Proceedings of the December 14, 2018

Forest Ecosystem Monitoring Cooperative Conference

Forests and Climate Change: Managing impacts and planning for the future

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 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-eight years.

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

Today, the FEMC funding stems primarily from a partnership between the USDA Eastern Region State & Private Forestry as part of the Cooperative Lands Forest Health Management Program, the Vermont Department of Forests, Parks and Recreation, and the Rubenstein School of Environment and Natural Resources at the University of Vermont. The majority of FEMC operations are handled by staff affiliated with the University of Vermont. 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 28th annual conference on December 14, 2018, at the Davis Center at the University of Vermont. The guiding theme ***Forests and Climate Change: Managing Impacts and Planning for the Future*** was chosen to help collaborators better understand the impacts of climate change on key forest ecosystem processes and services.

Following the plenary session, the conference included two sessions of concurrent talks where 40 collaborators from across the region presented their most recent research and monitoring efforts. The afternoon included four working group sessions on the topic of climate change that were offered by members of the Cooperative.

These proceedings represent a combination of summaries of the plenary session talks written by FEMC staff, syntheses and outcomes from a series of afternoon working sessions, and the abstracts submitted by researchers to the concurrent sessions. Additional details, including videos and downloadable PowerPoints of presentations can be found on the meeting home page at: www.uvm.edu/femc/cooperative/conference/2018/content.

Climate change impacts on Northeastern Forests, water and wildlife

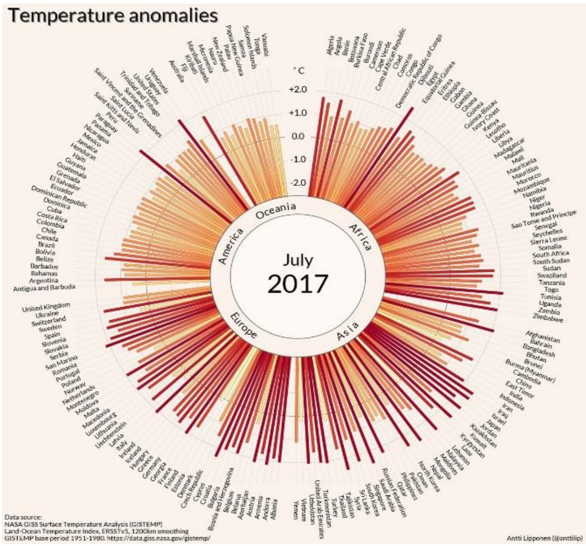

Figure 1. July 2017 temperature anomalies (°C) by country (Antti Lipponen, 2017).

What have we learned about climate change in the past year? Two important and useful publications were released in 2018 that improve our understanding of climate change and its impacts. The first is the *Fourth National Climate Assessment*[1], which provides an in-depth assessment of the US climate, including a chapter focusing on the Northeast. This report showcases how far climate science has advanced since the previous assessment, including improvements in modeling local climate projections and attribution of observed changes. Second, the US Forest Service and Northern Institute of Applied Climate Science published a *Climate Change Response Framework*[2] that outlines the implications of climate change for forested ecosystems and provides strategies for adaption.

To date, there have been observed changes in the global, national, and local climate. While there may be high variability in climate from year-to-year and location-to-location, overwhelmingly the trend shows an increase in temperature. These changes are happening quicker than in our historical past, trends are robust and confirmed by multiple lines of evidence, and humans are the primary driver. In New England and New York, the mean annual temperature has increased 2.4 °F between 1901 through 2011, with bigger changes observed in winter[2]. Precipitation has also increased, but it is quite variable, and more is falling during extreme events. Moving forward, we will continue to see increases in temperatures across all seasons. We can expect increases in extreme events, including heat waves, floods, droughts, and high winds.

> *By 2035, under both lower and higher scenarios, the Northeast is projected to be more than 3.6 °F warmer on average than during the preindustrial era. This would be the largest increase in the contiguous United Sates and would occur as much as two decades before global average temperatures reach a similar milestone*[1]

Considering these changes, it is imperative that we understand the impacts climate change will have on the region's forested ecosystems, including impacts to forests, wildlife, and water. To address these topics, the plenary session featured three keynote speakers addressing the observed and potential impacts of climate change on forests, wildlife, and water resources in the Northeast.

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[1] USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018. Available at https://nca2018.globalchange.gov/

[2] Janowiak, M.K., D'Amato, A.W., Swanston, C.W., Iverson, L., Thompson, F.R., Dijak, W.D., Matthews, S., Peters, M.P., Prasad, A., Fraser, J.S. and Brandt, L.A., 2018. New England and northern New York forest ecosystem vulnerability assessment and synthesis: a report from the New England climate change response framework project. Gen. Tech. Rep. NRS-173. Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station. 234 p., 173, pp.1-234. Available at: https://www.fs.usda.gov/treesearch/pubs/download/55635.pdf and https://forestadaptation.org

What's at risk? Implications of climate change in our region's forests

Maria Janowiak, Deputy Director, Northern Institute of Applied Climate Science

Photo courtesy of USFS

In examining the effects of climate change on forests, Maria addressed three important takeaways: shifting seasons, shifting species, and shifting stressors.

(1) Shifting seasons - There are many examples of recent changes in local weather and climate in the Northeast. While there will be some positive outcomes to these changes, like a lengthened growing season that can lead to greater forest growth and productivity, there will also be negative consequences to these shifts. We will continue to see shorter, warmer, and more variable winters, resulting in lessened snowpack depth and duration. These changes will be especially problematic for winter logging, the ski industry, and belowground soil processes – all of which depend on continuous winter snow cover. We will also continue to experience extreme precipitation events that can cause significant impacts to infrastructure, ecosystem services, and the economy.

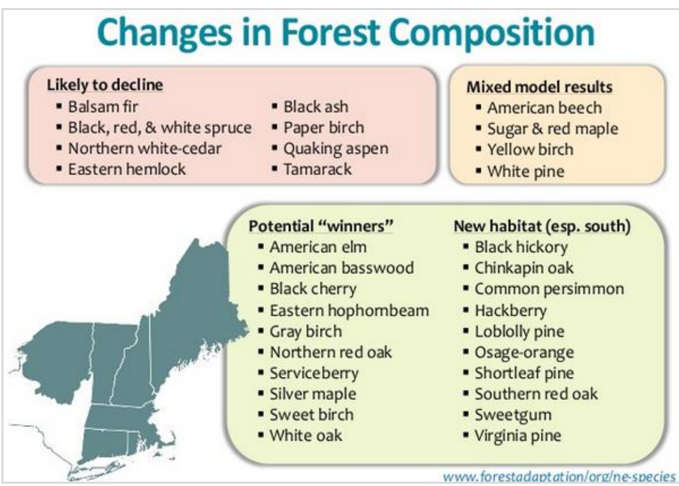

Figure 2. Projected changes in forest composition[3].

(2) Shifting species - Maria and her co-authors used three climate scenarios to project the outcomes of different tree species under climate change[3]. They found that the species at greatest risk were adapted to cold climates. These species may see their ranges contract to more northerly and higher-elevation habitats where cold temperatures persist. Other tree species may expand their range to novel habitats, but it remains unclear where this will happen, at what pace it will occur, and what the ecosystem implications will be. There were also many generalist species with uncertain outcomes that may nonetheless face habitat restriction and increased stress levels. The more the climate changes, the more those species will be put at risk.

(3) Shifting stressors – Forest stressors, like insects, diseases, and weather events, can push trees beyond their ability to withstand change. The US Department of Defense has labeled climate change a "threat multiplier", and this same concept relates to the impacts of climate change on forested ecosystems. Chronic stress, disturbances, insect pests, forest diseases, invasive species, and other perturbations may change in

[3] Janowiak, M.K., D'Amato, A.W., Swanston, C.W., Iverson, L., Thompson, F.R., Dijak, W.D., Matthews, S., Peters, M.P., Prasad, A., Fraser, J.S. and Brandt, L.A., 2018. New England and northern New York forest ecosystem vulnerability assessment and synthesis: a report from the New England climate change response framework project. Gen. Tech. Rep. NRS-173. Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station. 234 p., 173, pp.1-234. DOI: https://doi.org/10.2737/nrs-gtr-173 Available at: https://www.fs.usda.gov/treesearch/pubs/55635 and https://forestadaptation.org

unpredictable ways. Local information and data are important to understand how an ecosystem will change in a specific location.

Adaptation is the adjustment of systems in response to change. NIACS developed a framework to address forest management under climate change called the "the spectrum of adaptation options", which includes resistance, resilience, and transition[4,5,6]. Resistance strategies protect high value systems. Resilience tools build the immunity of the system so that it can better cope with changes and recover. Transition strategies can be utilized when ecosystems are challenged to such a degree that they need to change to better match future conditions.

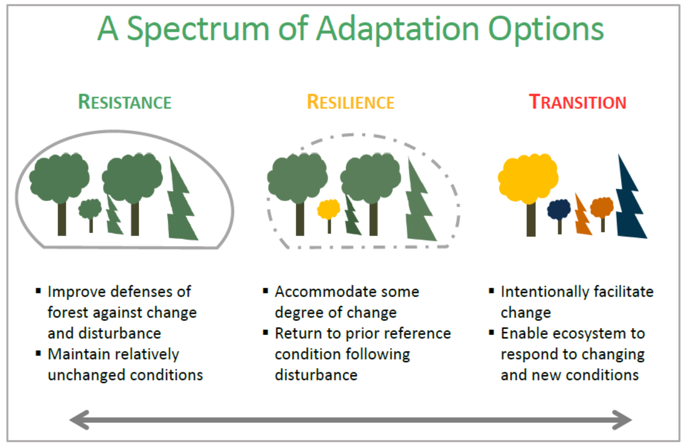

Figure 3. Options for adaptation to climate change in the New England forest[4,5,6].

Maria and her co-workers have provided real-world examples of these three types of climate change adaption projects, including more than 50 projects in New England. Of the adaptation projects underway, most projects focus on increasing resilience, such as bolstering diversity or reducing stressors. Increasingly, there are more projects using transition strategies. Sharing these projects and their outcomes allows managers to figure out what works in a particular location. In an era of change, every action becomes an experiment, with a need to record and evaluate the efficacy of outcomes.

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[4] Millar, C.I., Stephenson, N.L., Stephens, S.L., 2007. Climate Change and Forests of the Future: Managing in the Face of Uncertainty. Ecological Applications 17, 2145–2151. https://doi.org/10.1890/06-1715.

[5] Swanston, C.W., Janowiak, M.K., Brandt, L.A., Butler, P.R., Handler, S.D., Shannon, P.D., Derby Lewis, A., Hall, K., Fahey, R.T., Scott, L., Kerber, A., Miesbauer, J.W., Darling, L., 2016. Forest Adaptation Resources: climate change tools and approaches for land managers. 2nd ed. (No. NRS-GTR-87-2). U.S. Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, PA. https://doi.org/10.2737/NRS-GTR-87-2

[6] Nagel, T.A., Firm, D., Pisek, R., Mihelic, T., Hladnik, D., de Groot, M., Rozenbergar, D., 2017. Evaluating the influence of integrative forest management on old-growth habitat structures in a temperate forest region. Biological Conservation 216, 101–107. https://doi.org/10.1016/j.biocon.2017.10.008

Climate change vulnerability and adaptation of forest wildlife

Toni Lyn Morelli, USGS Research Ecologist, DOI Northeast Climate Adaptation Science Center

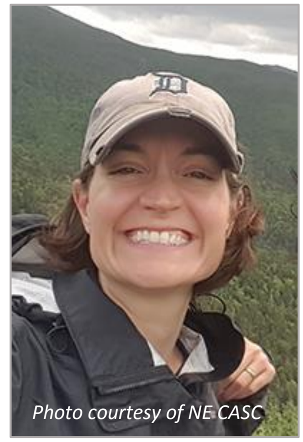
Photo courtesy of NE CASC

There have been many observed indicators of climate change. The Northeast has been affected by these changes more than other regions[7]. Temperatures are increasing. Winters will continue to warm, which will reduce the number of freezing days. Under both high and low emissions scenarios, the warmest winters we experience now will be equivalent to the coldest winters we will experience in the future. Ecologically these changes have resulted in longer growing seasons, drier summers and falls, and shorter winters with less snow. With decreased snowpack there will be an increase in forest vulnerability due to soil frost.

Globally, we have seen local wildlife extinctions[8] due to climate change, and the Northeast is particularly vulnerable to continued losses. Risk of extinction will increase with more emissions. We have also observed phenological shifts in the timing of events, such as juvenile birds being born earlier in the season because of temperature changes. While these may be helpful adaptations, it is imperative that we monitor these changes as they occur.

What makes species vulnerable to climate change? To understand how a species may respond to climate change and aid in adaptation planning, each species is assessed for its vulnerability[9] (Figure 4). This process allows scientists and managers to identify species and habitats at greatest risk from climate change impacts and assess their specific adaptive capacity.

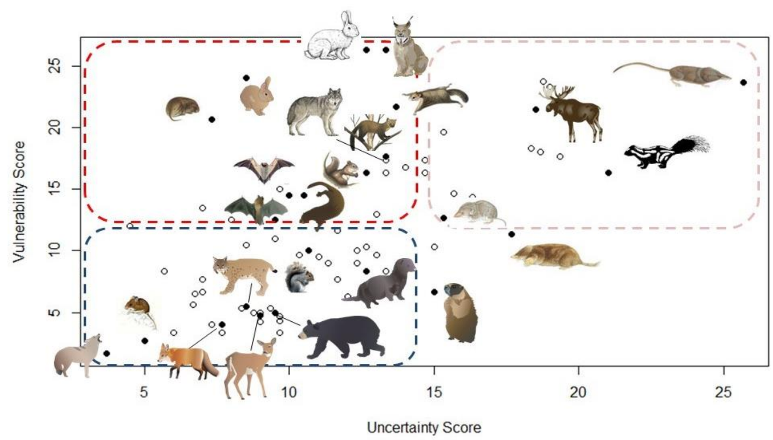

Figure 4. Predicted vulnerability of forest mammals in the Northeast compared to the relative certainty of those predictions[8].

The boreal forest, which provides habitat to some of the most iconic species in our region, is one of the most vulnerable habitats under a changing climate. Scientists expect that with habitat deterioration, spruce-fir obligate wildlife species will also decline. To date, we have seen blackpoll warbler populations decline by 60% across its range. In general, mammal species found further north might be the most vulnerable to climate change. Generalist species, on the other hand, may be able to relocate up in latitude and elevation as needed to mitigate changes. Specifically, moose will continue to be vulnerable, with higher numbers of winter ticks, greater infestation of other pests, and elevated heat stress.

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[7] USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. DOI: 10.7930/NCA4.2018. Available at https://nca2018.globalchange.gov/

[8] Wiens, J.J., 2016. Climate-Related Local Extinctions Are Already Widespread among Plant and Animal Species. PLOS Biology 14, e2001104. https://doi.org/10.1371/journal.pbio.2001104

[9] Toni Lyn Morelli, 2018. Climate change vulnerability and adaptation of forest wildlife. 2018 FEMC Annual Conference. Available at https://youtu.be/QsUjM4Dzw-g

Water and aquatic ecosystems in a changing regional climate

Keith Nislow, Research Fisheries Biologist, USDA Forest Service Northern Research Station

Already we have observed climate-driven changes in water quantity and quality and continued changes are projected for the future. The climate will get warmer and wetter, and we will experience more extreme events. As the Northern Forest socioecosystem depends on abundant and predictable water, changes in precipitation or flow regimes accompanied by changes in thermal regimes will impact water quantity and quality. These changes will have profound effects on water, aquatic organisms, and the economy.

Climate-induced changes to the water regime will continue to impact aquatic ecosystems and habitats. Long-term monitoring records of stream temperatures show that water temperature has risen concurrently with increases in air temperature. Both observed records and future models indicate increases in annual stream flows and peak flows. Models further show that as emissions increase, the frequency of large precipitation events will increase, such that floods that used to occur every 50 years are now occurring every 20-30 years. The magnitude of large storm events, like 100-year floods, have been also getting bigger. Low flows are more complicated, however, and we have not seen a constant pattern in the observational record. The cost of increased evapotranspiration due to a longer growing season and warmer temperatures may mean that we see more short-term droughts.

These changes will have persistent impacts to water in the region, and will affect cold-water ecosystems particularly hard. For example, in water temperature above 21° C, brook trout show a marked stress response. In fact, this temperature threshold demarks the current habitat distribution of this species. As stream temperatures continue to increase, the amount of suitable habitat for cold-water species will decline, highlighting the importance of land conservation in some of these refugia. We will also continue to see a decrease in the reliability and duration of high spring flow pulse that is critically important for many aquatic wildlife species and flood plain forests. Extreme events will have a disproportionate effect on sediment and nutrient transport. In fact, we may already be seeing a shift in the sediment regime, from one dominated by chronic processes to one dominated by episodic processes.

For management approaches aimed at addressing aquatic habitats under climate change, a combination of existing and novel tools should be utilized. There are many effective and established approaches that may help aquatic wildlife, such as conservation and restoration of forestland, restoring aquatic connectivity via barrier removal, and base cation restoration to watersheds and waterbodies. In addition, we should establish new approaches based on climate resilience and assisted migration. Following implementation, we can then examine how well these established and novel strategies help mitigate the challenges we face.

Summary of Working Sessions

Summaries of the afternoon working sessions were written by presenters and FEMC staff.

Bird conservation in the year of the bird

Organizer: John Lloyd, Vermont Center for Ecostudies

Summary Prepared by: *Kevin A. Solarik, NCASI, Jason Hill, Vermont Center for Ecostudies, Tom Rogers, Vermont Fish and Wildlife Department, Bridget Butler, Bird Diva Consulting, Katherine Yard, NYS Department of Environmental Conservation, Kent McFarland, Vermont Center for Ecostudies.*

This working-group session was the culminating event in a day-long workshop focused on the conservation of forest birds, and was preceded by eight invited talks delivered by scientists and conservation practitioners working across the FEMC region. Participants included representatives from academia (University of Vermont); non-governmental research organizations (Vermont Center for Ecostudies, National Council on Air and Stream Improvement); the forest-products industry (Weyerhaeuser); private, non-industrial woodland owners (American Forest Foundation); environmental NGOs (Audubon Vermont, Massachusetts Audubon, Bird Diva); land-conservation organizations (Cold Hollow To Canada); the conservation-finance sector (National Fish and Wildlife Foundation); and state and Federal resource-management agencies or departments (Vermont Department of Fish and Wildlife, New York Department of Environmental Conservation, U.S. Fish and Wildlife Service).

We sought to address two questions during this working-group session, both of which emerged from the series of invited talks:

1) What are the targets of our conservation efforts, and are they the appropriate targets?

2) Are our conservation interventions adequate in both the short and long terms?

The answer to the first of these questions was straightforward and largely unanimous: our conservation targets are, and should continue to be, guilds of species defined by their association with forest type and the various seral stages (early, mid, and late-seral). Guilds were preferred over single species approaches as they can better reflect the relatively coarse nature of our interventions; that is, whereas we can use forest management to adjust the area of different seral stages on the landscape, we rarely manage intentionally for the specific combinations of biophysical conditions that define habitat for a particular species. Developing individualized conservation strategies for the hundreds of forest-bird species in the region, especially those that are not threatened or endangered, is also impractical and perhaps undesirable. Guilds also offer greater flexibility in tailoring outreach messages to landowners, as landowners may have different affinities for different birds. Finally, the guild concept is often easier to cross-walk with more general conservation strategies (e.g., Vermont Conservation Design[10]).

[10]Sorenson, E., and R. Zaino. 2018. Vermont Conservation Design. Summary Report for Landscape, Natural Communities, Habitats, and Species. Vermont Department of Fish and Wildlife. Available online at: https://anr.vermont.gov/sites/anr/files/maps/biofinder/Vermont%20Conservation%20Design%20-%20Summary%20Report%20-%20February%202018.pdf.

The second question proved more difficult. A key problem identified by participants is that we often lack the monitoring framework(s) to accurately evaluate our actions, and as such it is difficult to know if our interventions are adequate. The lack of suitable monitoring is due in part to the logistical challenges of monitoring at the right scale – eBird was proposed as a possible solution – and also to the unwillingness of funders to commit money to long-term monitoring. The latter is a more general problem related to an increasing focus among funders on demonstrating short-term outcomes, which are often less useful in an adaptive-monitoring framework (e.g., they focus on surrogate measures like “acres of young-forest created” instead of more meaningful measures like “change in population size of young-forest birds”). An additional problem noted is that different monitoring schemes are not always comparable, which can hinder efforts to compare outcomes of different projects.

Participants noted that it is also hard to know if any particular action is effective in the broad sense because the global impact of the action depends on what actions are being taken concurrently by other landowners or land managers. Yet, given the lack of coordination among landowners, rarely do we know how our efforts fit in with those of our neighbors. For example, a landowner that creates young forest by harvesting late-seral forest is contributing relatively little to overall conservation goals if adjacent landowners are already providing the desired amount of young forest. The goal of managing forest-bird populations holistically by offering a shifting mosaic of seral stages across large spatial scales and multiple ownerships requires communication and coordination processes not currently in place. A related concern was that we do not always implement conservation efforts strategically, in the sense of focusing on key locations, but that we instead are forced to implement our conservation efforts where it is convenient to do so. Ideally, we should integrate predictions from climate- and land-use change models when we decide where to focus our efforts, but rarely can we do so at present. We should also consider the landscape arrangement of our conservation actions, striving to connect areas where we work and endeavoring to avoid creating “islands” of conservation within our priority landscapes. One possible model is that employed by Cold Hollow to Canada[11], which seeks to engage groups of landowners holding adjacent properties.

We closed the session by identifying key action items:

1) Work with scientists to develop and implement better approaches to monitoring that would allow us to evaluate the efficacy of our actions and truly adopt the adaptive-management paradigm. Monitoring should focus not only on the impact of our actions on birds but also on the people affected by our conservation efforts, which will mean increased efforts to recruit social scientists into our community of practice.

2) Work with the conservation-finance community to increase awareness about the need for long-term funding that supports both conservation actions and monitoring of the outcomes of these actions. Neither the actions needed to implement conservation at scale nor the monitoring required to measure outcomes can be accomplished with the timeline of most grants (i.e., several years).

3) Identify or create regular opportunities for dialogue among stakeholders involved in forest-bird conservation. These opportunities should be designed to improve the flow of information between conservation practitioners and scientists and to increase coordination among landowners.

[11] http://www.coldhollowtocanada.org

By land, water, or air: Invasive species management in a changing forest landscape

Organizer: Joanne Garton, Vermont Department of Forests, Parks and Recreation

The objectives of this workshop were to meet professionals addressing invasive species in the northeast forest, to learn about invasive species of particular concern to a series of panel members invited to the workshop, to understand the components, timeline, and inconsistencies of an invasive species management plan at a particular site, and to share and understand challenges that land managers experience when working with invasive species.

Although daunting, the task of invasive species management is possible with partnerships and collaboration on a statewide or regional level. State agencies, land managers, and landowners need to work together to create an effective management plan and see that the plan is enforced. Suggested improvements to the processes that inform these plans include:

- Clear and well-publicized definitions of what determines a species as invasive;
- Easy access to the permits and rules set forth by the Vermont Agency of Agriculture;
- Further research on treatment methods for invasive species and public outreach to quell misconceptions;
- A tool, website, or app that allows landowners and land managers to easily learn about the latest research and findings regarding local invasive species, and;
- Established liaisons between multiple agencies who address invasive species.

Regarding the requests for increased coordination, the group acknowledges the responsibilities placed on a network of researchers, managers, and landowners. Program managers could facilitate communications between all of the various groups working on similar projects and even connect with other states who have already dealt with similar invasive species. The state that came to mind in the discussion was New York, which is often the first place to experience invasions due to their port system. Unfortunately, there is a lack of political will to push for effective regulation to manage invasive species. This can lead to insufficient funding and other resources.

