
Presenter: Gary Lovett, *Cary Institute of Ecosystem Studies*

Geospatial analysis of tree species at risk from nitrogen deposition in the northeastern U.S.
Presenter: Linda Pardo, *U.S. Forest Service, Northern Research Station*

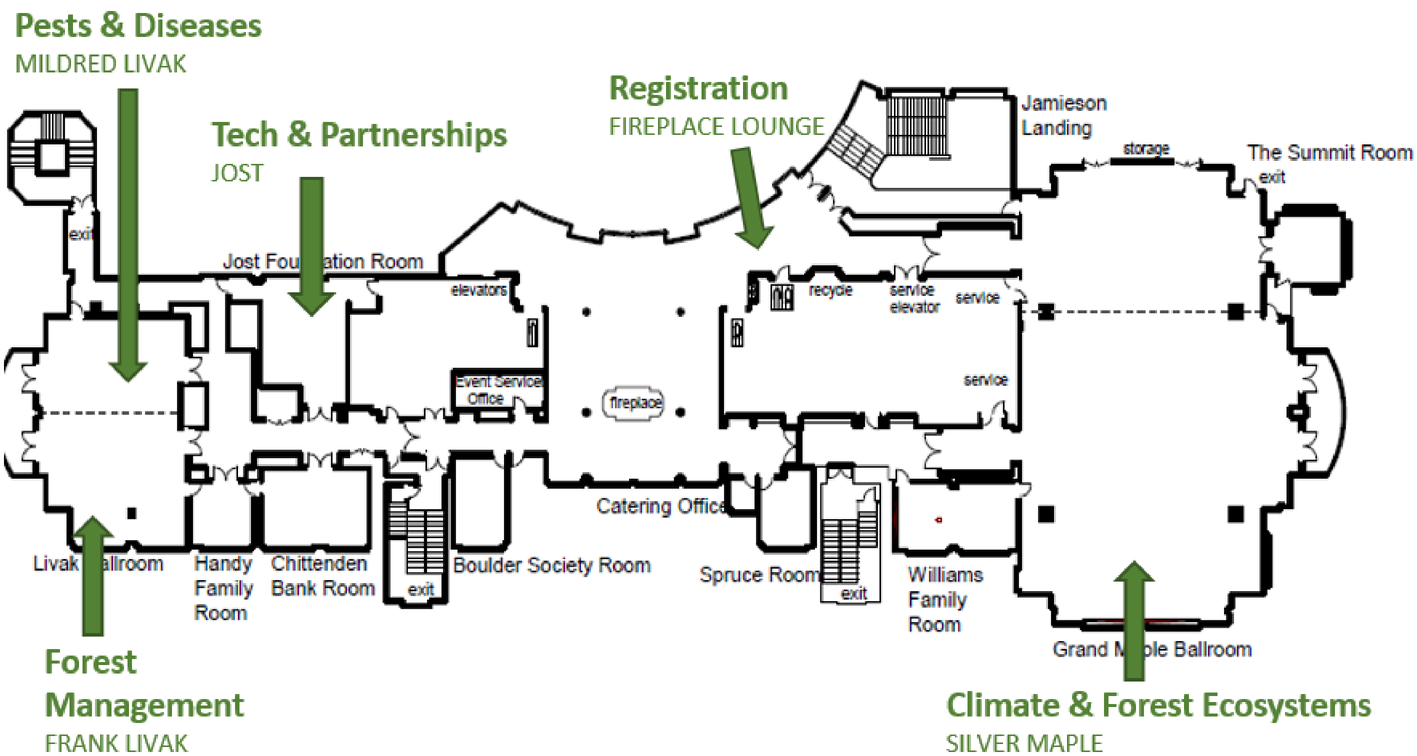
Monitoring the Health of Vermont's Forests: Data from 2019 and Changes in Tree Health
Presenter: Julia Pupko, *Forest Ecosystem Monitoring Cooperative*

