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

Vermont Monitoring Cooperative

Proceedings of the December 12, 2013 Vermont Monitoring Cooperative Conference

New Collaborations for Emerging Forest Needs

Vermont Monitoring Cooperative

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

The Vermont Monitoring Cooperative (VMC) was established in 1990. In 1996, a memorandum of understanding was signed by the Vermont Agency of Natural Resources, the University of Vermont, and USDA Forest Service outlining the roles and responsibilities of each partner.

The partners agreed to work together to operate VMC to better coordinate and conduct long-term natural resource monitoring and research within Mount Mansfield State Forest, the Lye Brook Wilderness Area of the Green Mountain National Forest, and other relevant areas in Vermont.

The Vermont Monitoring Cooperative works in partnership with the USDA Forest Service State & Private Forestry as part of the Cooperative Lands Forest Health Management Program. The majority of VMC operations are handled by staff affiliated with the Rubenstein School of Environment and Natural Resources at the University of Vermont, the Vermont Department of Forests, Parks & Recreation in the Vermont Agency of Natural Resources, and the USDA Forest Service's Green Mountain National Forest.

Online at http://www.uvm.edu/vmc

VMC Steering Committee and Advisory Committee – http://www.uvm.edu/vmc/about/committees.php

VMC staff – http://www.uvm.edu/vmc/about/contactus.php

VERMONT AGENCY OF NATURAL RESOURCES

The University of Vermont

USDA FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Proceedings of the December 12, 2013 Vermont Monitoring Cooperative Conference

New Collaborations for Emerging Forest Needs

Published February 20, 2014

From material presented at the Vermont Monitoring Cooperative Conference
December 12, 2013
Davis Center
University of Vermont
Burlington, VT, USA

Contributing Editors: Jennifer Pontius, James Duncan, Miriam Pendleton, Judith Rosovsky and Carl Waite

Acknowledgments: The Vermont Monitoring Cooperative would like to thank everyone who participated in the planning and production of this conference, from those who coordinated all of the details behind the scenes, to our speakers and workshop participants who made the meeting such a success. This conference would not have been possible without the continued support from the Vermont Department of Forests, Parks and Recreation, the US Forest Service Northeastern Area State and Private Forestry, and the University of Vermont. Thank you especially to Steve Sinclair for moderating the morning session, the Rubenstein School of Environment and Natural Resources for helping to provide lunch, the University of Vermont for the use of the Davis Center, and the Media Services Center at the Bailey-Howe Library for audiovisual equipment. In addition, VMC would like to acknowledge the efforts of Rich Poirot from the Vermont Department of Environmental Conservation, Nathan Reigner from the Rubenstein School, and Sandra Wilmot from the Vermont Department of Forests, Parks and Recreation for their time and effort in helping to plan the conference.

Preferred Citation: Pontius, J., J. Duncan, M. Pendleton, J. Rosovsky, and C. Waite (Eds.) 2014. Proceedings of the December 12, 2013 Vermont Monitoring Cooperative Conference: New Collaborations for Emerging Forest Needs. Burlington, VT, Vermont Monitoring Cooperative. Available online at http://www.uvm.edu/vmc/annualMeeting/2013/proceedings.php.

Cover Photo: Flowering birch tree by Sandra Wilmot.
Hub Vogelmann Dedication Photos: Hub Vogelmann profile picture from the Nature Conservancy; Camel's Hump Fall Scene by Timothy Perkins, Proctor Maple Research Center.
Lawrence Forcier Recognition Photo: Rubenstein School of Environment and Natural Resource, University of Vermont.

Dedicated to the Memory of Hub Vogelmann

The Vermont Monitoring Cooperative dedicates these proceedings to the memory of Dr. Hubert "Hub" Vogelmann, a much respected teacher, conservation leader and pioneer in studying the effects of acid rain deposition in Vermont's forests. During the conference, a remembrance of Dr. Hub Vogelmann was given by Dr. Timothy Perkins, Director of the Proctor Maple Research Center, who had worked with Hub for many years. Tim recalled that Hub and his graduate students spent over a decade studying the effects of acid rain transport in Vermont. He brought national attention to the importance of cloud water chemistry and the perturbations caused by low pH to tree growth, health and survival, especially in red spruce growing on Camel's Hump. His efforts at the national level eventually helped bring about passage of the federal Clean Air Act Amendments in 1990 specifically addressing acid rain impacts to forested ecosystems.