The main takeaway from this working session was the management of invasive species should be one coordinated through partnership and collaboration instead of single groups. This includes efforts to make this a priority for lawmakers and landowners alike by including either members from those groups directly in the larger management groups or making sure there are individuals focused on outreach and communication of management efforts.

Notes taken by Joanne Garton (moderator) during the session:

The session began with asking the group to generate a list of the current needs for invasive species management:

- Body of management research
- A clear definition for what is an invasive and what is native such as the case for phragmites.
- Management goal – maintain emerald ash borer (EAB) or hydrology
- Local or GIS-picture approach
- Network of managers at different stages of EAB infestation
- Biocontrol resources-research site
- Feasibility of chemical treatments in WL
- EAB – can't see, so monitor, ID hazard trees, create task force, enforcement
- EWM – lake associations (stakeholders), municipal grants, boat wash stations, know that eradication is not realistic
- Roadside survey, forest survey, knowledge of what threats each invasive species pose
- Need to start by setting priorities
- Identify the source of the problem – are we making it worse?
- Understand how to contain invasives
- Is it a forever problem? Monitor indefinitely
- Outreach to landowners. Consider life cycle when choosing treatment methods.
- Do cut and paint, herbicide treatment with volunteers
- Decide what resources are available and who is doing the management.
- Need money, time and people!
- CISMAs are super important.

Based on the list of needs the group proceeded to identify what was missing in terms of invasive species management:

- EAB – missing visible enforcement, visible big signs, source of funding
- A means to reach out of town landowners who don't get the message and bring in foreign firewood
- Wants for Eurasian Water Milfoil (EWM) = money and political will
- Money and Resources
- Rare species inventory
- Starting monitoring plans early
- Emergent timeline
- Statewide coordination and funding for invasive species management
- How can we work together on invasives? Need greater partnerships.

Lastly the session was opened to anyone that had a challenge question that they wanted the group to think about and provide solutions for:

- Develop an integrated coalition of state, regional & local invasive controllers who can collaborate to raise the profile of the problem, need & solutions. Use this to get needed funding and support.
- When does something begin to be considered invasive (i.e. white-tailed deer when overpopulation threatening hard wood regeneration)?
- How do we treat knotweed, spotted lanternfly, and ailanthus?
- How do resources from other regions translate to Vermont?

Managing climate change impacts: what questions still remain?

Organizer: Maria Janowiak, Northern Institute of Applied Climate Science and Amanda Mahaffey, Forest Stewards Guild

This working session focused on forest climate adaptation and what information we may need to help address the problem of a changing climate. Following a full day of presentations, this session was designed to create a space for listening to conference participants' thoughts on their experiences and science needs. After briefly outlining the 'listening session project,' the organizers asked participants to choose a discussion group out of five available topics: tree species, invasives, wildlife, forest and watershed impacts, and a wildcard group (everything else). Maria then posed four major questions for each group to discuss, with a focus on the final two questions:

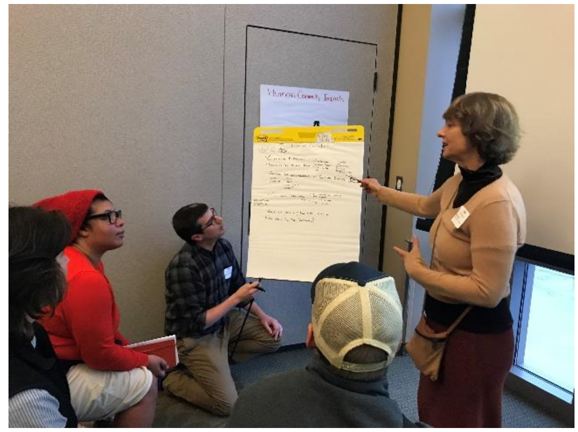
- What do we know about forest climate adaptation relative to this theme?
- What don't we know?
- What would we most like to know?
- What would move the needle on forest adaptation under this theme?

Within the context of the five topics available, some key themes came up repeatedly in the ensuing discussion, including: stakeholder and community outreach/involvement, cross disciplinary communication, and how to strategize using the complexities of ecosystems and an ecosystem's propensity for change.

Stakeholder & Community Outreach and Involvement

The participants noted the importance of a grassroots effort in order to produce a change. Participants expressed a desire to create a 'social energy' that would invigorate local communities, partners, and citizens to take action in order to combat climate impacts on forest ecosystems. Group discussion illuminated the importance of analyzing this issue through different lenses at varying scales and finding a 'story' to motivate citizens to take action. The participants found it crucial to find avenues of action that would be of low cost to the citizen; in other words, to have low risk so that they would be motivated to take action themselves. The gap between citizens and science is still extremely present, and to adapt to a changing climate and overcome this challenge, it is crucial that the gap be bridged. Participants made note of the importance of success stories and demonstration in order to inspire change.

Cross Disciplinary Communication



It was stressed throughout and at the end of the working session how important it is that scientists from all disciplines communicate in order to build a community around education and the sharing of knowledge at all levels to help further advance the goal of creating adaptive landscapes. Many in the room identified as data crunchers and manipulators, but it cannot be left at that. The knowledge gained from studies and data synthesis must then be communicated among scientists of all disciplines in order to come up with creative and effective strategies. Drawing on the skills and knowledge of peers can also help do this.

How to Strategize Using the Complexities of Ecosystems and Their Propensity for Change

Many of the groups touched base on how ecosystem interactions are extremely complex and how a changing climate only makes it more so. When discussing what they needed to know, participants often referred to a better understanding of how parts of a system (including invasive species) will respond to change, how individual species will respond, and how biotic and abiotic systems interact at varying scales. Participants mentioned numerous times the challenge of predicting future issues and the difficulty of creating adaptive management plans to address them, but at the same time noting their importance. One group of participants, the wildlife team, mentioned the importance of defining 'resilient landscapes'/'refugia', finding them, and understanding what makes them resilient.

During the course of this working session brainstorming and discussion were held and notes were taken by participants on flip-charts. For access to the information from these notes please contact the session organizers, Maria Janowiak and Amanda Mahaffey.

Northeastern forest, wildlife and climate change: understanding impacts and planning for the future

Organizers: Toni Lyn Morelli, Bill Deluca, Alexej Siren, and Mike Hallworth of the Northeast Climate Adaptation Science Center and the University of Massachusetts. For questions contact Dr. Morelli at tmorelli@usgs.gov

As global change complicates forest and wildlife management, a better understanding of both impacts and potential responses is needed. Natural resource managers, scientists, and others came together for two hours to discuss the impact of climate change on forest wildlife conservation on local, state and federal lands. The objectives were to share successes and ongoing initiatives, as well as identify needs. Most of the conversation centered around mammals and birds in the northeastern U.S., but it often expanded to include human use of the land and public perceptions and engagement.

Participants identified a few examples where much attention is focused and still more information and research is needed, such as the impacts of climate change on moose and waterfowl. Potential monitoring opportunities such as looking at parasites, evolving survey methods (e.g., game cameras instead of hunting data), and looking at invertebrates (vulnerable and problematic).

Much of the time was spent in groups discussing what information would concretely aid management and conservation decisions. Here are some examples:

<u>Information we don't have but wish we did</u>

- Identify links between habitat management and parasite populations, e.g., relationship between shrub habitats, rodents and ticks
- When and where does population limitation occur (e.g., what part of the annual cycle for migratory animals)?
- The specific mechanism by which climate affects wildlife populations: habitat, food, predation, parasites, competition, directly, etc.?
- A better understanding of the regional responsibility managers might have for protecting a species - If we are on the trailing edge of a northern species, should we care?
- More collaboration across state lines (VT in particular) for stream crossing information.

<u>If I had/knew...I could</u>

- Spatially explicit dynamic deer browse data; better model forest cover on the landscape scale.
- Relative importance of stressors on species of interest; prioritize:
  - The relationship between precipitation and lower trophic levels like primary consumers and other arthropods; could inform management of water resources and connections.
- Clearly documented connections (stories); public would be more invested.
- If we knew deer would be a big stressor; manage deer yards.
- Quantify the adaptive capacity for each species of concern; inform management.
- Where the leading edge of invasive was; we could try to stop it?
- Where the leading edge of southern flying squirrels is; kill them? Save them?
- Where the leading edge was; could create atlas, could help facilitate.
- How important habitat is vs climate; could manipulate habitat.
- Impact of recreation on wildlife; have more backup for managing public.
- Which species resonate with public; we could use them as flagship species.
- How marten would be affected by climate change; could better inform listing decision.
- The historic range of variability for natural disturbance; inform habitat management.

Abstracts from Morning Plenary Speakers

There were three speakers invited to speak during the morning plenary session. Maria Janowiak, Toni Lyn Morelli, and Keith Nislow spoke on the observed and potential impacts of climate change on forests, wildlife, and water resources in the Northeast

What's at risk? Implications of climate change in our region's forests

Maria Janowiak, *deputy director of the Northern Institute of Applied Climate Science, led by the USDA Forest Service.*

Forests are a defining landscape feature across New England and northern New York, covering more than 40 million acres from the coast of the Atlantic Ocean to the peaks of the Appalachian Mountains. The changing climate is altering the region's forests, and the foresters and other natural resource professionals working to keep the region's forest ecosystems healthy and productive are increasingly considering climate change in their work. The New England Climate Change Response Framework, a collective effort among dozens of scientists and natural resource professionals, produced a report that summarizes the best available information about climate change and regional forests based on published research, ecosystem models, and manager expertise. New projections of forest change from three forest impacts models—the Climate Change Tree Atlas, Linkages, and LANDIS PRO—were combined with a review of recent literature to understand the potential for forest change during the next century under different climate scenarios. An expert panel of research scientists and forest practitioners then worked together to consider this information, as well as their personal experience and expertise on local ecosystems, to assess the vulnerability of eight forest communities present across the region. Montane spruce-fir, low-elevation spruce-fir, and lowland mixed conifer forests were determined to be the most vulnerable to climate change. Panelists assessed lowland hardwood and riparian forests as being moderately vulnerable. Northern hardwood, transition hardwood, central hardwood-pine, and pitch-pine scrub oak forests were rated as having lower vulnerability to projected changes in climate. Projected changes in climate and their associated impacts and vulnerabilities will have important implications for ecologically and economically valuable forest types, forest-dependent wildlife and plants, recreation, and long-term natural resource planning.

Climate change vulnerability and adaptation of forest wildlife

Toni Lyn Morelli, research ecologist with the U.S. Geological Survey at the Department of the Interior Northeast Climate Adaptation Science Center

No abstract provided.

Water and aquatic ecosystems in a changing regional climate

Keith Nislow, Research Fisheries Biologist of USDA-Forest Service Northern Research Station

The Northern Forest (New England and northern New York) is a mesic region blessed with abundant and reliable water. Climate-associated changes in temperature and hydrologic regimes pose water-related risks to the structure and function of ecosystems and the goods and services they provide. In this presentation, using examples from the work of the US Department of Interior Northeast Climate Adaption Center and its cooperators, I will 1) describe what we know about current and forecasted climate-driven changes in water quantity and quality 2) discuss how these effects likely translate into impacts on aquatic ecosystems 2) demonstrate how existing and novel management and conservation approaches can help to reduce water resource vulnerability to climate change along multiple dimensions. Increasing regional air temperatures will threaten coldwater habitats and the species that depend on them in streams, rivers, and lakes. At the same time, portions of the region will become increasingly important as climate refugia for these species as habitats are lost from southern parts of their distribution. Increases in total precipitation, with a greater proportion of rain versus snow, and a higher frequency and magnitude of extreme precipitation events will impact regional hydrologic regimes in complex ways. Most forecasts expect an increase in flow variability with a greater frequency and magnitude of floods, but also a risk of increased short-term drought associated with increasing temperatures and high evapotranspiration rates. These combined changes in hydrologic and temperature regimes will have complex effects on ecosystems ranging from changes in biogeochemical cycles and nutrient loading rates to receiving water bodies to changes in species occurrence, abundance and distribution. Established management strategies (maintaining or restoring forest cover, increasing connectivity via removal of barriers to movement, restoring floodplain connectivity) can help to mitigate these impacts and also reduce the need for 'grey' infrastructure responses to the prospect of increasing hydrologic uncertainty. In addition, established regional monitoring networks for water quantity and quality are essential for assessing the pace and magnitude of future change.

Abstracts from Contributed Talks

There were 40 talks contributed to the conference, presented between two sessions throughout the day. In the morning there were five concurrent sessions. The sessions were *Forests and Climate* moderated by Maria Janowiak, *Wildlife and Climate* moderated by Toni Lyn Morelli, *Water and Climate* moderated by Kacey Clougher, *Forest Health* moderated by Rebecca Stern, and *Year of the Bird 1* moderated by John Lloyd. In the afternoon session of talks there were five concurrent sessions. The concurrent sessions were *Forest Ecology* moderated by Kacey Clougher, *Forest Monitoring* moderated by Adam Noel, *Planning, Implementation and Stakeholder Engagement* moderated by Alex Neidermeier, *Wildlife Monitoring* moderated by Brendan Case, and *Year of the Bird 2* moderated by John Lloyd. Below are the abstracts submitted for these talks, including author affiliation. The presenting authors name is in bold type.

Adaptive silviculture for climate change: Examining strategies for adapting northern forests to global change

Peter Clark[1], Anthony D'Amato[1], Chris Woodall[2]

[1]UVM, Rubenstein School for Environment and Natural Resources
[2]USDA Forest Service Northern Research Station

Forests managers, scientists, and policy makers must respond to the need for climate-adaptive strategies in the face global change. While strategies to mitigate impacts from climate change and increase forest resilience have been broadly proposed, there are nascent formal empirical evaluations that indicate what locally-calibrated adaptation measures might be most effective in preparing forest ecosystems to deal with climate change. The Adaptive Silviculture for Climate Change (ASCC) project is a national, replicated, operational-scale experiment co-designed with managers to test ecosystem-specific climate change adaptation treatments across a gradient of adaptive approaches. Here we present on the first-year results from the New England ASCC installation at the Second College Grant in northern New Hampshire, highlighting the Transitional approach which actively accommodates change primarily by facilitating species range expansion. In this experiment, over 7,000 seedlings from nine "future-adapted" tree species were planted across harvest intensities. We examine seedling response to treatments as a means to promote compositional shifts in species and functional diversity.

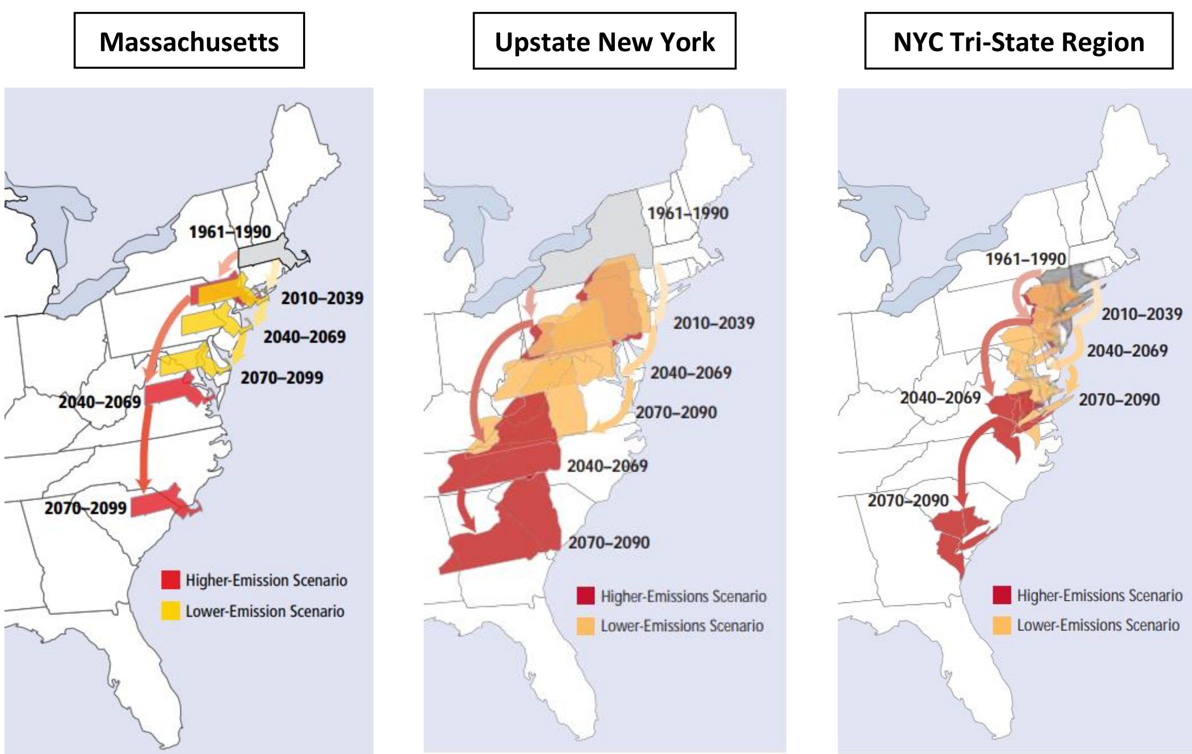
Vermont Agency of Natural Resources guidelines for implementing assisted migration of plants on agency lands

Robert Popp[1], Sandy Wilmot[2], Nancy Patch[3], Lisa Thornton[3]

[1]Vermont Department of Fish and Wildlife
[2]Vermont Department of Forest, Parks, and Recreation emeritus
[3]Vermont Department of Forests, Parks, and Recreation

In 2015, the Agency of Natural Resources Lands Team appointed a small group to review information on the climate change adaptation strategy known as assisted migration and present recommendations for implementation on lands owned and managed by the Agency of Natural Resources. Assisted migration is typically defined as the human assisted movement of species beyond their historic ranges. However, these guidelines are broader in scope and also encompass assisted migration and augmentation of populations. The committee sought to attain two goals: maintaining functional ecosystem services and rescuing species from extinction. The guidelines present five tiered options from most passive to most active depending on the resource involved and the long term goal.

Projected Climate Migrations Based on Summer Heat Index

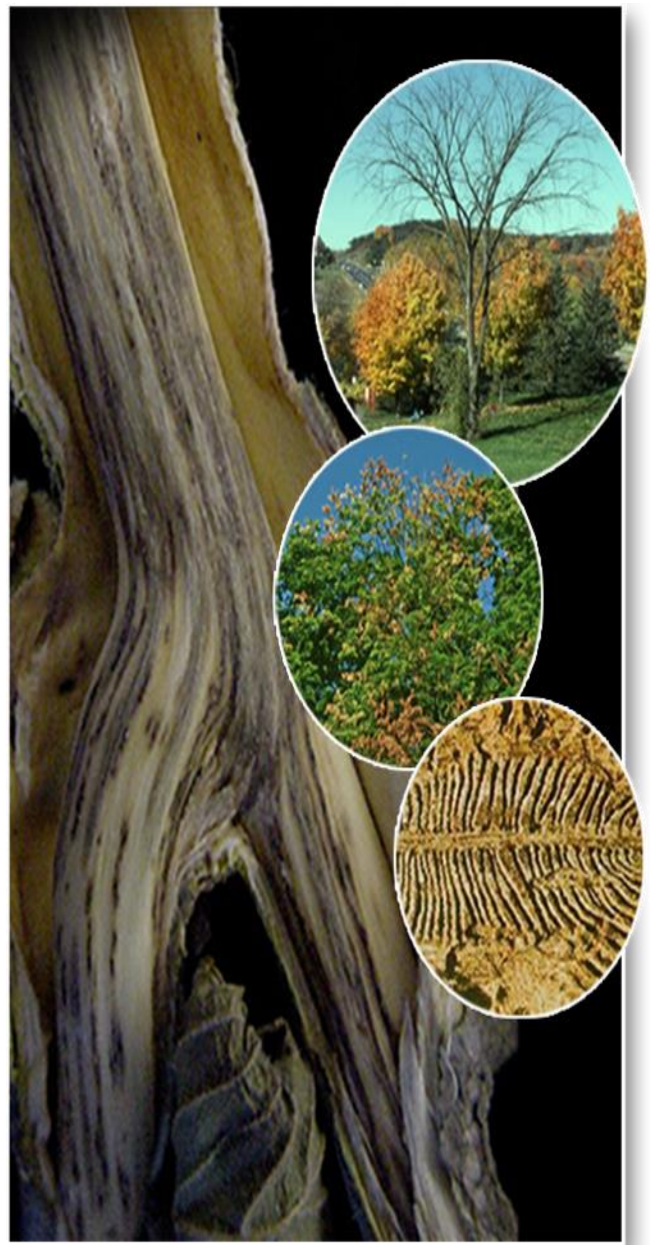


Cold hardiness of American elm crosses bred for Dutch elm disease tolerance

Paul Schaberg[1], Gary Hawley[2], Paula Murakami[1], Christopher Hansen[2], Christian Marks[3], James Slavicek[1]

[1]USDA Forest Service
[2]University of Vermont
[3]The Nature Conservancy

Dutch elm disease (DED) is the primary threat to American elm (*Ulmus americana L.*) populations in North America. However, shoot freezing injury may also limit elm productivity and survival in the north. We assessed shoot cold tolerance and field winter injury for the current-year shoots of American elm crosses bred for DED tolerance planted in a restoration planting in Lemington, VT. We tested for differences in cold tolerance associated with season (fall, winter and spring), maternal DED tolerance source (R18-2 and Valley Forge), paternal sources from three USDA Plant Hardiness Zones (5a, 6a and 6b), and the interactions of main effects. Cold tolerance was greatest in the winter, followed by fall and then spring. Cold tolerance never differed between maternal sources of DED tolerance. However, during winter cold tolerance did differ among paternal sources from different hardiness zones; crosses with paternal sources from the coldest zone 5a were significantly more cold tolerant than sources from zone 6b, and sources from zone 6a were intermediate in cold tolerance. The difference between zone 5a and zone 6a cold tolerance means was about 7.4 C, which is within 1 C of the average difference in winter low temperature experienced in these zones over the last 30 years. Freezing injury in the field confirmed that shoots were only marginally cold tolerant relative to ambient temperature lows. Future breeding efforts should target sources from temperature zones as low as 3a (the coldest zone in the native range of American elm) to better assure adequate local adaption for restoration in the north.



Examining the future forest through tree seedling experiments

Nick Fisichelli[1]

[1]Schoodic Institute, Acadia National Park

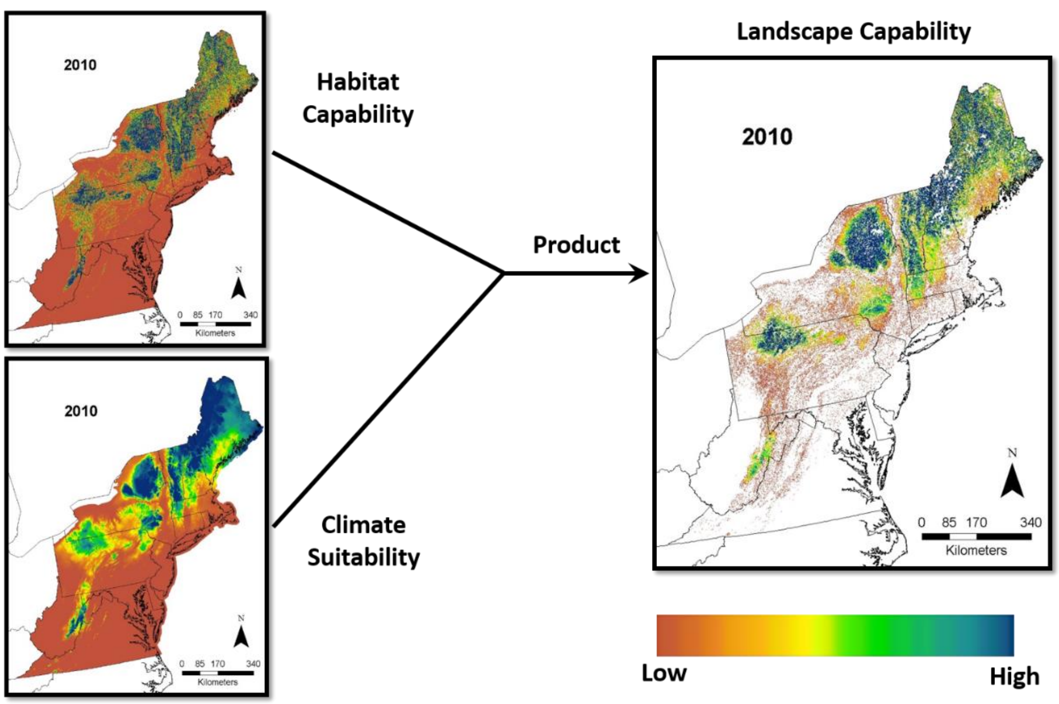
Ongoing and future climate change challenges land managers to foster both current and future forest ecosystems. The magnitude of potential forest change is matched by the uncertainties in future conditions and how trees will respond to these conditions. On-the-ground research experiments are needed to understand which tree species will thrive and which will struggle under emerging conditions and to help guide forest management responses to climate change. This talk will highlight distributed networks of common garden seedling experiments contributing to the expanding toolbox of climate adaptation approaches.