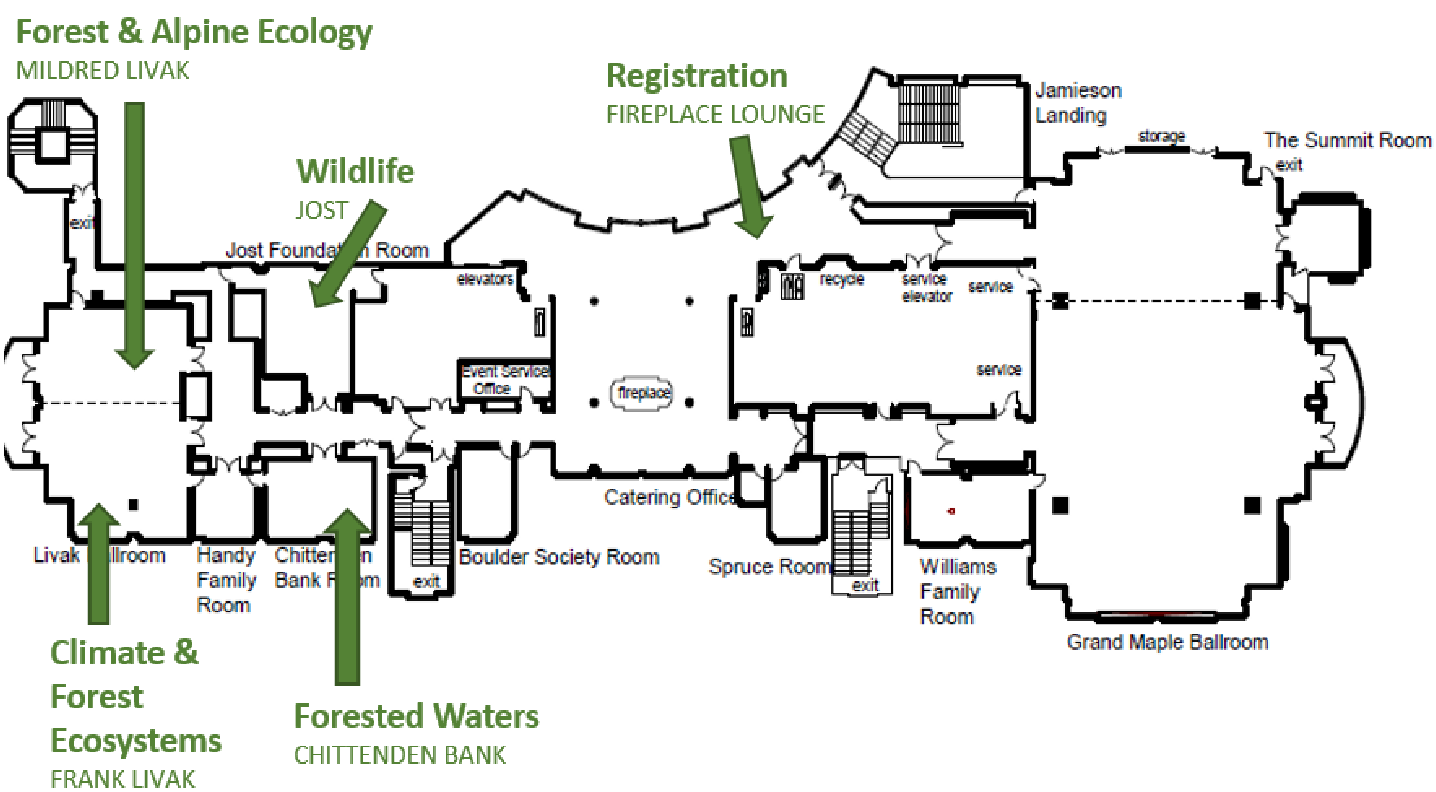
2019 Forest Ecosystem Monitoring Cooperative Partner Projects
Presenter: *Forest Ecosystem Monitoring Cooperative*

2019 Forest Ecosystem Monitoring Cooperative Regional Projects
Presenter: *Forest Ecosystem Monitoring Cooperative*

Room Assignments for Contributed Talks 1 (11:20-12:20)

Room Assignments for Contributed Talks 2 (1:30-2:50)





Room Assignments for Working Groups and Poster Session 3:00 – 5:30