Hub's actions locally led to the creation of the Field Naturalist Program at the University of Vermont, which continues to educate and train future conservation leaders. He was co-founder of the first Vermont branch of The Nature Conservancy, volunteering his time, including time as chairman, helping The Nature Conservancy, the State of Vermont, and many other groups to protect hundreds of thousands of acres of important natural areas across the state. Hub's other crusades included leading the acquisition of the first parcel of land at the Shelburne Pond Natural Area and a leading role in the creation, in 1970, of Act 250, Vermont's nationally important land-use law. Throughout his career, Hub served on many environmental boards including the Governor's Advisory Board under Governor Howard Dean. Hub was also instrumental in the establishment of air quality monitoring at the VMC intensive monitoring site located at the Proctor Maple Research Center. An early adopter of interdisciplinary thinking, his vision for rigorous forest health monitoring in the 1980s led to the establishment of the VMC. His contributions to the field will live on and continue to inspire us in our work for years to come.

Recognition of Lawrence Forcier

The VMC staff wishes to recognize Lawrence K. Forcier for his leadership and insight over the past seven years. Larry stepped into the leadership role during a time of rapid turnover in VMC's senior administration, and provided direction and a renewed sense of purpose to the organization. During Larry's tenure as "Principal Investigator", the VMC and its cooperating scientists produced a multi-disciplinary synthesis report on the status of Vermont's forested ecosystems, based on VMC data. VMC also solicited proposals through an RFP to examine forest growth at the Mt. Mansfield intensive site using both existing VMC and newly collected data. Larry felt that it was essential to VMC's mission for us to know how well Vermont's forests were growing. Through Larry's efforts, membership of both our Steering and Advisory Committees was broadened, thus strengthening representation across disciplines and agencies. VMC offices were relocated to the Aiken Forestry Sciences Lab on Spear Street, and our connections to the Rubenstein School and City of Burlington were strengthened when Larry mobilized his NR-1 students to establish urban forest monitoring plots in Burlington. This service learning course brought together forestry measurement skills being developed by students with a specific need in the Burlington community.

In the early 1990s, Larry was part of the group of forestry professionals, scientists and policy makers, along with then Governor Madeleine Kunin, who realized that there were imminent threats to Vermont's forests which were poorly understood. There was an urgent need for long-term data to help address and, hopefully, mitigate these threats. Working with people from many different spheres, Larry helped to launch the VMC. His direct involvement later waned over time until 2008 when Larry took the helm of the VMC. He obviously had a soft spot for us as was demonstrated by his willingness to work on our behalf for no salary. His good humor and insightful approach to building strong collaborations has strengthened the VMC. His dedication to the organization and its mission has been instrumental in the long-term success of this organization.

> *"The VMC Steering and Advisory Committees express our appreciation to Lawrence Forcier for his years of service, many of them in VMC's formative years, and his dedication to VMC and Vermont's forested ecosystems."*

Table of Contents

Introduction

The Vermont Monitoring Cooperative (VMC) held its annual meeting on December 12, 2013 at the Davis Center on the University of Vermont Campus. The Conference theme, ***New Collaborations for Emerging Forest Needs,*** was in direct response to recent conversations across the state among state, federal and academic partners eager to increase collaborations. In a time of merging stresses on forested ecosystems and tight fiscal budgets, it has become clear that we need to encourage collaboration across disciplines and organizations, use those collaborations to expand the scope and impact of our collective work, while finding synergies and efficiencies in our efforts. From a morning plenary session of invited talks on key challenges facing state and federal natural resource managers, to contributed talks diving into the latest forest ecosystem findings, and afternoon work sessions to facilitate collaborations around key projects of interest to VMC collaborators, the conference provided a range of opportunities for networking and learning across disciplines and organizations.

These proceedings represent a combination of presentation summaries written by VMC staff, syntheses and products from a series of afternoon working sessions, and abstracts submitted by researchers studying forest ecosystems in Vermont.