Quantifying the relative projected impacts of climate change and urban growth on the capability of the northeast to support wildlife

William V. DeLuca[1,2], Ethan B. Plunkett[1], Bradley W. Compton[1], Joanna Grand[3], W. Scott Schwenk[4], Kevin McGarigal[1]

[1]University of Massachusetts
[2] Northeast Climate Adaptation Science Center
[3]National Audubon Society
[4]U.S. Fish and Wildlife Service

Climate change and urban growth are projected to be major drivers of environmental change over the next century and wildlife species distributions are likely to shift to reflect these changes. Therefore, understanding the relative importance of each of these drivers is vitally important for developing effective conservation strategies. As part of a landscape conservation design for the northeastern U.S., Nature's Network, we developed landscape capability models for 30 representative species and applied them to a custom built urban growth model and climate change projections for the northeast. We then quantified the relative importance of climate and land use change for shifts to the future distribution of each species. We found that, in general, the future distribution of the 30 representative species will be substantially more sensitive to climate change than urban growth. When considering only negative impacts of both drivers of change on species distributions, climate change also had a substantially greater impact than urban growth. This work will provide users with information that identifies the primary mechanism by which future species distributions will be influenced. Management strategies can then be customized for surrogate species and the systems they represent with an understanding of whether climate or urban growth are likely to drive distribution shifts.



Distribution dynamics of mesocarnivore populations along trailing and leading edges in the northeastern U.S.

Alexej P. K. Siren[1,2,3], Jilian Kilborn[4], Toni Lyn Morelli[1,5]

[1]DOI Northeast Climate Adaptation Science Center
[2]University of Massachusetts
[3]Department of Environmental Conservation
[4]New Hampshire Fish and Wildlife Department
[5]U.S. Geological Survey

The boreal-temperate ecotone of the northeastern U.S., ecologically important due to cool climate and spruce (*Picea spp.*)-fir (*Abies balsamea*) forests, defines distributional edges for carnivores such as American marten (*Martes americana*) and Canada lynx (*Lynx canadensis*). However, predicted declines in snowpack and loss of boreal forest habitat due to climate change may fundamentally alter community dynamics. We established 250 remote cameras, programmed to collect local climate data, along elevational (188-1,917 m) and latitudinal (42.8-45.3 N) gradients to evaluate the influence of snowpack and vegetative characteristics on carnivore species' distributions for 5 winters. We used data to estimate occupancy for lynx, marten, fishers (*Pekani pennanti*), bobcats (*Lynx rufus*), coyotes (*Canis latrans*), and red fox (*Vulpes fulva*). Snow depth was the best predictor of occupancy for most species, with forest type/age also acting as an important predictor. Martens and lynx were positively associated with sites that contained deep snow whereas fishers, bobcats, and coyotes were primarily detected at low elevations with shallow snowpack during winter. However, as snowpack receded during spring, these generalist carnivores were more frequently detected at high elevations. Our results highlight that changes in snowpack characteristics are reverberating through wildlife communities across elevational and latitudinal gradients and that dramatic shifts can occur within a few years. To gain a mechanistic understanding of factors influencing range shifts, we are currently evaluating the extent at which climate mediates biotic interactions (e.g., competition) and biotic factors ameliorate harsh climate conditions along distributional edges.

A slow loss of northern forest icons: Dynamics of boreal birds at the edge of their range in the Adirondack Park

Michale Glennon[1,2], Steve Langdon[3]

[1]Adirondack Watershed Institute
[2]Paul Smith's College
[3]Shingle Shanty Preserve and Research Station

The Adirondack Park is in the southern edge of the range for several species of boreal forest birds within eastern North America. The habitats of these boreal specialists are thought to be particularly vulnerable to climate change. Effects may include encroachment by trees into open bog landscapes, increased competition with southern plant and animal species expanding northward, and altered timing of annual events like insect emergence upon which these birds depend for food. Passerine and piciform birds have been monitored in low elevation boreal habitats in the Adirondacks for more than a decade and most focal species are exhibiting a pattern of decline. For some, like the boreal chickadee and Lincoln's sparrow, declines are modest. For others--such as the rusty blackbird, yellow-bellied flycatcher, olive-sided flycatcher, and black-backed woodpecker--the declines are more troubling. Of the boreal birds, only the palm warbler appears to be increasing in our landscape. Initial analysis of these data demonstrated that boreal birds in the Adirondacks exhibit metapopulation dynamics, are more likely to persist in large, connected wetlands with low human footprint, and may be moving northward or upslope in response to climate change. More recent analyses have explored the influence of temperature and precipitation patterns on dynamic rates in order to understand the potential role of climate change in shaping the future for these species and in an effort to identify potential refugia. These species appear to be influenced strongly by precipitation patterns in the breeding season and by temperature characteristics during the non-breeding. Habitat structure appears to mediate bird response to a number of factors, and the largest open peatland habitats in the park have lower local extinction rates for boreal species than boreal upland forest and swamp habitats. Examining changes in these habitats and in the broader bird community within them is helping us to understand the future of boreal birds in the Adirondacks and the sites which may be serving as refugia.

The cost of production in a greening world

Michael T. Hallworth[1], T. Scott Sillett[1], Nick Rodenhouse[2], Sara Kaiser[1], Mike Webster[3]

[1] Migratory Bird Center – Smithsonian Conservation Biology Institute
[2] Wellesley College
[3] Cornell University

Life history theory postulates that individuals balance current reproductive investment with future reproductive potential. Previous work has demonstrated that reproductive investment varies between sexes, age classes and along habitat quality gradients. Reproductive strategies likely differ in the amount of effort required, as such their influence on survival may differ. Furthermore, environmental conditions experienced at the start of the breeding season contribute to the investment in reproduction. At Hubbard Brook, the start of the breeding season is closely tied to spring leaf-out. During years with warm springs individuals are more likely to double brood and produce more young. Therefore, reproductive investment is higher in years with warm spring temperatures and early leaf expansion. Here, using long-term demographic data of breeding Black-throated blue warblers we address the following questions 1) is there a cost of reproductive effort on survival? and 2) does the environment mediate the cost of reproduction? We found that female survival was negatively associated with the timing of leaf-out and length of the green period regardless of age but positively associated with the number of eggs laid for experienced females. Male survival was negatively associated with within-pair young and duration of the green period. Our results support previous findings that the cost of reproduction differs between sexes and age classes. In addition, they suggest that environmental change resulting in earlier springs and an extended green period negatively influences survival of Black-throated blue warblers. Further research is needed to determine where within the annual-cycle the cost of reproduction is occurring.

Climate change effects on water quantity and quality in the Northern Forest

Jamie Shanley[1]

[1]US Geological Survey

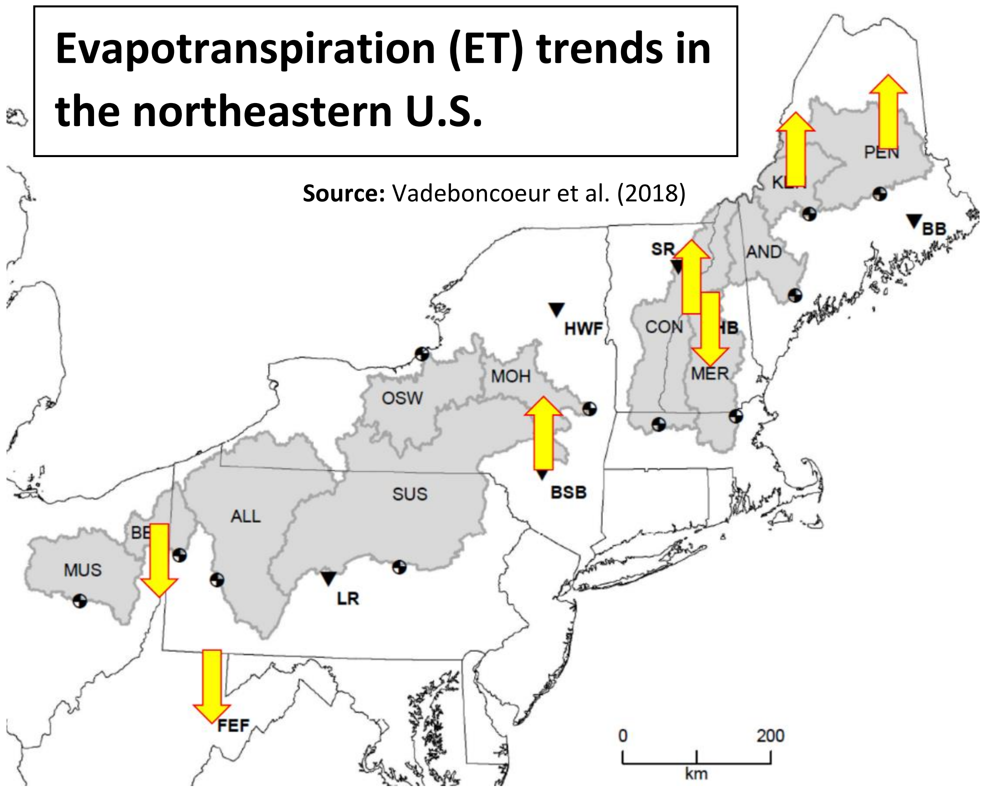
Through the 21st century, both air temperature and precipitation are projected to increase in the northeastern USA. Warmer temperatures will increase the length of the growing season. A longer growing season will increase annual evapotranspiration by an amount greater than the projected increase in precipitation, thus reducing streamflow. Lower snowpack and earlier snowmelt combined with higher evapotranspiration will cause lower water availability in the summer low-flow period, increasing the incidence and severity of drought. Water quality will also shift with the changing climate. Reduced snow cover will increase the incidence of frozen ground, which has been found to liberate carbon and nitrogen from soils to streams. Increased organic matter decomposition from warming may play a role in the observed widespread increases in dissolved organic carbon (DOC). We will explore potential climate effects based on research at Sleepers River in Vermont and at other small instrumented watersheds in the northeastern USA.

Tracking trajectories and sensitivities in forest water use

Mark Green[1, 2]

[1]Plymouth State University
[2]U.S. Forest Service

Forest water use via transpiration is a major way that forests control hydrology in the northeastern U.S. Understanding long-term changes in transpiration is of strategic importance to predicting future flooding risk, forest regulation of climate, and sub-canopy microclimate, just to name a few. Recently quantified trends in evapotranspiration suggest increases in the coldest parts of the northeastern U.S. region and decreases in the warmest. The drivers behind these patterns are not well understood. Direct measurement of evapotranspiration with eddy covariance towers provide opportunities to understand the controlling mechanisms. In particular, these measurements are allowing new insight into forest water use sensitivities to climate change.



Effects of extreme high flow events on macroinvertebrate communities in Vermont streams

Jen Stamp[1], Aaron Moore[2], Steve Fiske[3], Anna Hamilton[1]

[1]Tetra Tech for Ecological Sciences
[2]Vermont Agency of Agriculture Food and Markets
[3]Vermont Department of Environmental Conservation (VTDEC)

In August 2011, parts of Vermont experienced major flooding from Tropical Storm (TS) Irene. Here we present results from an evaluation of stream macroinvertebrate data from nine reference quality sites in Vermont affected to varying degrees by flooding from TS Irene. Macroinvertebrate data collected the year of the event were compared to samples collected two years prior and two years after. In addition, effects on substrate composition and periphyton cover were assessed based on pebble count and rapid periphyton assessment data. Macroinvertebrate density showed a significant association with TS Irene, with reduced densities the year of the event. The density reduction was most evident at small to medium-sized, higher gradient streams, which, on average, received the greatest amount of rainfall. Densities rebounded the year after TS Irene. No significant patterns related to TS Irene were found in the pebble count and periphyton cover data, although the percent of substrates with no moss or periphyton cover increased the year of the event, most noticeably at medium-sized, high gradient streams. These types of data take on added importance as extreme high flow events occur with greater frequency and magnitude in many areas.

A simulation modeling approach to investigate hydrologic regime transformations following eastern hemlock mortality

Kanishka Singh[1], James Knighton[2], James P. Lassoie[1], M. Todd Walter[2]

[1]Department of Natural Resources, Cornell University
[2]Department of Biological and Environmental Engineering, Cornell University

Eastern hemlock (*Tsuga canadensis*) is a foundation tree species present throughout much of eastern North America that exerts considerable control over local hydrologic budget by sustaining year-round transpiration and consistent spatial patterns of throughfall, thereby potentially modulating soil moisture, groundwater recharge, baseflow regime, and stream discharge patterns and volumes. Forest communities dependent on Eastern hemlock-regulated microclimatic conditions are threatened by the hemlock woolly adelgid (*Adelges tsugae*), an invasive sap-feeding insect. As eastern hemlock serves an important function with regards to hydrologic cycling as the preponderant contributor to leaf-off season transpiration, loss of this species, or a vitiation of its hydraulic properties, is projected to cause significant declines in the actual evapotranspiration component of the local water budget. This research applies a simple streamflow and overland flow simulation model to investigate the potential water balance, soil moisture, and streamflow regime consequences of hemlock woolly adelgid invasion across 76 USGS gauging stations categorized by eastern hemlock health and hemlock woolly adelgid presence, calibrating key parameters that determine hydrologic conditions to each site with a global optimization algorithm, and investigating relationships between optimal parameter value outputs and gauge station categories.

Forest health monitoring in northeastern National Parks

Aaron Weed[1], Kathryn Miller[2], Camilla Seirup[2]

[1]National Park Service, Northeast Temperate Inventory and Monitoring Network, Woodstock, VT
[2]National Park Service, Northeast Temperate Inventory and Monitoring Network, Bar Harbor, ME

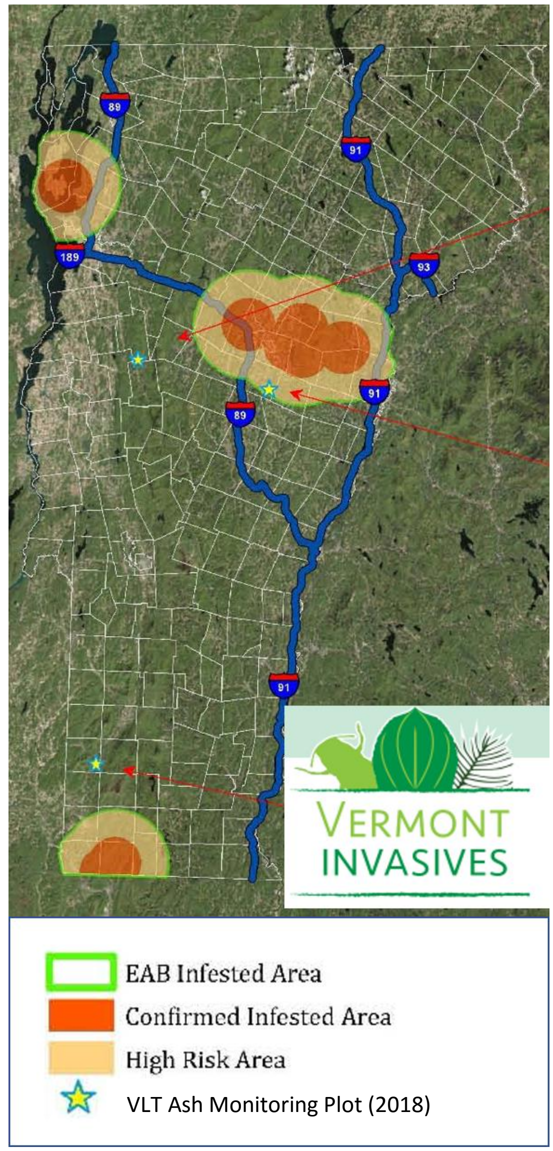
Vistas of colorful fall foliage hold tremendous public and media interest, and associated tourism is estimated to add billions of dollars to the regional economy each year. This natural spectacle of diverse leaf coloration is based on the physiology of leaf pigments. There are three primary pigments in tree leaves - green chlorophyll and yellow carotenoid pigments that are in leaves all growing season, and red anthocyanins that are newly produced in the leaves of some species (e.g., maples, ash, red oak, etc.) during autumn. The initial change in color associated with fall color development is the fading of chlorophyll to reveal yellow carotenoids that were always there but had been masked by green. This process is triggered by reductions in day length, but is greatly hastened by exposure to environmental stresses (e.g., drought or seasonal low temperatures) that can speed leaf senescence. Environmental stress is also associated with the production of anthocyanin pigments in the fall. Anthocyanins serve as protective compounds that may help leaves stay on trees longer and allow for greater sugar and nutrient resorption prior to leaf fall. Greater resource recovery from leaves before they abscise may benefit tree health and productivity in later growing seasons. The specific timing and intensity of leaf color displays depends on the interplay of environmental triggers that either speed up (e.g., drought and low temperatures) or slow down (e.g., ample precipitation and mild temperatures) chlorophyll breakdown and anthocyanin production. Several examples of how these processes can play out across the landscape will be provided.

Partnering with land managers to guide the search for EAB-resistant ash

Jonathan Rosenthal[1], Radka Wildova[1], Allaire Diamond[2]

[1]Ecological Research Institute
[2]Vermont Land Trust

The U.S. Forest Service's EAB Resistance Breeding Program has shown that a small percentage of native ash trees have heritable resistance to emerald ash borer and can be used for propagation of resistant trees for eventual ash restoration. The Ecological Research Institute's Monitoring and Managing Ash (MaMA) program MonitoringAsh.org) for ash conservation and EAB mitigation, developed in collaboration with Dr. Jennifer Koch and Dr. Kathleen Knight of the USFS, includes four citizen-science/land manager projects that facilitate the search for likely EAB-resistant "lingering ash". These are native, chemically untreated trees that persist in healthy condition significantly after the overwhelming majority of nearby ash have died from EAB infestation - such trees form the basis for EAB-resistance breeding. To ensure the widespread restoration of native ash, it is necessary to find locally adapted lingering ash across the species' ranges.



One particular project of the of the Monitoring and Managing Ash (MaMA) program, the rapidly growing MaMA Monitoring Plots Network, relies upon land manager participation to set aside appropriate trees for monitoring ash mortality to determine when particular EAB-induced mortality thresholds have been met in an area. This determination is crucial, because lingering ash can only be reliably identified within particular time-windows after these thresholds have been reached. MaMA Monitoring Plots Network's plot requirements and data recording and reporting protocols were designed by the Ecological Research Institute (ERI) to be user-friendly while being sufficiently scientifically rigorous to enable reliable detection of actual lingering ash. Its plots form the only such network designed specifically to detect when crucial EAB-induced mortality thresholds have been reached.

This talk presents an overview of the scientific basis for the MaMA Monitoring Plot Network, how it fits into MaMA's overall ash conservation framework, and how partners can participate in it, highlighting in particular the ongoing role of the Vermont Land Trust in establishing and monitoring such plots at several locations in this state. For more information on the Monitoring and Managing Ash (MaMA) program for ash conservation and EAB mitigation, please see MonitoringAsh.org.

Beaver foraging preferences and impacts on forest structure in New York's Adirondack Mountains

Michael J Mahoney[1], John C. Stella[1]

[1]State University of New York, College of Environmental Science and Forestry, Syracuse, NY

Beavers (*Castor canadensis*) are ecosystem engineers, causing changes at the landscape scale due to a combination of their damming and foraging behaviors. While these behaviors - and the impacts they have on riparian communities - have been well studied in several forest regions, they are poorly understood within the forests of northeastern North America. Field surveys at 19 beaver locations throughout New York's Adirondack State Park assessed beaver foraging preferences and the impacts of beaver activity on forest structure and composition. Forest canopy closure decreased with proximity to beaver impoundments, and forest structure and composition also varied along this gradient. Beavers preferentially harvested stems between 2 and 10 cm diameter, with the 2 to 5 cm size class most generally preferred. Deciduous species were also preferentially harvested, with typically disfavored species such as American beech (*Fagus grandifolia*) harvested at higher rates than in studies from other regions. Logistic regression models showed clear foraging preferences for stems closer to the impoundment of intermediate sizes for all modeled groupings and species. Understanding the impacts beavers will have on riparian forests in the Northeast is critical as beaver continue to recolonize their historic range, creating new management challenges and opportunities in years to come.

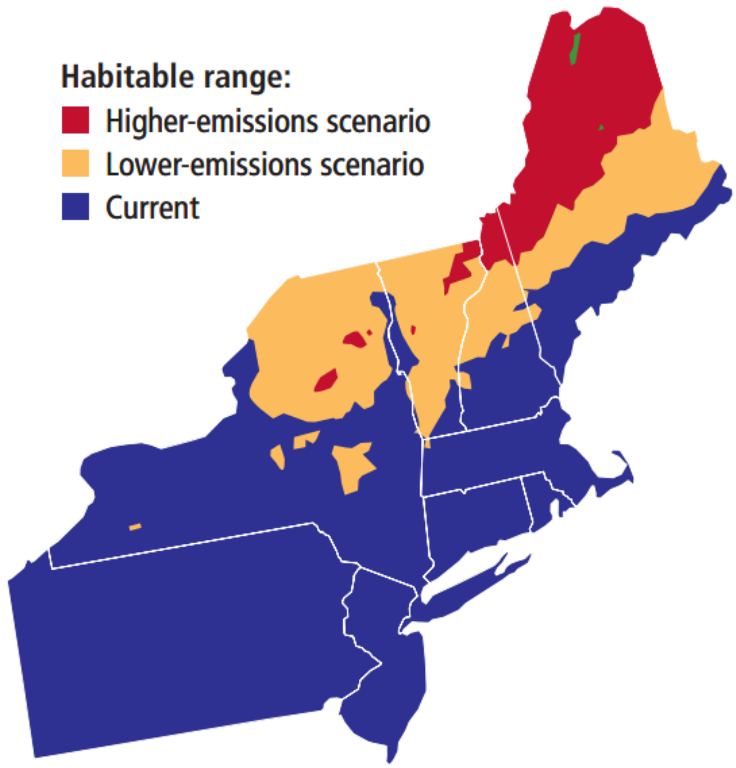
Managing invasive species in light of climate change

Carrie Brown-Lima[1], Bethany Bradley[2], Toni Lyn Morelli[3]

[1]NY Invasive Species Research Institute, Cornell University
[2]UMass Amherst
[3]USGS Northeast Climate Adaptation Science Centers

The amendment to the Executive Order on invasive species issued on December 5, 2016 ordered that agencies should "consider the impacts of climate change when working on issues relevant to the prevention, eradication, and control of invasive species, including in research and monitoring efforts…" however how to do this isn't clear to many invasive species managers and policy makers. This talk will outline some of the ways that climate change has been shown to influence invasive species spread and impact and will provide an overview of the efforts of the Northeast Regional Invasive Species and Climate Change (NE RISCC) Management Network to address the gaps in knowledge and translate existing knowledge into management and policy actions.

Range of the Hemlock Woolly Adelgid



Forest management on New York wildlife management areas

Katherine Yard[1]

[1]New York State Department of Environmental Conservation

New York State Department of Environmental Conservation manages over 120,000 acres of forest throughout the Wildlife Management Area system. Currently, one of our top forest management priorities is restoring young forest to improve habitat for wildlife from game species to Species of Greatest Conservation Need. To address that priority, the goal of our Young Forest Initiative is to create, enhance, and maintain 10% of the forested acreage as young forest. To date, we have developed over 40 habitat management plans and created over 600 acres of young forest using even-aged management and target species Best Management Practices. We monitor project areas to document baseline conditions, avoid impacts to sensitive species, and evaluate the effectiveness of habitat management. Bird surveys may include target species (woodcock, grouse, turkey, whip-poor-will, golden-winged warbler), woodland raptor surveys, and/or avian point counts. Preliminary results indicate that whip-poor-wills, golden-wings, and numerous songbirds have responded to management. Moving forward, plans are currently in place to manage an additional 2,500 acres, advancing towards our long-term goal of creating a more diverse forested landscape in the WMA system and contributing to a collaboration of partners working to restore young forest on public and private lands throughout the Northeast.

What do woodland owners in the northeast think of bird conservation?

Elizabeth Varanas[1]

[1]American Forest Foundation

How do we best engage family and individual woodland owners in the Northeast in active forest management with birds in mind? This presentation will highlight our findings about some of the major motivations and challenges related to active forest management for woodland owners – and how the challenges to active management may shift along levels of engagement. We will also discuss lessons learned from our Woods, Wildlife and Warblers project – a partnership with American Forest Foundation, Audubon Vermont, Vermont Tree Farm and Vermont Woodlands Association – which has the goal of equipping Vermont's woodland owners with the tools and resources they need to manage their forest with birds and other wildlife in mind.

A new paradigm for forest bird conservation: A holistic approach to managing for multiple species guilds

Steve Hagenbuch[1]

[1]Audubon Vermont

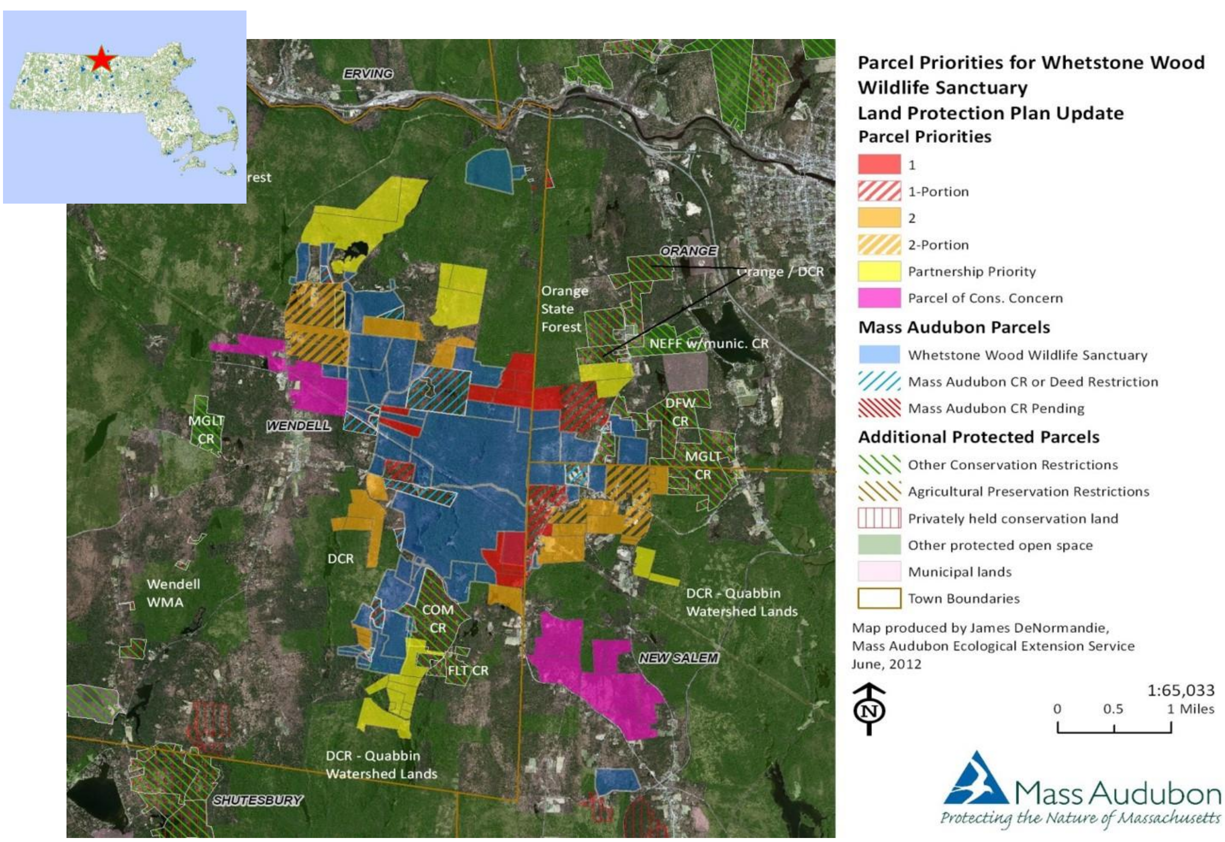
Historically forest bird conservation has focused on single species, particularly those which have exhibited widespread population declines and/or those that utilize a specific forest seral stage. While often successful these efforts may not prove as broadly effective or efficient as taking a landscape-level approach that recognizes a wider range of bird species guilds. Additionally programs that address species not currently "at risk" may require fewer resources and serve as a form of proactive conservation. Examples from Audubon programs throughout the northeast will be used as case studies for a holistic approach to forest bird habitat management.

Forest bird conservation at Mass Audubon: The role of sanctuaries and private lands

Jeff Ritterson[1]

[1]Mass Audubon

Mass Audubon is a well-recognized leader among the conservation community and general public of Massachusetts, with almost 100 sanctuaries distributed evenly across the state. Currently comprising over 15,000 hectares, continued land protection and management initiatives are prioritized to maximize conservation value. Meanwhile, approximately 65% of Massachusetts forests are in nonindustrial private ownership, and scaling up conservation efforts requires work on these lands. A unique take on the Foresters for the Birds model has successfully promoted forests with diverse vertical structure and interspersed canopy gaps to broadly meet nesting and post-fledging habitat needs of forest birds. However, challenges and questions arise during implementation, mostly surrounding 1) demographic and land ownership patterns and 2) the ecological implications of creating young forest. Ideas for potential solutions will be shared, including the introduction of an online decision support tool for the creation and prioritization of young forest habitat projects. Overcoming these and other challenges will better inform management decisions on and off of Mass Audubon sanctuaries, and improve our collective ability to shape landscape-scale habitat conditions.



Importance of woody debris dynamics in understanding the forest carbon cycle

Shawn Fraver[1], Chris Woodall[2], Anthony D'Amato[3], Jodi Forrester[4]

[1]University of Maine
[2]U.S Forest Service, Northern Research Station
[3]University of Vermont
[4]N.C. State University

Coarse woody debris (here downed trees > 10 cm diameter) plays a crucial role in forest ecosystems, where it influences biological diversity, nutrient cycling, and soil development. The current amount of woody debris on a site represents a balance between additions (forest disturbance) and depletions (wood decay). Recent interest the forest carbon cycle, in the context of global climate change, has highlighted the need to better understand woody debris dynamics, particularly the controls of decay rates. One particular knowledge gap concerns the effect of woody debris 'burial' by colonizing mosses (a common occurrence in our northern conifer forests), which is thought to slow decay rates. We present here a set of ongoing experimental studies, as well as results from our recent empirical studies, that characterize woody debris dynamics following forest disturbance. Our empirical work in old-growth red spruce forests demonstrates dramatic fluctuations in woody debris mass, with amounts fluctuating between ca. 15 and 45 Mg / ha over a 100-year period, as the balance shifted between additions from disturbance and depletions from decay. A related study - using uniform-sized, fabricated 'decay stakes' - reveals higher decay rates under experimental forest canopy gaps when compared to those under intact forest canopies, presumably the result of altered microclimates. An additional, ongoing study using decay stakes, some of which are placed below moss cover, is designed to test the influence of moss 'burial' on wood decay rates. Taken together, these studies are shedding light on the woody debris dynamics and clarifying an important and under-studied part of the forest carbon cycle.

Major species of the Northern Hardwood forest: Evaluating trends and environmental drivers of growth in the state of Vermont

Rebecca L. Stern[1], Paul G. Schaberg[2], Shelly A. Rayback[3], Chris F. Hansen[1], Paula F. Murakami[2], Gary J. Hawley[1]

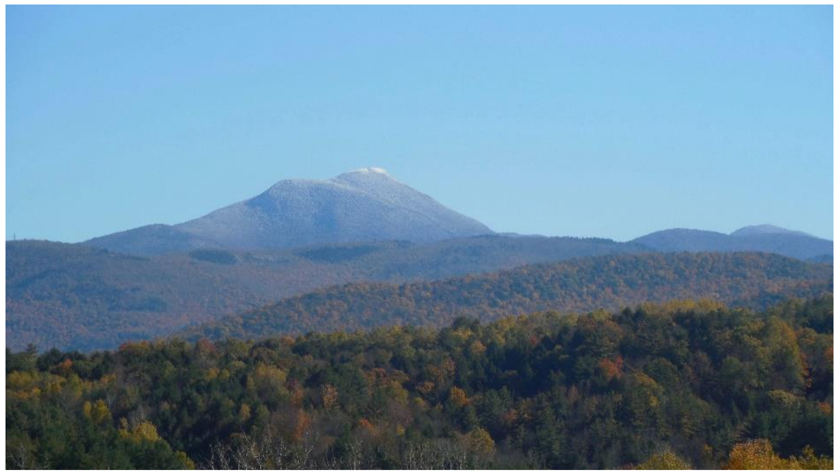
[1]Rubsentein School of Environment and Natural Resources, University of Vermont
[2]USDA Forest Service
[3]Depart of Geography, University of Vermont

Vermont is known for the Northern Hardwood Forest's iconic species: sugar maple (*Acer saccharum Marsh.*), yellow birch (*Betula alleghaniensis Britton*), and American beech (*Fagus grandifolia Ehrh.*). With a changing climate, understanding the future of these forests is dependent on our knowledge of how tree species have responded to anthropogenic factors such as climate change and pollution inputs in the past. Experimental evidence indicates that these factors can significantly alter the health and productivity of some tree species. We are examining the three major species of the Northern Hardwood Forest, as well as red maple (*Acer rubrum L.*), a species whose abundance has increased in this region over the past few decades.

Long-term monitoring reveals forest community change driven by atmospheric deposition and contemporary climate change

Brittany Verrico[1], Jeremy Weiland[1], Timothy Perkins[1], Brian Beckage[1], Stephen Keller[1], Stephen Keller[1]

[1]University of Vermont



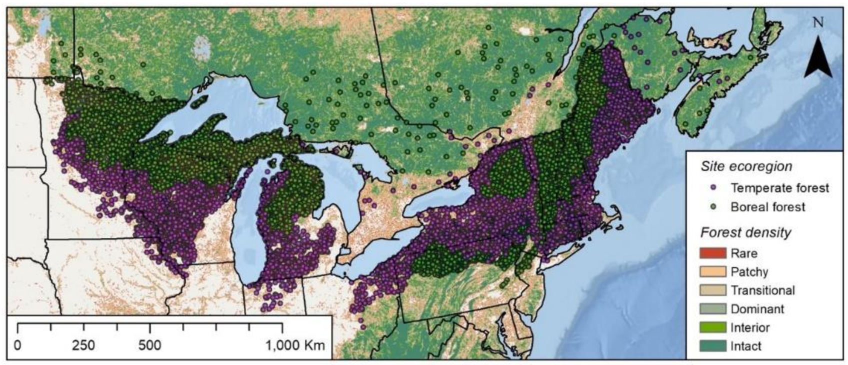
Temperature and atmospheric pollution have been shown to influence forest community composition, as well as the productivity and distributions of individual tree species. Empirical studies however, demonstrate conflicting individualistic and community level responses regarding elevational range shifts and often ascertain the importance of environmental drivers for individual species. In this study, we seek to investigate patterns of biodiversity along environmental gradients by modelling community turnover, or the rate of change in beta diversity, which can be quantified using pairwise changes in species composition (e.g. dissimilarity). We couple Generalized Dissimilarity Modelling (GDM) with a long-term forest tree inventory (years 1965-2015) on Camels Hump, VT to (1) characterize how the elevational gradient in forest community composition has shifted over a 50-year period, both in terms of beta diversity and the relative distribution of individual species, and (2) determine the relative importance of atmospheric pollution and climate change as drivers of temporal shifts in forest communities. The rate of compositional turnover along the elevational gradient was highest between 800-900m elevation, the area encompassing the boreal-deciduous ecotone, and decreased in lower and higher elevations. While the pattern of turnover was consistent over time, the total magnitude of community change was significantly reduced in the last census, consistent with a more homogeneous forest community. Notably, mid-elevation forests have shifted from high diversity with few dominant species to lower diversity dominated by red spruce, Balsam fir, and American beech. At low elevations, red spruce first contracted then expanded its range in 2015, and sugar maple has been in decline. We provide evidence to support realized niche expansion of red spruce in low elevations, possibly as a result of competitive release due to sugar maple decline. Temporal models showed S deposition and mean annual temperature are significant drivers of temporal changes in forest communities, which corroborates previous findings of the climate effects on northeastern forests, as well as the role of recovery from acid deposition.

Ecosystem services and biodiversity as outputs of forest stand development in the American Northeast

Dominik Thom[1], Marina Golivets[1], Laura Edling[1], Garrett Meigs[2], Jesse Gourevitch[1], Laura Sonter[3], Gillian Galford[1], William Keeton[1]

[1]University of Vermont
[2]Oregon State University
[3]The University of Queensland

Study Area



The composition and structure of forest ecosystems shift across successional stages. These shifts drive changes in the provision of ecosystem services and habitat conditions for forest-dwelling species. Anecdotal evidence suggests that not all ecosystem services and species respond similarly to forest succession, thus creating potential trade-offs between management objectives. The impacts of climate change on these relationships are also expected to be heterogeneous, leading to emerging challenges to manage ecosystem services and biodiversity. To address these challenges, we (i) quantify ecosystem services and biodiversity along a stand development gradient, (ii) identify trade-offs and synergies related to forest succession, and (iii) assess sensitivities of ecosystem service and biodiversity indicators to climate.

We complied a dataset of 18,643 individual forest plots from forest survey databases and peer-reviewed literature, and gathered additional information about site conditions from various data sources. Our dataset comprised five carbon storage indicators, one growth indicator, and three biodiversity indicators. We used Bayesian generalized linear models to assess the effects of environmental conditions and forest vegetation on each of these indicators. In particular, we derived the partial effects of dominant forest age as indicator for stand development.

The combined performance of carbon storage, forest growth, and biodiversity was lowest in young and highest in old forests. In particular, carbon storage increased over stand development while growth rate peaked at an early mature stage, followed by a decrease and a subsequent increase of growth in old forests. Biodiversity did not change markedly with stand age but was highest in mature forests. The response of carbon storage, growth, and biodiversity to increasing temperature and precipitation were highly variable.
Indicator performance differed markedly, implying multiple trade-offs and synergies related to stand development. However, the results have clear implications for sustainable forest management. The low performance of all indicators in young stands suggests that forest management should avoid resetting forest development to early successional stages on a large scale. Conversely, the high performance of late development stages indicates old growth forest should be prioritized in management schemes to maximize ecosystem performance. These implications are particularly important for some indicators to maintain high performance under climate change.

What have we learned from monitoring Maine's ecological reserves?

Andy Cutko[1], Justin Schlawin[2], Christian Kuehne[3], Don Cameron[2], Aaron Weiskittel[3], Joshua Puhlick[3]

[1]The Nature Conservancy in Maine
[2]Maine Natural Areas Program
[3]University of Maine

Approximately 50 locations totaling 175,000 acres make up Maine's Ecological Reserve System. Maine Ecological Reserves were established in 2000 as benchmarks for monitoring change over time, and they encompass some of the most ecologically important places in Maine, extending from the Southern Maine coast to the boreal forest and from sea level to over 4,000 feet in elevation. As of 2017, plots in 20 Reserves were remeasured 10 years after initial inventory, which allowed for the first analysis of changes over time. Furthermore, this initial assessment of Ecological Reserve Monitoring data quantified differences in forest structure and composition between Reserves and Maine's managed forests.

Stand metrics analyzed at the plot level included live tree basal area, very large live trees per acre, standing dead trees, large standing dead trees per acre, total and large downed woody debris volume, and various growth and yield metrics. US Forest Service Forest Analysis and Inventory (FIA) data from managed forests across Maine were used to calculate the same metrics. Mixed effects modeling was used to evaluate the influence of program (i.e., Ecological Reserve Monitoring or FIA) and time (inventory round 1 or 2 for Ecological Reserve Monitoring plots) on the studied metrics.

Multiple metrics suggested greater stand complexity on Ecological Reserves than managed forestland in Maine. This result was most evident in two attributes: very large live trees per acre and large standing dead trees per acre. The means of these two metrics were nearly twice as high on Ecological Reserve plots compared to FIA plots on managed forestland. Ecological Reserves plots also had significantly greater mean live basal area and downed woody debris. These results confirm findings of other studies that have shown the abundance of ecologically valuable structural forest attributes is commonly greater in unmanaged than in managed forests. More specifically, The Nature Conservancy's Big Reed Forest in northern Maine is one of the Northeast's largest tracts of old growth forest. Using results from 25 Ecological Reserve plots of Big Reed for comparison, much greater structural complexity can be expected in old forests with no history of harvest. In particular, very large live trees per acre, large snag density, and total downed woody debris volume were all considerably higher on Big Reed Forest.

Our assessment of ten-year changes indicated that Ecological Reserves are still accumulating volume, partially reflecting the past harvesting history of many sites prior to their formal establishment as Ecological Reserves. Longer term sampling data will be needed to verify trends over time. The latitudinal and elevation gradients covered by the Reserves, coupled with the variety of habitats encompassed, suggest that the Reserve system will be an ideal outdoor laboratory for observing long term forest changes in the Northeast.

Trends (?) in exchangeable cations after fifteen years into a 150-year soil monitoring study

Don Ross[1], Scott Bailey[2], Angie Quintana[2], Thom Villars[3], Sandy Wilmot[4], Jim Duncan

[1]Plant and Soil Science, University of Vermont
[2]USDA Forest Service
[3]USDA NRCS
[4]Vermont Forests Parks and Recreation
[5]Forest Ecosystem Monitoring Cooperative

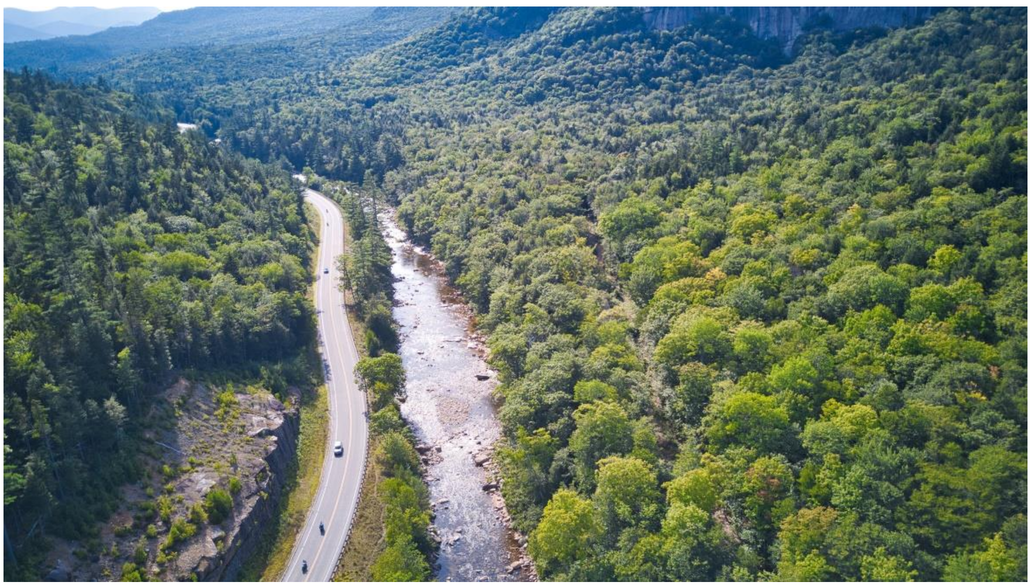
Continued monitoring of forest soils is crucial for detecting, predicting and addressing environmental change. In cooperation with the FEMC, we have established a long-term soil monitoring study on five plots in Vermont. Three are around Mt. Mansfield and two are in southwestern Vermont in the Lye Brook Wilderness Area. Elevation ranges from 590 to 1140 m with forest type varying from typical northern hardwood (*Acer saccharum, Betula alleghaniensis and Fagus grandifolia*) to high-elevation spruce-fir (*Picea rubens and Abies balsamea*). Each 50 x 50 m plot contains 100 5 x 5 m subplots with sampling date assigned randomly (10 per date). The initial sampling of these plots took place in the summer of 2002, and resampling occurred in 2007, 2012, and 2017. Following intensive understory and overstory vegetation inventories, small pits were dug in the center of each plot and the soils were sampled both by genetic horizon and depth increments. All B horizon samples have been analyzed for exchangeable cations and we will discuss temporal trends, or lack thereof, in exchangeable calcium, aluminum, magnesium and potassium. Analysis of mercury, carbon and nitrogen is in progress. Methodological challenges include the intrinsic variability within and among subplots, which affects our ability to detect temporal changes. One plot on Mt. Mansfield presents thought-provoking spatial differences in exchangeable calcium pools. Ongoing challenges of the monitoring study include sustainable funding, robust long-term storage of samples, and continuity of sampling efforts. Continued sampling will allow detection of soil change in response to a changing climate, shifting abiotic stressors, and transitions in vegetation, providing an assessment of impacts independent of land management.

Forest disturbance: there is more of it than you think

Jarlath O'Neil-Dunne[1]

[1]University of Vermont

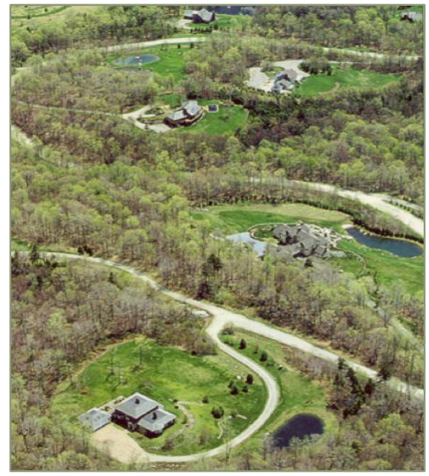
Forest fragmentation in the Northeast is challenging to map, monitor, and measure. It often occurs at very fine scales and for most of our history the remote sensing technologies available to us either lack the spatial resolution or were too costly for us to carry out detailed forest disturbance mapping. The availability of statewide high-resolution imagery and LiDAR has changed this in Vermont. This presentation will discuss how these technologies are being used to quantify not only the fragmentation but identify its causes. Spoiler alert: there is a lot more forest fragmentation than you think.



Tracking parcelization over time to inform planning and policy

Jamey Fidel[1], Kate McCarthy[1], Brian Voigt[2]

[1]Vermont Natural Resources Council
[2]Rubenstein School of Environment, UVM



Parcelization, or the breaking up of land into smaller and smaller parcels, typically occurs through subdivision. Subdivision, and subsequent land conversion and development, can negatively affect plant and animal species, wildlife habitat, water quality, recreational access, and the ability of forests to sequester and store carbon. Increasing parcelization and subdivision can also affect the contiguous ownership, management, and viability of forest parcels, and reduce their contribution to the working lands economy.