Figure 1. Stream on the eastern slopes of the Green Mountains, Vermont. Photo credit: Vermont Monitoring Cooperative.

Invited Presentations from State, Federal and University Leadership

Keynote Address: Building a Vermont forest research network – The need for increased coordination and cooperation among disciplines and across organizations

Jon Erickson, Interim Dean of the Rubenstein School of Environment and Natural Resources, UVM

Dr. Jon Erickson introduced the topic of collaboration by highlighting the obvious; everyone agrees that collaborations can be productive and are integral to meaningful work. But a quick poll of the audience about existing barriers to collaboration solicited many responses such as: too little time and money, reluctance to leave one's "silo", lack of communication, too much distance, and different organizational goals.

Reasons not to collaborate

This led into the heart of Erickson's discussion where he presented his top ten reasons that collaborations are not emphasized more, and a rebuttal to each. The top ten list began with the common opinion that **we collaborate enough already**. He urged the audience to go a step beyond the basic connections (i.e. attending meetings) and urged them to "walk the walk" when it comes to collaboration. The next reason laid the blame squarely on our institutional cultures with its **"winner takes all" mentality**. The competitive environment that permeates our culture creates the feeling that "second place is the first loser". From early on we are trained to compete for grades, for jobs and for funding, making collaboration a foreign concept. People are also reluctant to collaborate because they feel that **breadth comes at the expense of depth.** Erickson made the case that one can be both broad and deep; that we need "more T-shaped people" and that the time for working in isolation on one's own little area of expertise has passed. Further, because it is difficult to step out of the area of one's expertise, it can be uncomfortable to leave **the comfort of the comfort zone** by working outside your traditional area. Another challenge is the reluctance of scientists to make unequivocal statements or state their opinions about controversial issues. Instead falling back on the refrain that **more study is required.** Holding out for such definitive results can stymie natural extensions and applications of their work, making "perfect" the enemy of the good. At some point, conclusions need to be made. Finally, Dr. Erickson pointed out that there are **few incentives** for increasing communication and collaboration, as the current structure does not incentivize or reward the additional

> *"We are entering an era of post-normal science, with a sample size of one (the planet Earth), where objective distance is a luxury"*
>
> *~ Dr. Jon Erickson*
>
> *Interim Dean, Rubenstein School of Environment and Natural Resources, University of Vermont*

effort that is necessary to establish and maintain productive collaborations.

Dr. Erickson also noted the cultural **science – policy gap** as a huge obstacle to transferring science into meaningful action. Science is complicated and difficult to explain to decision makers because the two cultures are quite different. To illustrate this common divide, Dr. Erickson exemplified the sometimes opposing worldviews of the two groups (Figure 2); from their tolerance of uncertainty to different operating time frames. Part of this dichotomy in world views is the common conception that scientist's must maintain **objective distance**, staying clear of policy to maintain unbiased purity. The divide between the **two cultures** of the humanities and science disciplines, first highlighted by C.P. Snow in 1959[1], is still observable when one examines the training of today's congressional leaders. Most are trained in business, law or the humanities, with only a rudimentary academic exposure to science, and as such often view science with distrust. In the US congress 478 members had humanities-based educations while only 54 had any kind of science-based educations[2]. Last on Erickson's list, but the number one reason for not collaborating and communicating more was that we are all **too busy.** While this is true, it suggests that perhaps what is needed is a reprioritization of how we spend our time. This would require a change in the structure of academia and government institutions alike, including how collaborations are facilitated and how we are evaluated for our efforts.

Science	Government
Probability accepted	Certainty desired
Inequality is a fact	Equality is desired
Anticipatory	Time ends at next election
Flexibility	Rigidity
Problem oriented	Service oriented
Discovery oriented	Mission oriented
Failure and risk accepted	Failure and risk intolerable
Innovation prized	Innovation suspect
Replication essential for belief	Beliefs are situational
Clientele diffuse, diverse or not present	Clientele specific, immediate, and insistent

Figure 2. Recreated from: Bradshaw, G. A. and J. G. Borchers. 2000. Uncertainty as information: narrowing the science-policy gap. Conservation Ecology 4(1): 7.