The phenomenon of parcelization is gaining momentum, and subsequent development is causing forest cover to decline in Vermont. According to the U.S. Forest Service, Vermont may have lost 102,000 acres of forestland from 2012 to 2017 (Morin et al., 2017). To minimize forest loss and fragmentation, it is necessary to understand where parcelization and subdivision are occurring, and the rate at which they are occurring; however, to date there has been no systematic way to track trends in Vermont to inform planning and resource management.

A recent project was designed to track and analyze parcelization trends on private land in Vermont by utilizing Grand List (tax) data, as well as Use Value Appraisal Program data, from 2004 to 2016. As part of the project, project partners developed a database of parcels in the state, compiled by size class and various other metrics, with a focus on large parcels and forestland, In addition, project partners developed a website with "data explorer tools" to examine parcelization trends at the town, county, regional planning commission, and state level.

This presentation will examine key parcelization trend findings (see below), provide a brief tutorial on the parcelization website, and identify priority policy and research recommendations.

Key Findings:

- Both the amount of land in parcels 50 acres and larger, and the number of parcels 50 acres and larger are decreasing, while both acreage, and the number of parcels under 50 acres, is increasing.
- The number of acres in the "residential" category is increasing, while "farm" and "woodland" acreage is decreasing. "Woodland," which represents undeveloped forestland parcel acreage, decreased the fastest.
- Across the state, the per-acre value of land in Vermont nearly doubled during the study period, though increases varied greatly depending on location.
- Most dwellings are built on smaller parcels compared to larger parcels.
- The Use Value Appraisal Program is playing a role in protecting large woodland parcels.

Morin et al (2017). Forests of Vermont, 2016. Resource Update FS-119. Department of Agriculture, Forest Service, Northern Research Station. Available at https://www.fs.fed.us/nrs/pubs/ru/ru_fs119.pdf

Progress report: Aligning the Northeastern States Research Cooperative and Forest Ecosystem Monitoring Cooperative

Elissa Schuett[1], William Bowden[1], Anthea Lavallee[2], William McDowell[3], David Newman[4], Aaron Weiskittel[5], Christopher Woodall[6]

[1]University of Vermont
[2]Hubbard Brook Research Foundation
[3]University of New Hampshire
[4]SUNY ESF
[5]University of Maine
[6]USDA Forest Service

Northeastern States Research Cooperative (NSRC) has long served as source of research funding for the Northern Forest region having awarded more than 300 grants totaling nearly $24 million to more than 50 institutions and agencies over the past 17 years. At the last Forest Ecosystem Monitoring Cooperative (FEMC) annual meeting, a vision was outlined for aligning NSRC and FEMC while recruiting stakeholder engagement to embolden greater regional impact. In the past year, efforts to further this vision have been pursued and will be presented in brief here. A business report highlighting achievements of NSRC over the past 17 years was released, a regional stakeholder meeting conducted, and potential partnership with the Northern Borders Regional Commission explored. As an outcome of these efforts, current concerns and future priority research areas were identified. The primary concerns included: (1) understanding environmental change effects on local ecological and economic systems and (2) better connecting science to the public via outreach and communications. Key priority research areas were: (1) rural and forest-based socioeconomics; (2) invasive species; (3) effective science linkages to policy; (4) sustainable forest management; (5) regional patterns in land use and effects of fragmentation; and (5) ecosystems services, particularly energy and carbon. These have helped guide a future organizational structure of NSRC and clearly showcases the need to maintain a strong partnership with FEMC. These outcomes and future vision will be more fully showcased in the presentation.

Young and old forest targets for an ecologically functional landscape

Bob Zaino[1]

[1]Vermont Fish and Wildlife Department

Northeastern States Research Cooperative (NSRC) has long served as source of research funding for the Northern Forest region having awarded more than 300 grants totaling nearly $24 million to more than 50 institutions and agencies over the past 17 years. At the last Forest Ecosystem Monitoring Cooperative (FEMC) annual meeting, a vision was outlined for aligning NSRC and FEMC while recruiting stakeholder engagement to embolden greater regional impact. In the past year, efforts to further this vision have been pursued and will be presented in brief here. A business report highlighting achievements of NSRC over the past 17 years was released, a regional stakeholder meeting conducted, and potential partnership with the Northern Borders Regional Commission explored. As an outcome of these efforts, current concerns and future priority research areas were identified. The primary concerns included: (1) understanding environmental change effects on local ecological and economic systems and (2) better connecting science to the public via outreach and communications. Key priority research areas were: (1) rural and forest-based socioeconomics; (2) invasive species; (3) effective science linkages to policy; (4) sustainable forest management; (5) regional patterns in land use and effects of fragmentation; and (5) ecosystems services, particularly energy and carbon. These have helped guide a future organizational structure of NSRC and clearly showcases the need to maintain a strong partnership with FEMC. These outcomes and future vision will be more fully showcased in the presentation.

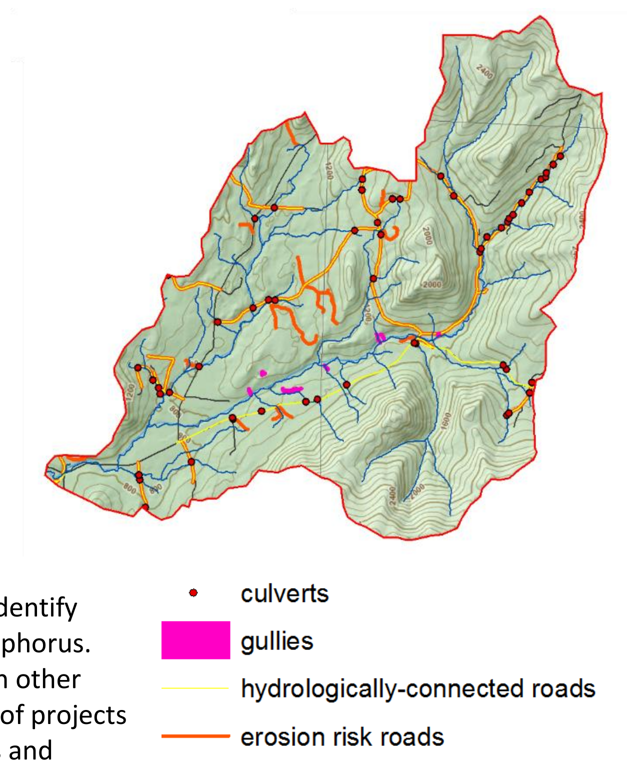
Flower brook watershed phosphorus mitigation: Landscape assessment and project implementation

Hillary Solomon[1], Kathleen Doyle[2,3]

[1]Poultney-Mettowee Natural Resources Conservation District
[2]Doyle Ecological Services
[3]Middlebury College

The Poultney Mettowee Natural Resources Conservation District (PMNRCD) and Doyle Ecological Services (DES) partnered to create a landscape-scale assessment of a geomorphically unstable, forested, headwater watershed. The aim of the assessment was to identify conservation and restoration projects to mitigate or attenuate phosphorus sources and to enhance or conserve phosphorus sinks within the Flower Brook basin, a subwatershed of southern Lake Champlain.

Flower Brook Landscape Assessment



The project had four main steps: mapping the watershed characteristics, field truthing the maps, identifying and prioritizing restoration and conservation projects, and implementing at least one of the identified projects. The assessment involved examining GIS data layers and manipulating them to show areas with specific overlapping features that could be used to identify landscape areas that were either sources or sinks of phosphorus. The landscape assessment was completed in tandem with other ongoing assessments in an effort to add to the inventory of projects in the watershed with a focus on attenuating phosphorus and conserving or enhancing phosphorus sinks.

Doyle Ecological Services used the raster calculator to weigh and combine GIS data layers to create numerical gradations encompassing multiple characteristics related to phosphorus stability on the landscape. The Brynn and Underwood paper, Enhancing Flood Resiliency on Vermont State Lands, and Vermont Conservation Design mapping served as important cornerstone studies influencing this work. Four maps were created: Vulnerable Areas- Most Likely to Contribute Phosphorus, Phosphorus Attenuation- High Priority Areas, Restoration and Conservation Priorities, and High Priority Riparian Areas.

The Conservation District used these maps to identify project opportunities, reach out to landowners, and implement a gully stabilization project on a tributary to Flower Brook. The District will use the information from the mapping exercise to implement a variety of projects and is monitoring the Flower Brook Watershed closely to determine the effectiveness of their conservation work. The watershed is also the focus of a High Meadows Fund Flood Resiliency Grant and several other studies that all work to decrease flood and climate vulnerabilities and implement high-priority restoration projects.

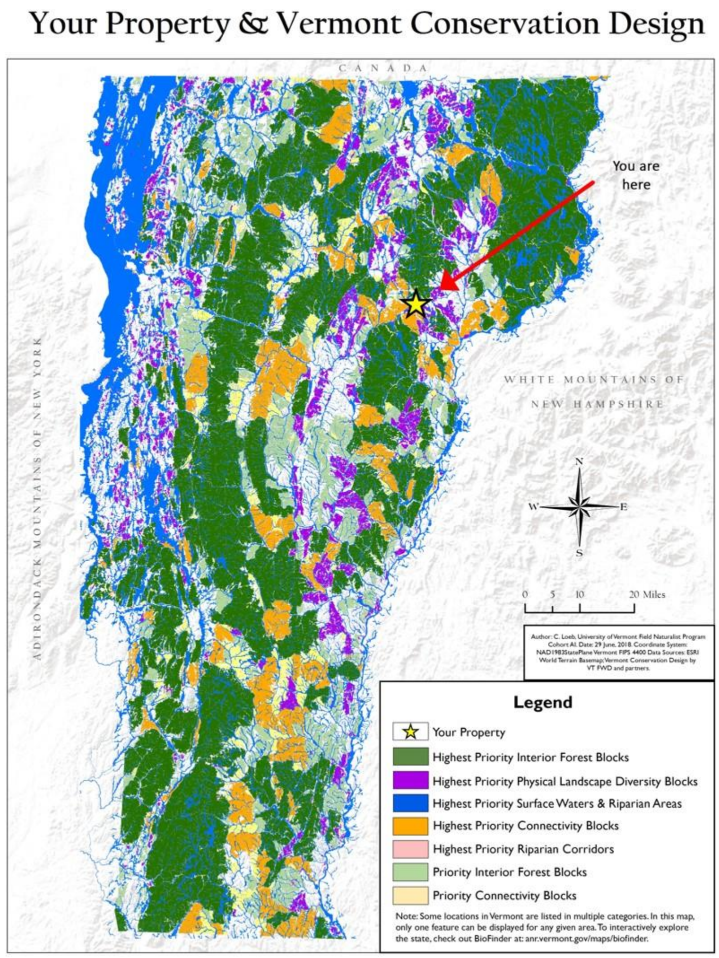
The two maps, Restoration and Conservation Priorities, and High Priority Riparian Areas, were created by DES to inform conservation work by the District. Among other combinations of features, these maps show highly productive lands with no forest cover, including areas within riparian and wetland buffers. The District can use these maps to target specific landowners and can update the maps to show changes over time with respect to conservation or forested status within high priority segments and can document cumulative changes on the landscape due to conservation practices that they and partners implement.

Bringing Vermont Conservation Design to private landowners in the VT Coverts Cooperator Network: strategies, challenges, and areas of opportunity

Carolyn D. Loeb[1]

[1]University of Vermont

Vermont Conservation Design is a new statewide vision for an ecologically functional future. But how do we translate this conservation roadmap into on-the-ground action, especially given that much of Vermont is privately owned and increasingly parcelized? Join UVM Field Naturalist graduate student Carolyn Loeb as she shares her experiences, results, and lessons learned from a summer pilot project for Vermont Fish & Wildlife and Vermont Coverts during which she introduced the new design to twelve private landowners in the Coverts Cooperator Network. Her findings--though preliminary--suggest that there are reasons to be optimistic when working with this demographic.

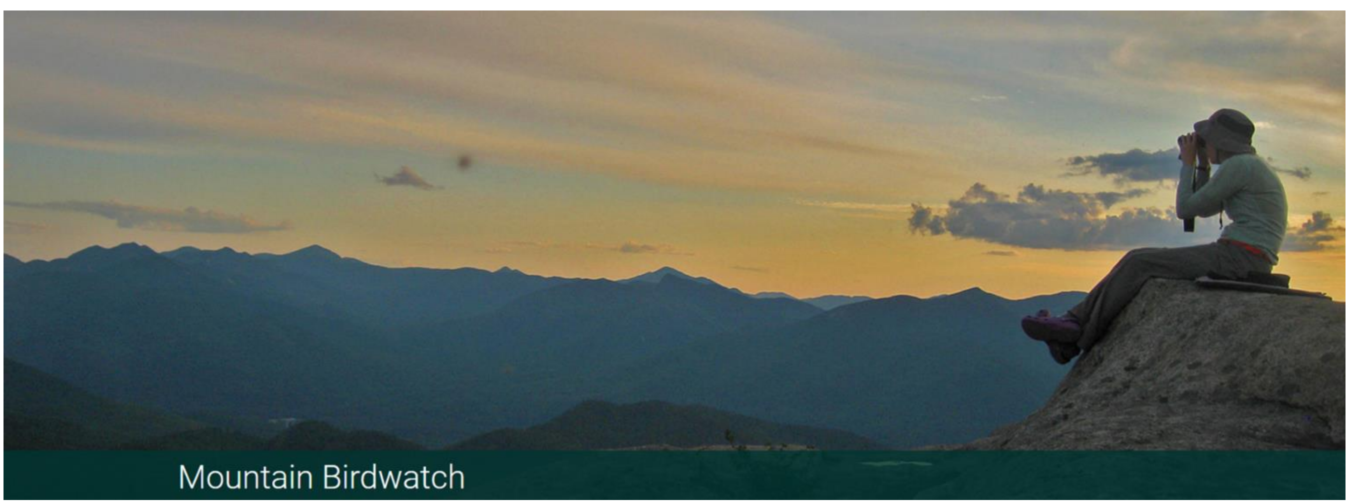


Staying relevant: a cooperatively-designed online database to house natural resource survey data collected by citizen scientists

Jason Hill[1], Mike Finnegan[2], Jim Duncan[2]

[1]Vermont Center for Ecostudies
[2]Forest Ecosystem Monitoring Cooperative

Citizen science has emerged as a global phenomenon and tool to conduct ecological research at unprecedented scales, and citizen scientist projects have correspondingly grown in scope and geographic scale. For example, the popular iNaturalist program grew out of a Master's project in California in 2008 and now includes more than 750,000 observers around the world. As the popularity of citizen science projects grows, so too does the challenge to efficiently collect, store, and retrieve those data. Furthermore, competition for attracting and retaining citizen scientists has also increased. In a recent study of volunteer interaction with online tools, volunteers identified "format" and "professional appearance" of the tools as having the greatest effect on their decision to use them. With these ideas in mind, the Vermont Center for Ecostudies and the Forest Monitoring Cooperative recently developed an online data entry portal and database for the citizen science project, Mountain Birdwatch. This project is an initiative by the Vermont Center for Ecosystems to engage wildlife enthusiasts, and to harness the power of the public to conduct wildlife monitoring across northern New England and eastern New York. Until 2017, Mountain Birdwatch had used the same online database (with few structural or cosmetic changes) for more than a decade, and the outdated appearance and limited functionality of the database likely stymied citizen scientist participation and lowered volunteer retention rates. At the same time, the volume of data resulting from >20,000 bird surveys since 2010, necessitated finding technological solutions to collect and manage and automate error checking of this growing mountain of data. In our talk, we will outline our collaborative design process and showcase the resulting online data entry portal and database that are now used by Mountain Birdwatch citizen scientists.

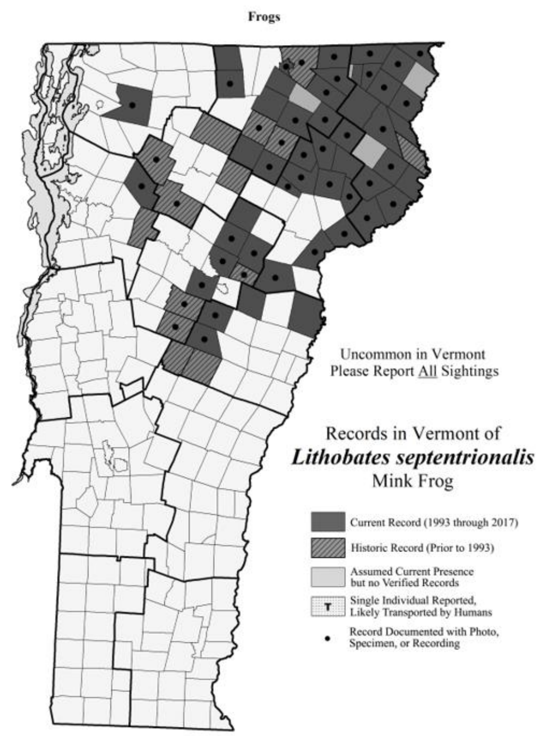


Establishing baseline distribution data on Vermont's reptiles and amphibians: the 2018 maps and species to watch

Jim Andrews[1]

[1]Vermont Reptile and Amphibian Atlas

The Vermont Reptile and Amphibian Atlas has just finished updating its maps showing the current distribution of reptiles and amphibians in Vermont. Establishing current baselines of distribution will allow us (and others) to monitor changes in distribution as a result of climate change, habitat loss, habitat fragmentation, and habitat degradation. Eastern Milksnake distribution very closely matches current hardiness zone 4B and would be expected to track its movement in coming years provided it is able to safely colonize appropriate habitat further north and east. Other lowland species such as DeKay's Brownsnake and Gray Treefrog may also extend their ranges into higher elevations and further north and east and anecdotal reports suggest this is happening. Mink Frogs are a northern species whose range extends into northeastern Vermont. It is a species that might be expected to disappear from Vermont in coming decades as the climate warms. Boreal Chorus Frog, another northern species, appears to have already been extirpated from Vermont. We do not know if this extirpation was climate change related or not. We will explore some of the new maps and how species ranges might change in the future if habitat and movement conditions allow.



Using remote-triggered camera traps to describe patterns of mammal species richness and abundance in relation to anthropogenic and ecological factors

Alyssa Valentyn[1], Declan McCabe[1], Jade Jarvis[1], Olivia Richardson[1], Schyler Schewe[1], Ethan Brookner[1]

[1]Saint Michael's College

The Saint Michael's College Natural Area in Colchester, Vermont is a fragmented agricultural floodplain which will soon undergo land-use changes, including floodplain restoration and increased trail use. In a series of study periods from May 2017 through July 2018, we set camera traps to describe the distribution of mammals in suburban Vermont in relation to the following anthropogenic and ecological factors: 1) human presence, 2) level of development, 3) presence of compost, 4) forest availability, and 5) wetland habitat availability. Among anthropogenic factors, we found a lower abundance of species at regularly visited cameras and the opposite trend at compost sites; and off-campus species richness was significantly greater than on-campus. Among ecological factors, we found more species in wooded habitats than in open habitats; and no difference between wetland and upland species richness. Because anthropogenic factors tended to decrease animal richness but increase abundance, we conclude that restoration to a more natural state may be beneficial to the area's biodiversity.

Monitoring the effects of prescribed burns on common nighthawk populations in New Hampshire's Ossipee Pine Barrens

Jason Mazurowski[1]

[1]Department of Plant Biology, Field Naturalist Program, University of Vermont

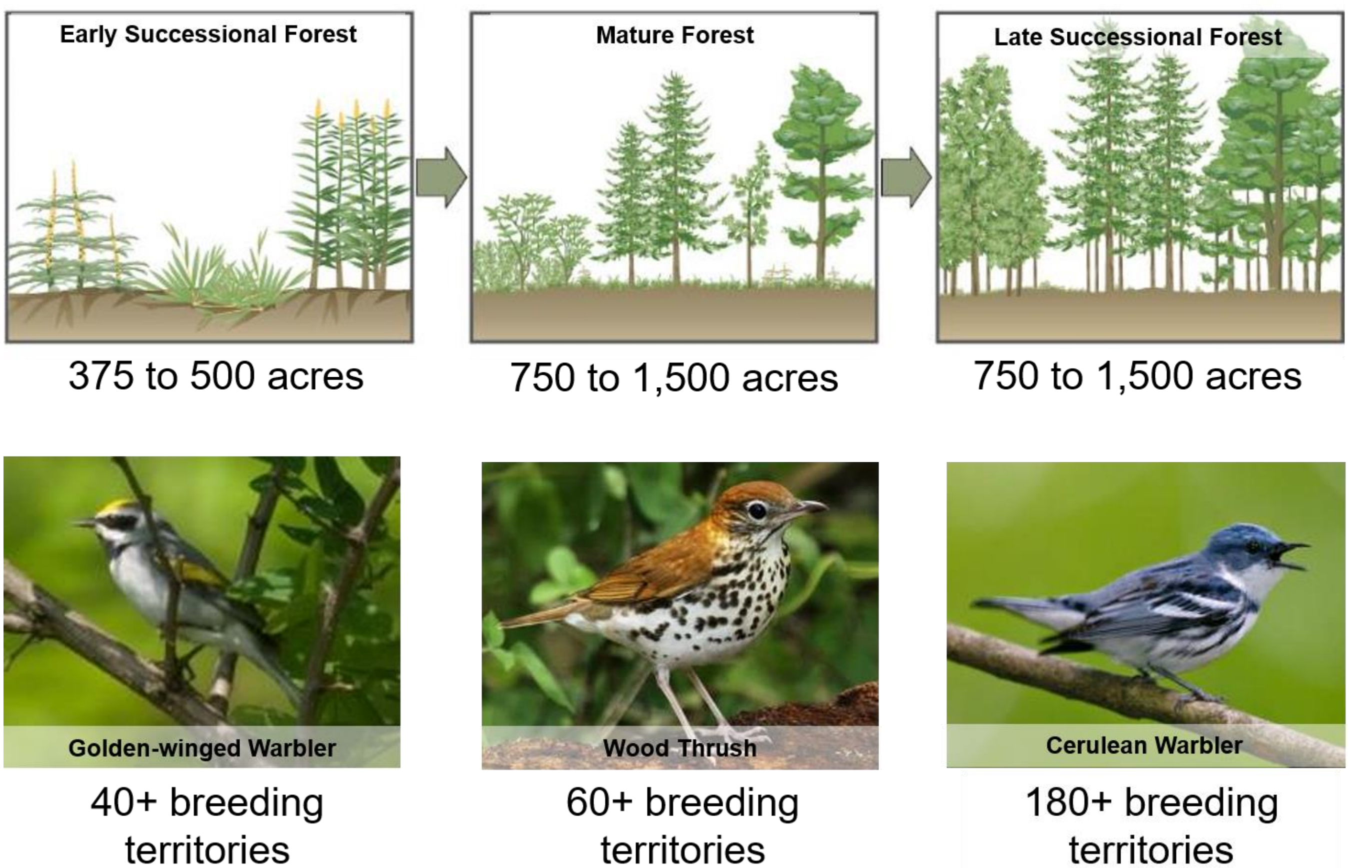
Common nighthawks (*Chordeiles minor*), once widespread throughout the Northeast, have been in rapid decline since the 1980s. A decline in insect diversity, combined with a lack of early successional habitat, are thought to be major contributors. The Ossipee Pine Barrens Preserve, owned and managed by The Nature Conservancy, represents one of the only locations in New Hampshire supporting breeding populations in their natural environment. Beginning in 2007, The Nature Conservancy has treated over 1,000 acres within the preserve -- combining prescribed burns, small-scale timber harvests, and regular mowing to maintain and regenerate pitch pine-scrub oak woodland communities. Partnering with New Hampshire Audubon and the New Hampshire chapter of The Nature Conservancy, 2018's monitoring project yielded updated estimates on distribution and abundance of nighthawk populations. A quantitative analysis of vegetation characteristics at 8 confirmed nighthawk nest sites, combined with extensive observations of nesting behavior throughout the breeding season suggest that a small but stable breeding population has persisted in the pine barrens, and has responded positively to management regimes.

From keystone initiatives to landscape programs: a decade of investing in forest conservation for birds – outputs, outcomes and lessons learned

Scott Hall[1]

[1]National Fish and Wildlife Foundation

The National Fish and Wildlife Foundation's early successional forest (ESF) keystone initiative business plan was focused on creating habitat for dependent bird species across a multi-state region. Time lags to implementation, initial implementation capacity, coordination gaps and ambitious 10-year funding, habitat and species goals contributed to program under-performance. However, increased implementation capacity, extensive outreach and key lessons resulting from ESF program investments combined with emerging science on bird habitat use of multiple forest seral stages during the breeding period are shaping current performance based landscape programs at NFWF. Current landscape efforts are focused on improving age interspersion and structural diversity within forest blocks (5,000 acre minimums); golden-winged warbler, wood thrush and cerulean warbler are serving as indicator species of forest seral stages with goals for each derived from minimum territory sizes multiplied by expected acres under improved management. Performance monitoring will be grounded in point count estimates and scaled using modeled data for occupancy, distribution and count estimates.



Bird conservation on commercial forests in the Northern Forest

Henning Stabins[1]

[1]Weyerhaeuser Inc.

Bird conservation on commercial forests involves multiple approaches at different scales. Here we highlight stand-scale habitat feature management, species-specific efforts, and coarse-scale landscape shifting habitat mosaic outcomes, along with continued involvement in research and monitoring through collaboration with state and federal agencies and non-governmental organizations. Sustainable forestry certification also includes standards that address bird conservation – examples include conservation of habitat features and listed species, attention to invasive species and healthy forests, contributions to research, and alignment with state wildlife action plans.

What remote sensing tells us about the regions changing forests

Alison Adams[1,2], Jennifer Pontius[2,3], David Gudex-Cross[2]

[1]Gund Institute for the Environment, University of Vermont
[2]Rubenstein School of Environment and Natural Resources, University of Vermont
[3]U.S. Forest Service Northern Research Station

Improvements in both sensor and computing technologies has allowed researchers to more closely examine historical changes in forest structure and function across the forested landscape and use this information to model future scenarios. Here we highlight the findings of recent papers that build off a 30+ year archive of satellite imagery to quantify the extent and pattern of changes in forest cover, species abundance and fragmentation patterns across the forested landscape. Remote sensing products like these are essential to understand the potential drivers of change in the region's forests, identify locations or forest types particularly at risk, and inform the sustainable management of this critical resource at a time of rapid environmental change.

South Hooksett, NH

Using citizen science data in integrated population models to inform conservation

Orin Robertson[1]

[1]Cornell Lab of Ornithology

No abstract provided.

Abstracts from Posters

There were 23 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.

12-Year forest trends in Acadia National Park

Sam Bietsch[1], Kathryn Miller[1], Camilla Seirup[1], **Aaron Weed**[2]
[1]National Park Service, Northeast Temperate Inventory and Monitoring, Bar Harbor, ME
[2]National Park Service, Northeast Temperate Inventory and Monitoring Network, Woodstock, VT

The Northeast Temperate Network Inventory & Monitoring Program (NETN) has been monitoring forest health annually in Acadia National Park since 2006. NETN monitors a suite of site and vegetation measures across a network of 176 randomly located permanent plots in Acadia. Plots are sampled on a 4-year rotating panel, such that one quarter of plots are sampled every year, and each plot is sampled every 4 years. Currently each plot has been sampled at least 3 times, allowing us to begin examining forest trends in Acadia. Overall patterns indicate that forests are succeeding to older successional stages. While this pattern is most apparent on the east side of Mount Desert Island, signals of succession are evident park-wide. Shade tolerant species are increasing in abundance, while early successional species like paper birch (*Betula papyrifera*) are declining. Most notably, red spruce (*Picea rubens*) is increasing in abundance across all strata in the forest, including seedlings, saplings, and canopy trees. Red spruce is also the most abundant understory species, occupying nearly double the percent cover of the next most abundant species of black huckleberry (*Gaylussacia baccata*) and lowbush blueberry (*Vaccinium angustifolium*). Invasive species continue to be at low levels, with invasive species documented in only 5 out of 176 plots. Red pine (*Pinus resinosa*) mortality from red pine scale (*Matsucoccus resinosae*) has been observed in the most recent 4-year cycle, although less than 1% of trees monitored by NETN in ACAD are red pine. As long as forest composition metrics remain stable (e.g., no new invasive species, stable tree condition/ forest pests, and continued regeneration), late-successional structure is expected to continue developing over time.

2018 Forest Ecosystem Monitoring Cooperative partner projects

James Duncan[1,2], Alexandra Kosiba[1,2], Mike Finnegan[1,2], John Truong[1,2]
[1]Univerisity of Vermont, Rubenstein School of Natural Resources and Environment
[2]Forest Ecosystem Monitoring Cooperative

In 2017 FEMC rebranded from the Vermont Monitoring Cooperative to the Forest Ecosystem Monitoring Cooperative. 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. These projects include; an assessment of hemlock woolly adelgid-induced losses in corridors in New York state, a clearcut inventory in the state of New Hampshire with the New Hampshire Department of Forests and Lands (NHDFL), a catalog and access portal for researchers, managers, and educators in the Catskills region of New

York with the Catskills Science Collaborative, a data entry portal for the Vermont Center for Ecostudies to use with their volunteer Mountain Bird Watch program.

26 Years of FEMC's Annual Forest Health Monitoring Program in Vermont

Stephen Rotella[1,2], **Josephine Robertson**[1,2], Danielle Ward[1,2], Gene O. Desideraggio[1,2], John Truong[1,2], James Duncan[1,2]
[1]Univerisity of Vermont, Rubenstein School of Natural Resources and Environment
[2]Forest Ecosystem Monitoring Cooperative

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 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. The FHM network contains 49 plots by co-locating with other forest health monitoring efforts such as the USFS 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.

Air temperature and humidity along an elevation gradient at Camel's Hump State Park, Vermont

John R. Butnor[1]
[1]USDA Forest Service

Montane environments create a range meteorological conditions in a relatively small area, creating islands of plant and animal communities usually found at higher latitudes. Sensitivities to climate along elevation gradients can affect species distribution and within species, differences in phenology. In much of Vermont, red spruce (*Picea rubens*) exists in the ecotone between high and low elevation forests. It thrives in humid environs that are neither too cold nor too warm and there is some evidence that adaptations to climate exist in high and low elevation populations that are geographical very close to each other. To better understand the selective pressure of climate gradients on red spruce a series of 7 data loggers that record air temperature and humidity every hour were installed along the Burrows trail on the western slope of Camel's Hump (570 m to 1113 m). For calendar year 2017, mean annual temperature and humidity ranged from 2.0 C and 93.3 % at 1113 m to 5.8 C and 82.6 % at 570 m. Variation in both mean annual air temperature (R2= 0.99) and relative humidity (R2 = 0.77) were linearly related to elevation. The mean temperature difference of 3.8 C was observed over 2.5 aerial km. Diurnal and seasonal patterns will be discussed.

Assessment of root system quality in container grown trees

Marie V. Ambusk[1], Gordon Mann[1]
[1]TREES ROI

The unintended consequences of container grown nursery stock trees have been clearly documented and understood by the industry. While attempts to build a “better mouse trap” have focused on the container designs, and nursery production practices, the current recommended methods to inspect the quality of a tree’s root system are: 1) use bare root stock, or 2) wash the soil off roots for container or b&b stock. The current practice to mitigate container root problems is to cut off the outer inch of the root ball before planting. These approaches do not solve the problem or allow reasonable verification of root system quality, and all depend on the person doing the planting to make the decisions.

The pragmatic challenge can be defined as: It’s hard to fix what you can’t see! Buyers purchase millions of trees without knowing the quality of the root systems, and many don’t realize they are receiving a poor-quality product. Those buyers that specify a quality level cannot confirm that every tree meets their specifications. How can one specify and confirm root system quality without seeing the roots? After delivery, the person planting the tree typically does not fix the root problems. The result is that the tree owner does not receive a high-quality tree asset.

TREES ROI is using noninvasive ground penetrating radar (GPR) technology to image root systems and measure quality. This innovation will allow the assessment of root systems to identify problems and consider appropriate action needed for correction, from the earliest stages of nursery production up to the day the trees are delivered for planting. The method uses GPR technology with three-dimensional (3D) visualization software to provide an image of the root system. It will allow growers to invest in viable plants through the entire growing cycle and will give buyers an objective confidence in root quality with visual assurance to support the purchase and installation of quality plants. It will also allow root quality specifications to be verified and confirm plants meet quality benchmark specifications.

In preliminary testing, we identified tree root system and GPR complexities for further analysis to be addressed at Geophysical Survey System Inc. (GSSI’s) Innovation Lab. The next steps will be to develop an enhanced 3D image, determine the best application of GPR technology to meet our requirements, and to combine our root defect recognition software with the system design. Our goal is to have a prototype for testing in 2019 and a viable tool for the industry in 2020. We look forward to achieving our vision to improve the value, benefits and lifespan of container grown tree stock and to grow better urban trees – a WIN-WIN! That is good Return on Investment at the Root of It.

Bumble bee (Bombus) distribution and diversity in Vermont, USA: a century of change

Kent P. McFarland[1], Leif L. Richardson[2], Sara Zahendra[1], Spencer Hardy[1]
[1]Vermont Center for Ecostudies, Norwich, VT
[2]Gund Institute for Ecological Economics, University of Vermont, Burlington, VT

Bombus spp. (bumble bees) play key roles as pollinators in temperate ecosystems. Some North American species have declined due to factors that include habitat loss, parasites, pesticides, and climate change. In many regions, conservation is hampered by lack of quantitative data on historical abundance and distribution, making status assessments difficult. From 2012 to 2014, with help from 53 citizen scientists, we conducted surveys to determine the status of bumble bees throughout Vermont. For historical comparison, we determined species identifications and databased bumble bee specimen data from 24 public and private collections. Our dataset contained 12,319 valid records, which we separated into historic (1915–1999; n = 1669) and modern (2000–2014; n = 10,650) periods, with our survey contributing 91% of modern data. Of 17 species, 4 were extirpated and 4 showed significant declines. Rarefaction indicated that both modern and historic datasets slightly underestimated true species richness, diversity, and abundance, but confirmed a strong decline for all 3 parameters. Declining species broadly accorded with those reported elsewhere in eastern North America, and included those in subgenera *Bombus* and *Psithyrus*, as well as *Bombus fervidus* and *B. pensylvanicus*. Four species in the subgenus *Pyrobombus* (*B. bimaculatus*, *B. impatiens*, *B. ternarius*, and *B. vagans*) increased strongly in relative abundance in the modern period. Landscape factors such as road density, elevation, and land use strongly predicted distribution of some species. Species diversity was correlated positively with grasslands, and negatively with deciduous and mixed forest cover, while abundance was correlated positively with evergreen forest cover, yet negatively with deciduous forest.

Changes in forest canopy cover reflect trends of increased runoff and potential loss of catchment from Vermont's main water supply

Kacey Clougher[1], James Duncan[1,2], Alexandra Kosiba[1,2]
[1]University of Vermont, Rubenstein School of Natural Resources and Environment
[2]Forest Ecosystem Monitoring Cooperative

Forested watersheds of Vermont provide the state with a large portion of its water supply. As Vermont is losing its canopy cover the effect on quality and quantity is unknown. Although there have been many studies looking at the linkage between change in land cover and discharge from streams, many of these studies reflect drastic changes in land cover such as clear cutting or human development. The objective of this study was to quantify the percentage of water that passes through forested watersheds and observe the relationship between forest canopy cover and in catchment trends over time. Daily discharge measurements for summer months were taken from USGS stream gauge data and quantified for runoff measurements specific to the size of the catchment basin of that gauge. National Land Cover Database (NLCD) provides 30 meter resolution estimates of percent forest canopy for 2001 and 2011 in which changes in canopy cover percentage were taken and averaged across 144 months to get an approximate rate of change. The average canopy cover changes ranged from +1.02% canopy cover growth to -3.34% canopy cover loss from 2001 to 2011. These basins saw little change in overall discharge trends between 2001 and 2011, however historical records dating from 1940's to 1970's indicate that over the century the same basin has seen a trend of increased runoff. A few basins had larger changes in forest canopy cover, between -5.64% to -7.54% loss from 2001 to 2011, showed a significant change in increased

runoff over the 10 year period. Though limited by lack of temporal data of canopy cover prior to 2001, historical data shows long term trends of increased runoff values. This study supports that gradual loss of percent canopy cover of a forested stream is reflected in changes in runoff trends. Increased runoff from these basins could mean increased runoff trends in Vermont's forest basins and impact the state's water supply.

Effects of fallen trees on wildlife species richness and abundance in the Saint Michael's College Natural Area

Risa Berman[1], Lauren Dunn[1], **Declan McCabe**[1]
[1]Saint Michael's College

Features such as logs, trails, and waterways in forest ecosystems have the potential to serve as pathways or barriers for animals, and therefore influence species richness and abundance in these areas. The Saint Michael's College Natural Area in Colchester, Vermont encompasses 340 acres of second-growth forest, wetland, and agricultural fields with many downed logs. Twenty-one wildlife cameras were deployed throughout this area to investigate whether the presence of logs influences species abundance and richness. Two different types of sites were compared: sites with a log present (n=6), and sites in unobstructed open or forested areas (n=15). Cameras at sites with logs were positioned to capture still images of animals on or near the logs. The cameras collected data between July and October 2018. For each camera site, the total number of observations of each species was recorded. For the cameras at sites with logs, we also noted if the animal was seen on or off the log. We recorded greater abundance and species richness from sites with logs versus the areas that lacked logs. Species observed included raccoons, opossums, hawks, red squirrels, gray squirrels, gray foxes, ravens, crows, chipmunks, mice, white tailed deer, coyotes, rabbits, various small bird species, woodchucks, turkeys, skunks, and weasels. The results of this study also provide insight into the biodiversity of a suburban natural area and microhabitat usage of different species that occur there.

Long term trends in the density of mayflies in the Middlebury area

Vickie Backus[1], Alison Nurok[1]
[1]Middlebury College

In this poster we will present data on long term patterns of mayfly density and proportional representation in the benthic macroinvertebrate population (BMI) of the New Haven and Middlebury Rivers in Addison County VT. Mayflies are an important group of BMI as they can live in more different kinds of habitats than other BMI (Voshell, 2012), and are generally the dominant order in our field sites (unpublished data). They are also important indicators of water quality (Alhejoj et al. 2014). We have noticed over the past 10 years that the density of mayflies varies greatly from year to year in our autumn collections. Some of this variation is due to large storms especially during the years 2010-2012; however large storms do not occur every year. Given the prediction that climate change may increase the magnitude and frequency of large storms in the northeast it is important to understand long term patterns in BMI abundance.

Modeling the effects of global change and associated adaptive silvicultural systems in northern New Hampshire

Jennifer Santoro[1], Anthony D'Amato[1]
[1] University of Vermont

Global climate change is predicted to have significant but unknown impacts on future forest structure, function, and composition in New England. Combined with a mixed-ownership landscape and dynamic land use history in this region, it may be challenging to meet diverse landowner management objectives using historic silvicultural techniques under future changing conditions. The Adaptive Silviculture for Climate Change (ASCC) project, which aims to provide a toolbox of approaches to forest management for many outcomes under global change, can be employed to break down barriers to communication and implementation between scientists and landowners, resulting in the creation of silvicultural strategies that are both attainable and promote forest resiliency in the face of future changes. This research integrates field measurements from an operational field study at the Second College Grant ASCC project site in Coos County, New Hampshire, with LANDIS-II landscape simulation models to model future forest conditions based on projected changes in climate, disturbance, and associated management regimes. It involves four main management approaches: resistance, resilience, transition, and no management treatments. These stochastic models allow us to evaluate the effectiveness of various adaptive silvicultural strategies at sustaining forest structure, composition, ecosystem services, and landowner management objectives in the context of a changing and uncertain climate future. Resilience and transition treatments are projected to fare the best in terms of maintained ecosystem services under simulated climate models by employing uneven-aged management strategies that emphasize species diversity, structural heterogeneity, and the influx of climate-adapted species. This work underscores the utility of landscape simulation models for evaluating the outcomes of adaptive silviculture and its impacts on future forest structure, function, and composition so as to aid decision making under an uncertain climate future.

Monitoring ash on conserved lands in Vermont: partnerships and potential for resilient

Allaire Diamond[2], Jonathan Rosenthal[1], Radka Wildova[1], Pieter van Loon[2], Liz Thompson[2], Dan Kilborn[2], Caitlin Cusac[2], David McMath[2]
[1]Ecological Research Institute
[2]Vermont Land Trust

The detection of emerald ash borer (EAB) in Vermont in 2018 realized a threat that the forestry community had been anticipating for years. With the potential to kill nearly all of the state's 150 million white, green, and black ash trees, including significant components of upland forest stands, extensive forested wetlands, and municipal street tree populations, EAB will undoubtedly change Vermont's landscape in complex ways. There is a high level of interest in and awareness of EAB in Vermont, and a strong desire on the part of foresters, landowners, and others with deep ties to the woods for practical management and response options, especially those that can promote long-term ash survival. Some hope resides in research from the US Forest Service on “lingering ash” trees, which can serve as a source for breeding EAB-resistant, locally adapted, native ash for eventual restoration. Vermont Land Trust (VLT) holds conservation easements on over 2500 properties, comprising over 420,000 acres of forestland, and has ongoing stewardship relationships with thousands of landowners. With such a large base of acres and people, VLT serves as an important resource for land management information, including the evolving best practices, emerging from ongoing research, on managing forestland in the face of EAB. Beginning in spring 2018, VLT foresters and ecologists have worked with scientists at Ecological Research Institute (ERI) to participate in their Monitoring and Managing Ash (MaMA) citizen science program. MaMA incorporates constructive steps for each stage of EAB invasion, from pre-invasion to aftermath forest, to help promote ash conservation in light of this invasive threat. In particular, it includes protocols that enable 1) documenting first detection and current status of EAB in a local area; 2) using the MaMA Monitoring Plots Network to assess local EAB-induced ash mortality in order to determine when areas throughout the network can be searched for lingering ash trees; and 3) reporting of lingering ash trees. In summer 2018, VLT foresters and ecologists set up plots in the MaMA Monitoring Plots Network on three pieces of conserved land in Arlington, Starksboro, and Williamstown. Plots are centered around ash swamps, but all also include trees in adjacent upland areas, and trees of multiple ash species. These are the first such plots in Vermont and are part of a larger VLT response to EAB. Additional information on the MaMA program can be found at MonitoringAsh.org.

Predicting impact of trails on wildlife in the Richmond Town Forest

Grace Glynn[1], Eric Hagen[1], Meridith Naughton[1]
[1]University of Vermont

The newly acquired Richmond Town Forest (428 acres), lying south of the town center and east of Route 2, adds to the already conserved 10,000-acre Chittenden Uplands forest. A town forest sub-committee was formed to oversee how the town forest should be used and two potentially conflicting interests of citizens dominated: mountain biking and wildlife protection. We (graduate students in the Field Naturalist Program) were asked to inventory the property this autumn and to assess the likely effects of a proposed trail system on the Forest's wildlife. Using field surveys, soil surveys, geology maps, and aerial photographs, we mapped the Forest and found significant natural communities including dry oak forests, seepage forest, and vernal pools. We also surveyed wildlife habitat in the Forest, focusing on forest structure, species composition, fruit and nut production, successional stage, and likely deer wintering yards. Of particular interest were use (or likely use) of the forest by black bear, bobcat, fisher and white-tailed deer. From our collective data sets, game camera footage, talking with hunters and other users of the property, and from consulting past research on the property, we identified the location of wildlife “hotspots”. We superimposed the proposed trail system on our map of wildlife hotspots and interpreted the potential impact on wildlife use in each specific location. The approach we employed, and how it could be used elsewhere, will be discussed.

Relationship between climate and growth for northern red oak (Q. rubra), eastern white pine (P. strobus), and eastern hemlock (T. canadensis) in northern Vermont

Kristen Switzer[1], Anthony D'Amato[1], Peter Clark[1]
[1]University of Vermont

The impacts of climate change on global ecosystems are becoming increasingly clear. Research consistently shows increasing global temperatures are affecting biodiversity, vegetation dynamics, oceans, and important environmental processes. This study examines how climate has influenced tree growth in northern Vermont over the last 100 years for three tree species, *Quercus rubra*, *Pinus strobus*, and *Tsuga canadensis*, in an attempt to understand how these species might respond to expected future shifts in temperature and precipitation. Increment tree cores for these species were collected in Jericho Research Forest and response function analysis was used to examine how temperature and precipitation patterns have affected their growth in this region of Vermont. The importance of precipitation and temperature in driving past growth varied between species. Precipitation only affected *Quercus rubra* growth, with strong positive correlations between growth rates and precipitation in June and July. Temperature was more important to the two conifer species examined (*Pinus strobus* and *Tsuga canadensis*), with the strongest correlations being negative correlations between growth and June temperature. *Pinus strobus* growth was also negatively correlated with October temperatures, whereas *Tsuga canadensis* growth was negatively correlated with the temperatures in May, July, and August. These results highlight the importance of diverse species forests in conferring resilience to future climate change, as these represent a range of potential climate responses and sensitivities. Findings indicate *Pinus strobus* and *Tsuga canadensis* may be most vulnerable to changes in future temperature regimes, particularly shifts towards warmer temperatures, whereas *Quercus rubra* demonstrated greater moisture sensitivity. Maintaining mixtures of these and other species may be an effective management strategy for ensuring a wide range of climate responses are present across the landscape. Future work on a wider range of sites and species will be critical for expanding the results of this study to the broader landscape of Vermont to inform conservation efforts and identify vulnerable trees species.

Ten-year regeneration and structural responses to patch selection with legacy retention in second-growth, northern hardwood forests

Emma Sass[1], Anthony D'Amato[1], Paul Catanzaro[2]
[1]University of Vermont
[2]University of Massachusetts

Late-successional forest is relatively uncommon across the New England landscape, but late-successional characteristics such as higher coarse woody debris (CWD) levels, diversity in tree species and sizes, and large trees are common management objectives. Patch selection using 0.12-ha openings was applied to a second-growth northern hardwood forest in western Massachusetts in 2007 in conjunction with different methods of increasing late-successional traits, including within-patch legacy tree retention and CWD creation. After 10 years, all of the harvested treatments had higher sapling density than the control (unharvested) plots. While there was no difference in sapling species diversity across treatments, yellow and black birch sapling densities were higher in the harvested plots. Mortality rate of legacy trees remained low across the measurement period at 2.0%, and growth of legacy trees averaged 0.004 m2/year. CWD levels remained significantly higher in patches with intentionally created downed wood. Combining larger group openings with structural retention may serve to increase structural diversity while also recruiting a diversity of tree species on sites with a high American beech component.

The DendroEcological Network

Shelly Rayback[1], Alexandra Kosiba[2], James Duncan[2], Paul Schaberg[3], Christopher Hansen[1,3], Paula Murakami[3], Gary Hawley[1], Jennifer Pontius[1], Rebecca Stern[1]
[1]University of Vermont
[2]Forest Ecosystem Monitoring Cooperative
[3]USDA Forest Service

In the context of a rapidly changing environment, there is an increasing need for large data networks to answer pressing questions and respond to new research priorities that span broad spatial and long temporal scales. The DendroEcological Network (DEN) is a collaboration among FEMC, University of Vermont and the USDA Forest Service to bring together tree ring and associated ecological data from sites across the northeastern forest. The study of tree rings and their associated metadata facilitate monitoring of long-term trends and annual conditions and link these to the physical, chemical and biological components of the forest ecosystem. The DEN provides an open centralized cyberinfrastructure for the discovery, exploration and sharing of dendroecological data by researchers, forest managers and the public for investigations of the past, present and future health of our forests and their management. This high quality and reliable network also multiplies the scientific value of an individual's research effort by facilitating greater discoverability and expansion of that data beyond its original purpose. For example, the ability to investigate ecological processes at different temporal and spatial scales is needed as certain dynamics are only interpretable in the context of larger scale and longer term biogeographical or climatic processes. We present snapshots of our work on red spruce recovery as an example of the power of this data network and suggest other lines of investigation and exploration that could be followed.

The difference of abundances and richness between two bays and an inland sea

Spencer Roberge[1], Melanie George[1], Connor Dunne[1], Declan McCabe[1]
[1]Saint Michael's College

Our focus with this project was to compare the abundance and richness of invertebrates in Lake Champlain's St. Albans Bay, Inland Sea, and Missisquoi Bay. Invertebrate populations make up much of the diversity within lake ecosystems. Determining the number of benthic invertebrate species in a lake system is one metric of overall ecosystem health. We used ponar dredges and a box corer to sample the Inland Sea (N = 229), Missisquoi Bay (N = 334) and Saint Alban's Bay (N = 129). A comparisons abundance and richness among the three sites were performed using single factor ANOVAs. I hypothesized that deeper bodies of water would have an overall lower number of diversity compared to shallower and potentially more productive habitats. I found that the data supported my hypothesis as the St. Albans Bay and Missisquoi Bay samples had higher species richness. The Inland Sea of Lake Champlain had a high abundance, but low richness which may well be explained by lack of light in the deeper benthic zone. The deeper water Inland Sea samples were dominated by zebra mussel and midges and there was reduced abundance of benthic periphyton grazers such as snails that tended to be common in Missisquoi Bay.

The Northeastern Forest Health Atlas: a compilation of aerial surveys and field datasets related to forest health in the northeastern U.S.

James Duncan[1,2], Emma Tait[1,2], **Alexandra Kosiba**[1,2], Jennifer Pontius[1,3]
[1]University of Vermont, Rubenstein School of Natural Resources and Environment
[2]Forest Ecosystem Monitoring Cooperative
[3]USFS Northern Research Station

The Northeastern Forest Health Atlas (NEFHA) is a compilation of contemporary and historic aerial survey data (1918-2016) and field datasets related to forest disturbance and health in the Northeastern US. NEFHA provides information on short- and long-term changes in forest health and disturbance to researchers, managers, policy makers, and the general public. The online NEFHA interface provides dynamic maps of forest damage collected from aerial surveys, as well as links to related forest health research. NEFHA users can filter by damage agent, damage type, state, and year, as well as view graphs and tables of disturbance patterns over time and download maps and data.

The Northeastern Fragmentation Information Network: a clearinghouse containing a wealth of various resources to understand and address forest fragmentation

James Duncan[1,2], **Alexandra Kosiba**[1,2], Mike Finnegan[1,2], John Truong[1,2]
[1]University of Vermont, Rubenstein School of Natural Resources and Environment
[2]Forest Ecosystem Monitoring Cooperative

The Northeast Forest Fragmentation Information Network (FragNet) is an information clearinghouse containing resources aimed at understanding and addressing forest fragmentation and parcelization in the northeastern US. FragNet makes it easier for researchers, land managers, policy makers, academics, and local governments to find and access all the available information on fragmentation occurring within their area of interest. In the initial pilot phase of FragNet, we focused on resources pertaining to the state of Vermont. With the initial framework built, we expanded FragNet to include other states in the northeast. Currently, FragNet houses nearly 300 resources that can be searched by type, topic, or primary purpose, as well as by location and time frame, facilitating access to information related to forest fragmentation.

The power of prioritization and volunteers: Approaches for mitigating the impacts of non-native invasive plants

Elizabeth Spinney[1], Heather Ewing[1], Lisa Thornton[1], Lina Swislocki[1]
[1]Vermont Department of Forests, Parks and Recreation

Being able to maintain resilient forests in the Northeast depends on addressing one of the most serious threats to natural ecosystems--invasive species. Climate change will continue to give these non-native species a competitive advantage and it is critical to put forth efforts to control their spread. In Vermont, the Department of Forests, Parks & Recreation is working to create model approaches for non-native invasive plant management prioritization of imperiled and sensitive areas, and for building capacity through a newly launched volunteer network and expansion of ongoing volunteer efforts.

Vermont Forest Indicators Dashboard: combining dozens of key datasets into a snapshot of the overall status of Vermont's forests

Jennifer Pontius[1,2,3], James Duncan[1,2], Alexandra Kosiba[1,2],
[1]University of Vermont, Rubenstein School of Natural Resources and Environment
[2]Forest Ecosystem Monitoring Cooperative
[3]USFS Northern Research Station

Ecological indicators are becoming commonly utilized to describe and monitor the status of complex ecosystems. Many policy-makers, educators, and managers have expressed a need for a comprehensive, yet dynamic assessment of the condition of the Vermont's forests. Recognizing this need, in 2015 a working group convened to identify key metrics and data aggregation methods for a data-driven group of indicators for Vermont's forests. The FEMC has led the development of the data aggregation and synthesis tool that resulted from this design effort, The Forest Indicators Dashboard. This tool is a dynamic, online, quantitative, systems-based assessment of the current status and long-term trends of Vermont's forested ecosystem. The resulting indicators provide a more holistic view of the structure, function, and services provided by forest ecosystems.

Vulnerability of forest ecosystems in New England and New York to climate change

Maria Janowiak[2,3], Tony D'Amato[1], Chris Swanson[2,3], Todd Ontl[2,4]
[1]University of Vermont, Rubenstein School of Natural Resources and Environment
[2]Northern Institute of Applied Climate Science
[3]USDA U.S. Forest Service
[4]USDA Northern Forests Hub

Forests are a defining landscape feature across New England and northern New York, covering more than 40 million acres from the coast of the Atlantic Ocean to the peaks of the Appalachian Mountains. The changing climate is altering the region's forests, and the foresters and other natural resource professionals working to keep the region's forest ecosystems healthy and productive are increasingly considering climate change in their work. The New England Climate Change Response Framework, a collective effort among dozens of scientists and natural resource professionals, has produced a new report that summarizes the best available information about climate change and regional forests based on published research, ecosystem models, and manager expertise. New projections of forest change from three forest impacts models--the Climate Change Tree Atlas, Linkages, and LANDIS PRO--were combined with a review of recent literature to understand the potential for forest change during the next century under different climate scenarios. An expert panel of research scientists and forest practitioners then worked together to consider this information, as well as their personal experience and expertise on local ecosystems, to assess the vulnerability of eight forest communities present across the region. Montane spruce-fir, low-elevation spruce-fir, and lowland mixed conifer forests were determined to be the most vulnerable to climate change. Lowland hardwood and riparian forests were assessed as being moderately vulnerable. Northern hardwood, transition hardwood, central hardwood-pine, and pitch-pine scrub oak forests were rated as having lower vulnerability to projected changes in climate. Projected changes in climate and their associated impacts and vulnerabilities will have important implications for ecologically and economically valuable forest types, forest-dependent wildlife and plants, recreation, and long-term natural resource planning.

Warblers and snakes: making the most of an agricultural past

Dylan O'Leary[1]
[1]The Nature Conservancy – Vermont Chapter

Forests are a defining landscape feature across New England and northern New York, covering more than 40 million acres from the coast of the Atlantic Ocean to the peaks of the Appalachian Mountains. The changing climate is altering the region's forests, and the foresters and other natural resource professionals working to keep the region's forest ecosystems healthy and productive are increasingly considering climate change in their work. The New England Climate Change Response Framework, a collective effort among dozens of scientists and natural resource professionals, has produced a new report that summarizes the best available information about climate change and regional forests based on published research, ecosystem models, and manager expertise. New projections of forest change from three forest impacts models--the Climate Change Tree Atlas, Linkages, and LANDIS PRO--were combined with a review of recent literature to understand the potential for forest change during the next century under different climate scenarios. An expert panel of research scientists and forest practitioners then worked together to consider this information, as well as their personal experience and expertise on local ecosystems, to assess the vulnerability of eight forest communities present across the region. Montane spruce-fir, low-elevation spruce-fir, and lowland mixed conifer forests were determined to be the most vulnerable to climate change. Lowland hardwood and riparian forests were assessed as being moderately vulnerable. Northern hardwood, transition hardwood, central hardwood-pine, and pitch-pine scrub oak forests were rated as having lower vulnerability to projected changes in climate. Projected changes in climate and their associated impacts and vulnerabilities will have important implications for ecologically and economically valuable forest types, forest-dependent wildlife and plants, recreation, and long-term natural resource planning.

What remote sensing tells us about the regions changing forests

Jennifer Pontius[1,3], David Gudex-Cross[1], Allison Adams[3]
[1]University of Vermont, Rubenstein School of Natural Resources and Environment
[2]University of Vermont, GUND Institute
[3]USFS Northern Research Station

Improvements in both sensor and computing technologies has allowed researchers to more closely examine historical changes in forest structure and function across the forested landscape. Here we highlight the findings of three recent papers that build off a 30+ year archive of satellite imagery to 1) quantify the extent and pattern of changes in forest cover, 2) track changes in tree species abundance across the landscape, and 3) document patterns in phenological events such as spring bud burst and fall senescence. Remote sensing products like these are essential to understand the potential drivers of change in the region's forests, identify locations or forest types particularly at risk, and inform the sustainable management of this critical resource at a time of rapid environmental change.

Images and Photo Credits

Cover Photo

Mt. Mansfield Summit. 2016. Photo by Diana Gurvich, FEMC.

Introduction

Jim Duncan, conference introductions. 2017. Photo by John Truong, FEMC.

Plenary Sessions

All photos from speaker presentations with the following exceptions:

Maria Janowiak. March 14, 2018. Photo by USDA U.S. Forest Service Northern Research Station. Accessed from https://www.nrs.fs.fed.us/people/mjanowiak .

Toni Lyn Morelli. 2016. Photo by Northeast Climate Adaptation Science Center. Accessed from https://necsc.umass.edu/people/toni-lyn-morelli .

Keith H. Nislow. Photo by USDA U.S. Forest Service Northern Research Station. Accessed from https://www.fs.fed.us/ne/amherst/staff/nislow.html .

Brook trout in cold water. May 31, 2011. Photo by U.S. Fish and Wildlife Service. Accessed from Flickr https://www.flickr.com/photos/usfwssoutheast/7725114898 and licensed under Attribution BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).

Summary of Working Sessions

Bird Conservation in the Year of the Bird:

John Lloyd. 2015. Photo by Vermont Center for Ecostudies. Accessed from https://vtecostudies.org/about-us/staff/john-lloyd/ .

By Land, Water, or Air: Invasive species management in a changing forest landscape

Emerald Ash Borer. August 10, 2010. Photo by U.S. Department of Agriculture. Accessed from Flickr (https://www.flickr.com/photos/usdagov/4878926306/) and licensed under Attribution-NoDerivs BY 2.0 license (https://creativecommons.org/licenses/by-nd/2.0/).

Managing Climate Change Impacts: What questions still remain?

Attendees participating in brainstorming activity. 2018. Amanda Mahaffey, Forest Stewards Guild.

Northeast Forests, Wildlife and Climate Change: Understanding impacts and planning for the future

Moose. September 27, 2013. Photo by Barbara Friedman. Accessed from Flickr (https://www.flickr.com/photos/btf5/10045645904/) and licensed under Attribution-NonCommercial BY 2.0 license (https://creativecommons.org/licenses/by-nc/2.0/).

Contributed Abstracts Session

All photos from speaker presentations with the following exceptions:

Distribution dynamics of mesocarnivore populations along trailing and leading edges in the northeastern U.S.

Canada Lynx Approaching. March 23, 2014. Photo by Eric Kilby. Accessed from Flickr (https://www.flickr.com/photos/ekilby/13360253515/) and licensed under Creative Commons BY 2.0 license (https://creativecommons.org/licenses/by/2.0/).

The Cost of Production in a Greening World

Paruline-bleue_Black-throated-Blue-Warbler_Neuville_MLP_DSC_3225. May 12, 2011. Photo by Jean-Pierre Marcil. Accessed from Flickr (https://www.flickr.com/photos/jpmarcil/5755309582/) and licensed under Creative Commons BY 2.0 license (https://creativecommons.org/licenses/by-nc-nd/2.0/).

Climate change effects on water quantity and quality in the Northern Forest

Melting. February 28, 2012. Photo by Irene Mei. Accessed from Flickr (https://www.flickr.com/photos/emyanmei/6959295521/) and licensed under Creative Commons BY 2.0 license (https://creativecommons.org/licenses/by-nc-nd/2.0/).

A simulation modeling approach to investigate hydrologic regime transformations following Eastern hemlock mortality

Eastern Hemlock. April 23, 2013. Photo by Jack Pearce accessed from Flickr (https://www.flickr.com/photos/jwpearce/8686103504/) and licensed under Creative Commons BY 2.0 license (https://creativecommons.org/licenses/by-sa/2.0/).

Managing invasive species in light of climate change

Late-Century Range of the Hemlock Woolly Adelgid. 2006. Photo from Confronting Climate change in the U.S. Northeast Science, Impacts, and Solutions. Accessed from (https://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/pdf/confronting-climate-change-in-the-u-s-northeast.pdf)

Forest Management on New York Wildlife Management Areas

A Very Young Oak. March 12, 2016. Photo by CameliaTWU. Accessed from Flickr (https://www.flickr.com/photos/cameliatwu/26011404582/) and licensed under Creative Commons BY 2.0 license (https://creativecommons.org/licenses/by-nc-nd/2.0/).

Long-term monitoring reveals forest community change driven by atmospheric deposition and contemporary climate change

Camels Hump from West I-89. Photo by Niranjan Arminius. Accessed from Flickr (https://www.flickr.com/photos/arminnius/23661922869/) and licensed under Creative Commons BY 2.0 license (https://creativecommons.org/licenses/by-sa/2.0/).

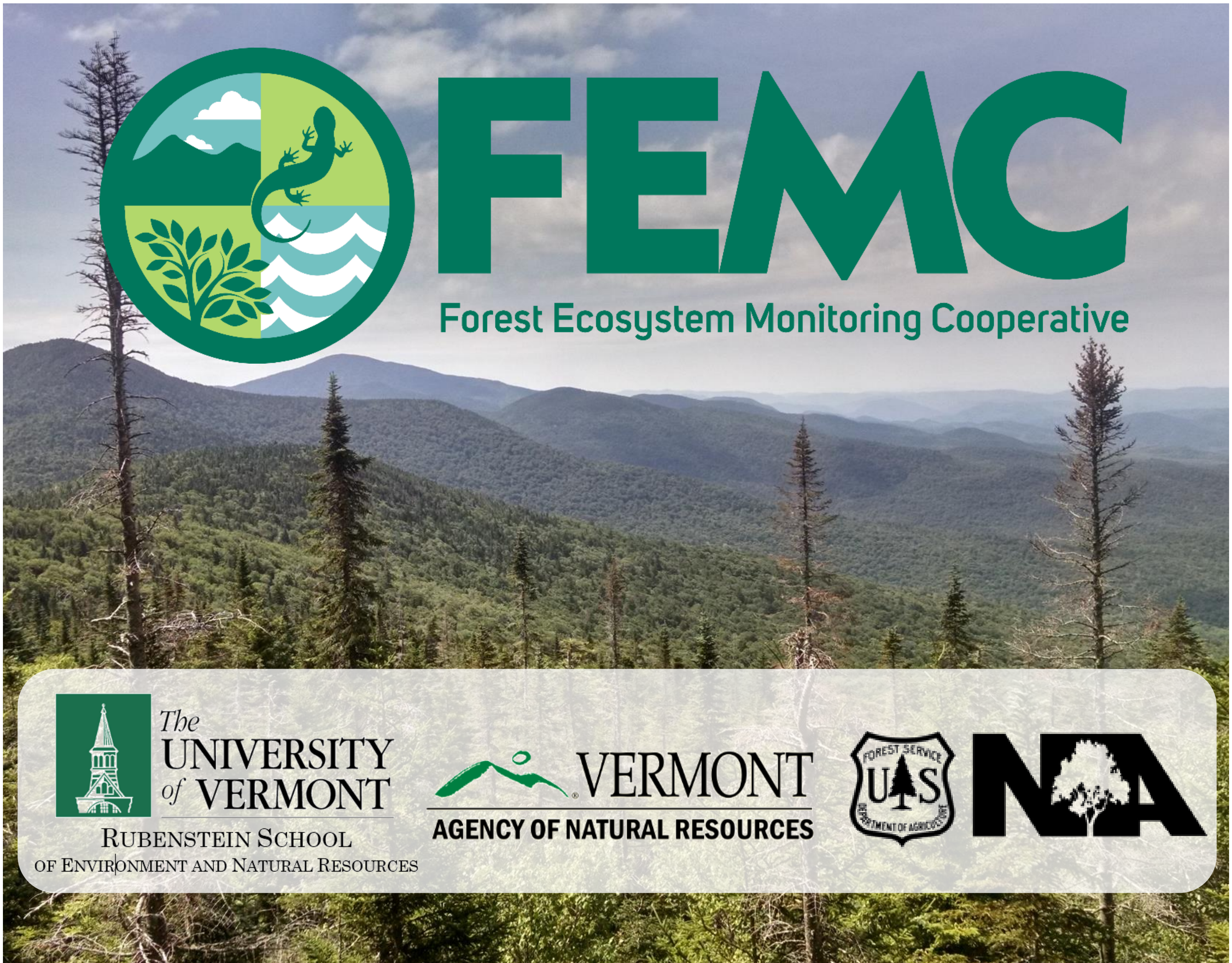
Forest Disturbance: There is more of it than you think

DJI_0123. Photo by Nick McMahon. Accessed from Flickr (https://www.flickr.com/photos/153133030@N05/29207449837/) and licensed under Creative Commons BY 2.0 license (https://creativecommons.org/licenses/by-nc-nd/2.0/).

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

Appendix: Agenda for 2018 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/2018/agenda



2018 Forest Ecosystem Monitoring Cooperative Conference

Forests and Climate Change: Managing impacts and planning for the future

December 14, 2018 – 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

Forests and Climate Change: Managing impacts and planning for the future

9:00 to 5:30, December 14, 2018

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 – 9:20 **Introduction and Welcome** *(Sugar/Silver Maple)*

9:20 – 10:30 **Plenary: Climate Change Impacts on Northeastern Forests, Water, and Wildlife** *(Sugar/Silver Maple)*

Confirmed speakers include:

Maria Janowiak, Deputy Director, Northern Institute of Applied Climate Science
What's at risk? Implications of climate change in our region's forests
The changing climate is altering the forests across the Northeast, leading natural resource professionals and woodland owners to learn how to evaluate risks for the lands that they own and manage and to prepare these systems for future conditions. This presentation will describe how climate change is expected to affect the 40 million acres of forest found in the region.

Toni Lyn Morelli, USGS Research Ecologist, DOI Northeast Climate Adaptation Science Center
Climate Change Vulnerability and Adaptation of Forest Wildlife
A synthesis of the impacts of climate change on the wildlife of northeastern forests, as well as what tools and products are available to aid in climate change adaptation.

Keith Nislow, Research Fisheries Biologist, USDA-Forest Service Northern Research Station
Water and aquatic ecosystems in a changing regional climate
This presentation will describe what we know about current and forecasted climate-driven changes in water quantity and quality, discuss how these effects translate into impacts on aquatic ecosystems, and demonstrate how existing and novel management and conservation approaches can help to reduce vulnerability to climate change along multiple resource dimensions.

10:30 – 10:50 **Coffee Break** *(Sugar/Silver Maple)*

10:50 – 12:10 Contributed Talks 1 *(Rooms listed below)*

SPECIAL TRACK: This track of talks continues throughout the day and connects to a working session in the afternoon.

Forests and Climate *Moderator: Maria Janowiak* *Room: Silver Maple*	**Wildlife and Climate** *Moderator: Toni Lyn Morelli* *Room: Chittenden Bank*	**Water and Climate** *Moderator: Kacey Clougher* *Room: Mildred Livak*	**Forest Health** *Moderator: Rebecca Stern* *Room: Frank Livak*	**Special Track** **Year of the Bird 1** *Moderator: John Lloyd* *Room: Jost Foundation*
Adaptive Silviculture for Climate Change: Examining strategies for adapting northern forests to global change *Peter Clark*	Quantifying the relative projected impacts of climate change and urban growth on the capability of the northeast to support wildlife *William V. DeLuca*	Climate change effects on water quantity and quality in the Northern Forest *Jamie Shanley*	Long-term bird monitoring in northeastern National Parks *Aaron Weed*	Forest Management on New York Wildlife Management Areas *Katherine Yard*
Vermont Agency of Natural Resources Guidelines for Implementing Assisted Migration of Plants on Agency Lands *Robert Popp*	Distribution dynamics of mesocarnivore populations along trailing and leading edges in the northeastern U.S. *Alexej P. K. Siren*	Tracking trajectories and sensitivities in forest water use *Mark Green*	Partnering with land managers to guide the search for EAB-resistant ash *Jonathan Rosenthal*	What do Woodland Owners in the Northeast Think of Bird Conservation? *Elizabeth Varanas*
Cold hardiness of American elm crosses bred for Dutch elm disease tolerance *Paul Schaberg*	A Slow Loss of Northern Forest Icons: Dynamics of Boreal Birds at the Edge of their Range in the Adirondack Park *Michale Glennon*	Effects of extreme high flow events on macroinvertebrate communities in Vermont streams *Jen Stamp*	Beaver Foraging Preferences and Impacts on Forest Structure in New York's Adirondack Mountains *Michael J Mahoney*	A New Paradigm for Forest Bird Conservation: A holistic approach to managing for multiple species guilds *Steve Hagenbuch*
Examining the future forest through tree seedling experiments *Nick Fisichelli*	The cost of reproduction in a greening world *Michael T. Hallworth*	A simulation modeling approach to investigate hydrologic regime transformations following Eastern hemlock mortality *Kanishka Singh*	Managing invasive species in light of climate change *Carrie Brown-Lima*	Forest bird conservation at Mass Audubon: the role of sanctuaries and private lands *Jeff Ritterson*

12:10 – 1:20 Lunch *(Sugar/Silver Maple)*

1:20 – 2:40 Contributed Talks 2 *(Rooms listed below)*

SPECIAL TRACK: This track of talks continues throughout the day and connects to a working session in the afternoon.

Forest Ecology *Moderator: Kacey Clougher* *Room: Frank Livak*	**Forest Monitoring** *Moderator: Adam Noel* *Room: Mildred Livak*	**Planning, Implementation, and Stakeholder Engagement** *Moderator: Alex Neidermeier* *Room: Chittenden Bank*	**Wildlife Monitoring** *Moderator: Brendan Case* *Room: Williams Family*	**Special Track** **Year of the Bird 2** *Moderator: John Lloyd* *Room: Jost Foundation*
Importance of woody debris dynamics in understanding the forest carbon cycle *Shawn Fraver*	What have we Learned from Monitoring Maine's Ecological Reserves? *Andy Cutko*	Progress Report: Aligning the Northeastern States Research Cooperative and Forest Ecosystem Monitoring Cooperative *Elissa Schuett*	Staying relevant: a cooperatively-designed online database to house natural resource survey data collected by citizen scientists *Jason Hill*	From keystone initiatives to landscape programs: a decade of investing in forest conservation for birds-outputs, outcomes and lessons learned *Scott Hall*
Major species of the Northern Hardwood forest: evaluating trends and environmental drivers of growth in the state of Vermont *Rebecca L. Stern*	Trends (?) in Exchangeable Cations after Fifteen Years into a 150-Year Soil Monitoring Study *Don Ross*	Young and Old Forest Targets for an Ecologically Functional Landscape *Bob Zaino*	Establishing Baseline Distribution Data on Vermont's Reptiles and Amphibians: The 2018 Maps and Species to Watch *Jim Andrews*	Bird Conservation on Commercial Forests in the Northern Forest *Henning Stabins*
Long-term monitoring reveals forest community change driven by atmospheric deposition and contemporary climate change *Brittany Verrico*	Forest disturbance: there is more of it than you think *Jarlath O'Neil-Dunne*	Flower Brook Watershed Phosphorus Mitigation: Landscape Assessment and Project Implementation *Hilary Solomon*	Using remote-triggered camera traps to describe patterns of mammal species richness and abundance in relation to anthropogenic and ecological factors *Alyssa Valentyn*	What remote sensing tells us about the regions changing forests *Alison Adams*
Ecosystem services and biodiversity as outputs of forest stand development in the American Northeast *Dominik Thom*	Tracking Parcelization Over Time to Inform Planning and Policy *Jamey Fidel*	Bringing Vermont Conservation Design to Private Landowners in the VT Coverts Cooperator Network: Strategies, Challenges, and Areas of Opportunity *Carolyn D. Loeb*	Monitoring the Effects of Prescribed Burns on Common Nighthawk and Eastern Whip-poor-will Populations in New Hampshire's Ossipee Pine Barrens *Jason Mazurowski*	Using citizen science data in integrated population models to inform conservation *Orin Robertson*

2:40 – 3:00 Coffee Break *(Silver Maple)*

3:00 – 4:30 Working Groups *(Rooms listed below)*

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:

By Land, Water, or Air: Invasive Species Management in a Changing Forest Landscape
Organizer: Joanne Garton, Vermont Forests, Parks, and Recreation
Location: Chittenden Bank

Managing Climate Change Impacts: What Questions Still Remain?
Organizer: Maria Janowiak, Northern Institute of Applied Climate Science
Location: Mildred Livak

Northeastern Forest, Wildlife, and Climate Change: Understanding Impacts and Planning for the Future
Organizer: Toni Lyn Morelli, USGS – Northeast Climate Adaptation Science Center
Location: Frank Livak

Special Track Bird Conservation in the Year of the Bird
Organizer: John Lloyd, Vermont Center for Ecostudies
Location: Jost Foundation

Data Scavenger Hunt and Lawn Game Social: Explore FEMC Tools, Play Games, Meet People
Organizer: FEMC Staff
Location: Sugar Maple Ballroom

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

Enjoy conversation, over 20 posters and a cash bar (21 and over only please) at the end of the day. Poster titles are listed at the end of the agenda.

Working Group Descriptions

By Land, Water, or Air: Invasive Species Management in a Changing Forest Landscape
Organizer: Joanne Garton, Vermont Forests, Parks and Recreation
Location: Chittenden Bank

From our backyards to our backwoods, invasive plants and insects have found permanent homes in Vermont's forested landscapes. While invasive species are not a new topic for forest land managers, the list of invasive plant and insect species present in Vermont grows each year. Human movement, climate change, and related landscape-scale disturbances serve to exacerbate the spread and longevity of invasive species.

Join our panel of invasive species experts as they address the whys and hows of invasive species management across physical and regulatory landscapes. Using example project sites currently under state management, this workshop will address how the treatment of one invasive species may affect the spread of another, who can control these treatments, and what landowners and land managers need to create and implement invasive species management plans in Vermont's changing landscape.

Managing Climate Change Impacts: What Questions Still Remain?
Organizer: Maria Janowiak, Northern Institute of Applied Climate Science and Amanda Mahaffey, Forest Guild
Location: Mildred Livak

Climate change is a game-changing issue for the region's forests, and we all have a stake in maintaining their health over the long-term. A tremendous amount of scientific information has been produced in recent years, which is providing important information to natural resource managers in adapting forests to climate change. At the same time, many questions still remain. More science is needed to address managers' specific challenges in different parts of New England. This working group session will facilitate discussion among research scientists and forestry professionals to identify what science is most needed and help answer key management questions. The outcomes of this session will inform a broader effort by the Northern Institute of Applied Climate Science and Forest Stewards Guild to enhance the community of practice around the topic of forest adaptation.

Northeastern Forest, Wildlife, and Climate Change: Understanding Impacts and Planning for the Future
Organizer: Toni Lyn Morelli, USGS - Northeast Climate Adaptation Science Center
Location: Frank Livak

As global change complicates forest and wildlife management, better understanding of the impacts and potential responses are needed. From a regional perspective of predictions of land use and climate change on species distributions, to a multi-state perspective on carnivore and hare population dynamics, to a long-term look at bird responses on the Hubbard Brook Experimental Forest, this session will focus on the latest research on how climate change is impacting forest birds and mammals in the northeastern U.S. and provide examples of how this research can be used to aid management and conservation decisions.

Working Group Descriptions Continued

Special Track Bird Conservation in the Year of the Bird

Organizer: John Lloyd, Vermont Center for Ecostudies

Location: Jost Foundation

Conservation of forest birds in the Northeast is a highly decentralized practice carried out by a host of groups, each with its own thematic and geographic focus. The populations we seek to conserve face a common suite of threats, and our organizations and agencies face a common set of challenges as we seek to implement effective conservation measures, yet we have few opportunities to learn from one another and to reflect on the state of our efforts.

In this Year of the Bird, we propose a special session on forest-bird conservation at the annual conference of the Forest Ecosystem Monitoring Cooperative. In doing so, we seek to offer a forum for sharing information on what works in bird conservation and for collectively identifying key knowledge gaps that hinder our collective efforts. The goal of the working session is to produce a consensus statement on the state of the practice and science of bird conservation across the Northern Forest. Working both in plenary and in topically focused breakout groups, we will answer the following questions:

Do our existing monitoring systems allow us to manage forest-bird populations adaptively? Are our current conservation solutions adequate in the short term (20 years), and how confident are we in our assessment? Are our current conservation solutions likely to prove adequate in the longer term (beyond 20 years), and how confident are we in our assessment? What information do conservation practitioners or policy-makers need, and how can scientists design research to provide it?

Data Scavenger Hunt and Lawn Game Social: Explore FEMC Tools, Play Games, Meet People

Organizer: FEMC Staff

Location: Sugar Maple

How many sugar maple cores are in the DendroEcological Network? How much forest tent caterpillar defoliation was mapped between 2002 and 2008? How acidic is precipitation in Vermont? Go on a scavenger hunt for these and more answers using FEMC tools, and reward yourself with a game of ladder ball, cornhole or bocce. This is a low-key time to learn more about some of the data-driven tools FEMC has developed and socialize with FEMC staff and your peers at the conference.

Poster Titles and Presenters

Abstracts available online - https://www.uvm.edu/femc/cooperative/conference/2018/agenda

12-year forest trends in Acadia National Park
Presenter: Aaron Weed, *National Park Service, Northeast Temperate Inventory and Monitoring Network, Woodstock, VT*

2018 Forest Ecosystem Monitoring Cooperative Partner Projects
Presenter: Forest Ecosystem Monitoring Cooperative

26 Years of FEMC's Annual Forest Health Monitoring Program in Vermont
Presenter: Josephine Robertson and Steve Rotella, *University of Vermont, Rubenstein School of Environment and Natural Resources and Forest Ecosystem Monitoring Cooperative*

Air temperature and humidity along an elevation gradient at Camel's Hump State Park, Vermont
Presenter: John R. Butnor, *USDA Forest Service*

Assessment of Root System Quality in Container Grown Trees
Presenter: Marie V. Ambusk, *Co-Founder*

Bumble Bee (Bombus) Distribution and Diversity in Vermont, USA: A Century of Change
Presenter: Kent P. McFarland, *Vermont Center for Ecostudies*

The DendroEcological Network
Presenter: Shelly A. Rayback, *Department of Geography, University of Vermont*

The Difference of Abundances and Richness between two bays and an inland sea
Presenter: Spencer Roberge, *Student from Saint Michael's College*

Effects of fallen trees on wildlife species richness and abundance in the Saint Michael's College Natural Area
Presenter: Risa Berman and Lauren Dunn, *Saint Michael's College*

Long Term Trends in the Density of Mayflies in the Middlebury Area.
Presenter: Vickie Backus, *Middlebury College*

Modeling the effects of global change and associated adaptive silvicultural systems in Northern New Hampshire
Presenter: Jennifer Santoro, *University of Vermont*

Monitoring ash on conserved lands in Vermont: Partnerships and potential for resilient
Presenter: Allaire Diamond, *Vermont Land Trust*

The Northeastern Fragmentation Information Network: a clearinghouse containing a wealth of various resources to understand and address forest fragmentation
Presenter: John Truong, *Forest Ecosystem Monitoring Cooperative*

Poster Titles and Presenters Continued

The Northeastern Forest Health Atlas: A compilation of aerial surveys and field datasets related to forest health in the northeastern U.S.
Presenter: Alexandra Kosiba, *Forest Ecosystem Monitoring Cooperative*

The Power of Prioritization and Volunteers: Approaches for mitigating the impacts of non-native invasive plants
Presenter: Elizabeth Spinney, *Vermont Department of Forests, Parks & Recreation*

Relationship Between Climate and Growth for Northern Red Oak (*Q. rubra*), Eastern White Pine (*P. strobus*), and Eastern Hemlock (*T. canadensis*) in Northern Vermont
Presenter: Kristen Switzer, *University of Vermont*

Ten-year regeneration and structural responses to patch selection with legacy retention in second-growth, northern hardwood forests
Presenter: Emma Sass, *University of Vermont*

Vermont Forest Indicators Dashboard: Combining dozens of key datasets into a snapshot of the overall status of Vermont's forests
Presenter: James Duncan, *Forest Ecosystem Monitoring Cooperative*

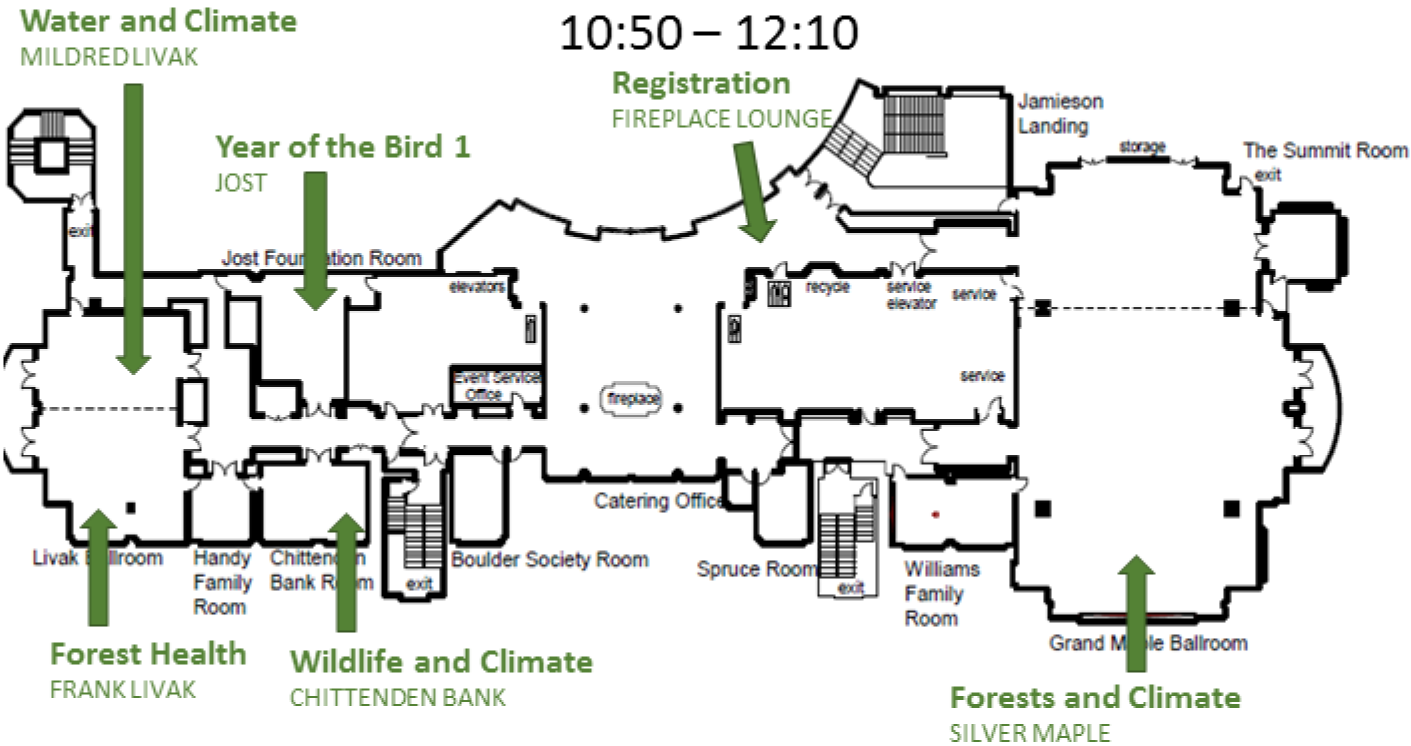
Vulnerability of Forest Ecosystems in New England and New York to Climate Change
Presenter: Maria Janowiak, *Northern Institute of Applied Climate Science, US Forest Service*

Warblers and Snakes: Making the Most of an Agricultural Past
Presenter: Dylan O'Leary, *TNC-VT Americorps Land Steward*

What remote sensing tells us about the region’s changing forests
Presenter: Jennifer Pontius, *UVM and USFS NRS*

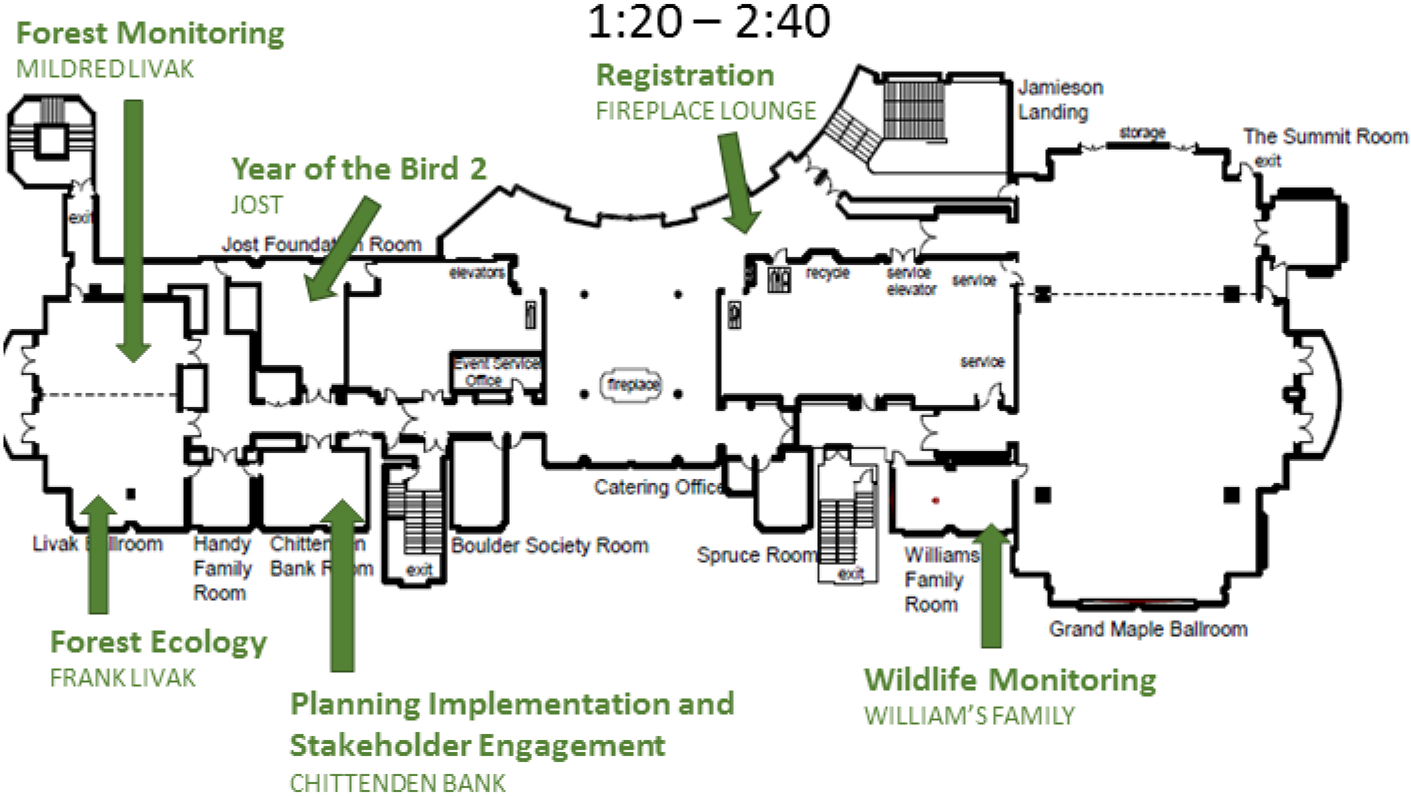
Room Assignments for Contributed Talks Session 1

10:50 – 12:10



Room Assignments for Contributed Talks Session 2

1:20 – 2:40



Room Assignments for Working Groups and Poster Session

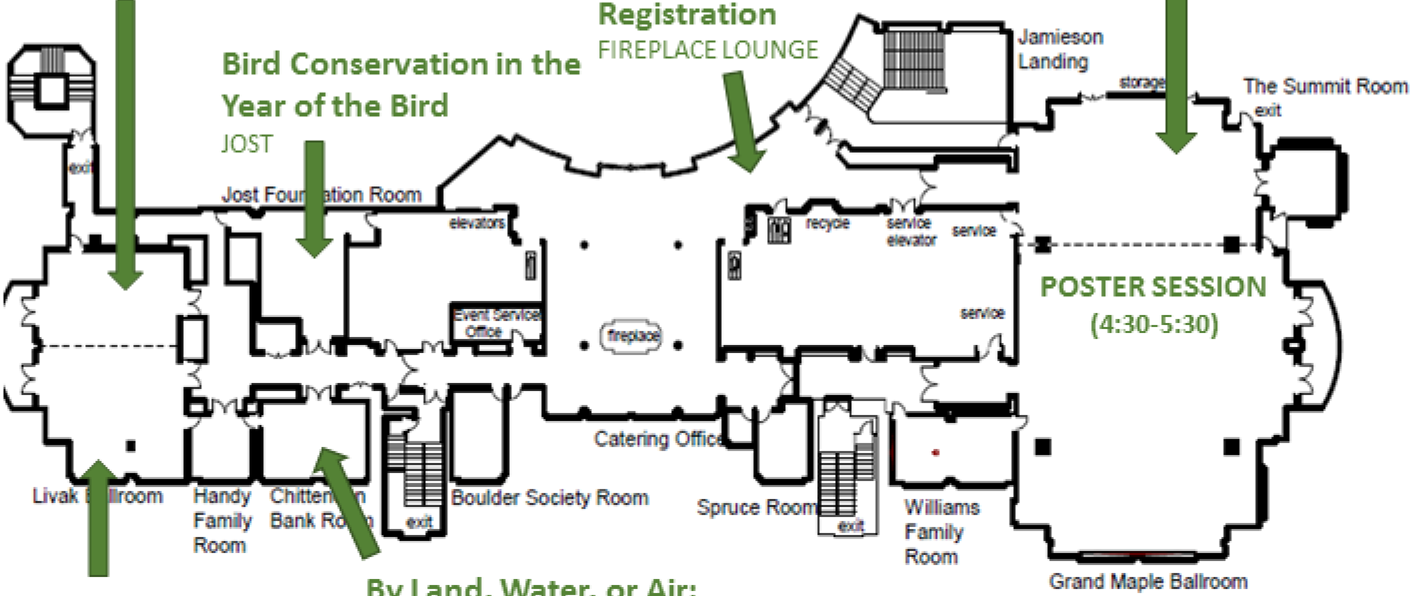
3:00 – 5:30

Managing Climate Change Impacts: What questions still remain?
MILDRED LIVAK

Data Scavenger Hunt and Lawn game social: Explore FEMC Tools, Play Games, Meet People
SUGAR MAPLE

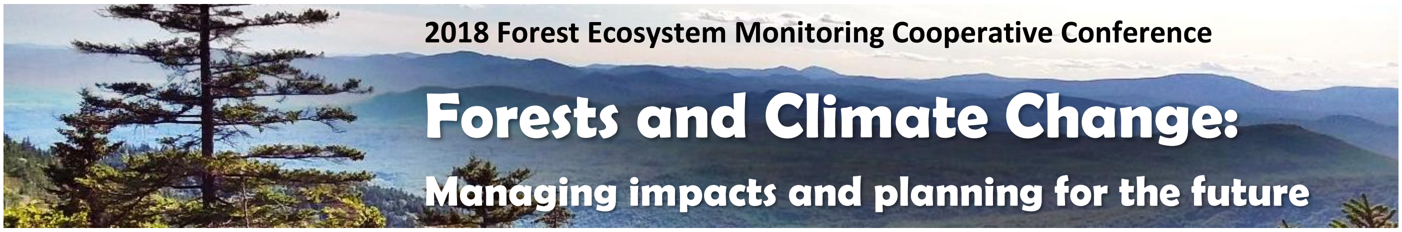
Registration
FIREPLACE LOUNGE

Bird Conservation in the Year of the Bird
JOST



Northeastern Forest Wildlife and Climate Change: Understanding impacts and planning for the future
FRANK LIVAK

By Land, Water, or Air: Invasive Species Management in a Changing Forest Landscape
CHITTENDEN BANK



VERMONT CENTER FOR ECOSTUDIES
Uniting People and Science for Conservation

FEMC
Forest Ecosystem Monitoring Cooperative

Bird conservation in the Year of the Bird

A special track at the annual Forest Ecosystem Monitoring Cooperative Conference

Burlington, Vermont
December 14, 2018

Organized by:

John D Lloyd, Vermont Center for Ecostudies
jlloyd@vtecostudies.org

Jim Duncan, Forest Ecosystem Monitoring Cooperative
james.duncan@uvm.edu

Problem statement

Conservation of forest birds in the Northeast is a highly decentralized practice carried out by a host of groups, each with its own thematic and geographic focus. The populations we seek to conserve face a common suite of threats, and our organizations and agencies face a common set of challenges as we seek to implement effective conservation measures, yet we have few opportunities to learn from one another and to reflect on the state of our efforts.

In this Year of the Bird, we are hosting a special track on forest-bird conservation at the annual conference of the Forest Ecosystem Monitoring Cooperative, held at the University of Vermont on December 14th (https://www.uvm.edu/femc/cooperative/conference/2018/). In doing so, we seek to offer a forum for sharing information on what works in bird conservation and for collectively identifying key knowledge gaps that hinder our collective efforts.

Agenda and Topics

The track will include 8 invited talks by scientists and conservation practitioners from around the region. Speakers will be drawn from a variety of disciplines and will represent a range of stakeholders. Topics will include a gap analysis of regional monitoring efforts, a review of key threats facing bird populations in the forests of New York and New England, examples of conservation interventions, and trends in some of the key drivers of change for forest birds.

These talks will set the stage for a working session that will round out the day's activities. The goal of the working session is to produce a consensus statement on the state of the practice and science of bird conservation across the Northern Forest. Working both in plenary and in topically focused breakout groups, we will answer the following questions:

- Do our existing monitoring systems allow us to manage forest-bird populations adaptively?
- Are our current conservation solutions adequate in the short term (20 years), and how confident are we in our assessment?
- Are our current conservation solutions likely to prove adequate in the longer term (beyond 20 years), and how confident are we in our assessment?
- What information do conservation practitioners or policy-makers need, and how can scientists design research and monitoring programs to provide it?

Target audience

A key goal for the proposed track on forest-bird conservation is to bring together diverse perspectives on the conservation of forests and forest birds, and to use this diversity of experiences and outlooks to collectively generate an action-oriented framework for coordinated regional conservation, research, and monitoring. With this in mind, we actively seek participation from:

- Conservation scientists
- State and Federal wildlife and forestry agencies
- Consulting foresters
- Forest ecologists
- Land-use planners
- Forest-products industry
- Small woodlot owners
- Land trusts and other conservation practitioners

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