Turning Barriers into Opportunities

To that end, Erickson enumerated changes to the "top ten" list that would promote collaboration; starting by expanding our existing collaborative associations into **genuine collaborations,** where collaborating is done up front to define research goals, write proposals and communicate with stakeholders so that they are a part of the team from the beginning rather than passively waiting for the "answer". Instead of competition, he suggested **co-opitition,** a catchy phrase to capture the spirit of efforts where competition and cooperation work together to ensure high quality work, while expanding the breadth and impact of work. This could be achieved through collaborative proposal development, where collaborative groups compete in limited, beneficial competitions to develop more integrative ideas.

This approach works well in the **new age of synthesis** currently evolving. Instead of endless study in an attempt to establish certainty, Erickson proposed a focus on **building wisdom** through a willingness to make statements about implications of scientific outcomes without waiting years for absolute certainty. In an era where we are awash in information, Erickson listed several examples of organizations that synthesize information to make it understandable, using a "confluence of evidence" to support meaningful interpretation of results.

---

[1] Snow, C. P. (1959). *The two cultures and the scientific revolution*. New York, Cambridge University Press.
[2] From Congressional Research Service, Bureau of Labor Statistics and US Census Bureau data, as presented by Dr. Erickson.

In order to promote collaboration and sharing of the scientific data and expertise required for broad syntheses, there needs to be **group incentives** to reward such activities. This could be as simple as providing travel and meal stipends to encourage communication, or as structured as including collaborative activities in employee reviews. To encourage leaving the comfort of the comfort zone, Erickson suggested creating safe **innovation spaces** using the business incubator model. He suggested extending this to physical locations such as the Jericho Research Forest to encourage joint meetings and projects. In an era of shrinking staff and increasing stressors on ecosystems, **changing priorities** is the necessary response, making time to emphasize collaboration and share resources.

> *The world henceforth will be run by synthesizers, people able to put together the right information at the right time, think critically about it, and make important choices wisely.*
>
> *~ E.O. Wilson*
>
> *Consilience, 1998*

In order to bridge the science-policy gap, Erickson suggested that more "**action research"** is needed. Scientific inquiries, from monitoring efforts, to basic research and even graduate theses, must have identified actionable outcomes. The researcher needs to emerge from the ivory tower and participate in the community. This is particularly important because we are entering an era of **post-normal science,** with a sample size of one (the planet Earth), where objective distance is a luxury. Post-normal science challenges our notions of who speaks with authority, what kind of information is needed and acceptable, and how much information is enough. We are in a new geological epoch, and we need to be **educating for the Anthropocene** to bridge the divide between the sciences and the humanities and ensure that the findings of our work can be translated into positive action on the ground.

Erickson closed by pointing out that all of the "required ingredients" are currently in place to make this happen. Many of us are already involved in long-standing and productive collaborations, but we could do more and do it more effectively. We have the infrastructure but need to capitalize on it by pooling the resources of universities, agencies, organizations, extension, properties, and laboratories. We need to work with the datasets we have to narrow the chasm between social and natural sciences. There is a willingness to collaborate, and Vermont is the prime place to make this happen.

Ryan Hanavan, Forest Entomologist, USDA Forest Service

> *"[We need to] get out front and stay out front because a lot of these [forest pests] are already ahead of us…."*
>
> *~ Dr. Ryan Hanavan*
>
> *Entomologist, USDA Forest Service*

Ryan Hanavan is a Forest Entomologist with the USDA Forest Service's Forest Health Protection Program for the Northeastern Area, in Durham NH. Dr. Hanavan's responsibilities include the annual aerial detection survey and the development and coordination of all aspects of major forest insect detection, evaluation, prevention, and suppression programs across Vermont's national forest lands. Dr. Hanavan's talk highlighted both the principal threats to forest ecosystem health in the region and the many federal activities and tools available to support land managers, researchers, and decision makers in sustaining forests across Vermont.

When questioned on the primary threat to Vermont's forested ecosystems, Hanavan's response was "all of them". While invasive pests (e.g. emerald ash borer, hemlock woolly adelgid, Asian longhorned beetle) often top the list, it is the need for coordinated monitoring and treatment that are critical to mitigating

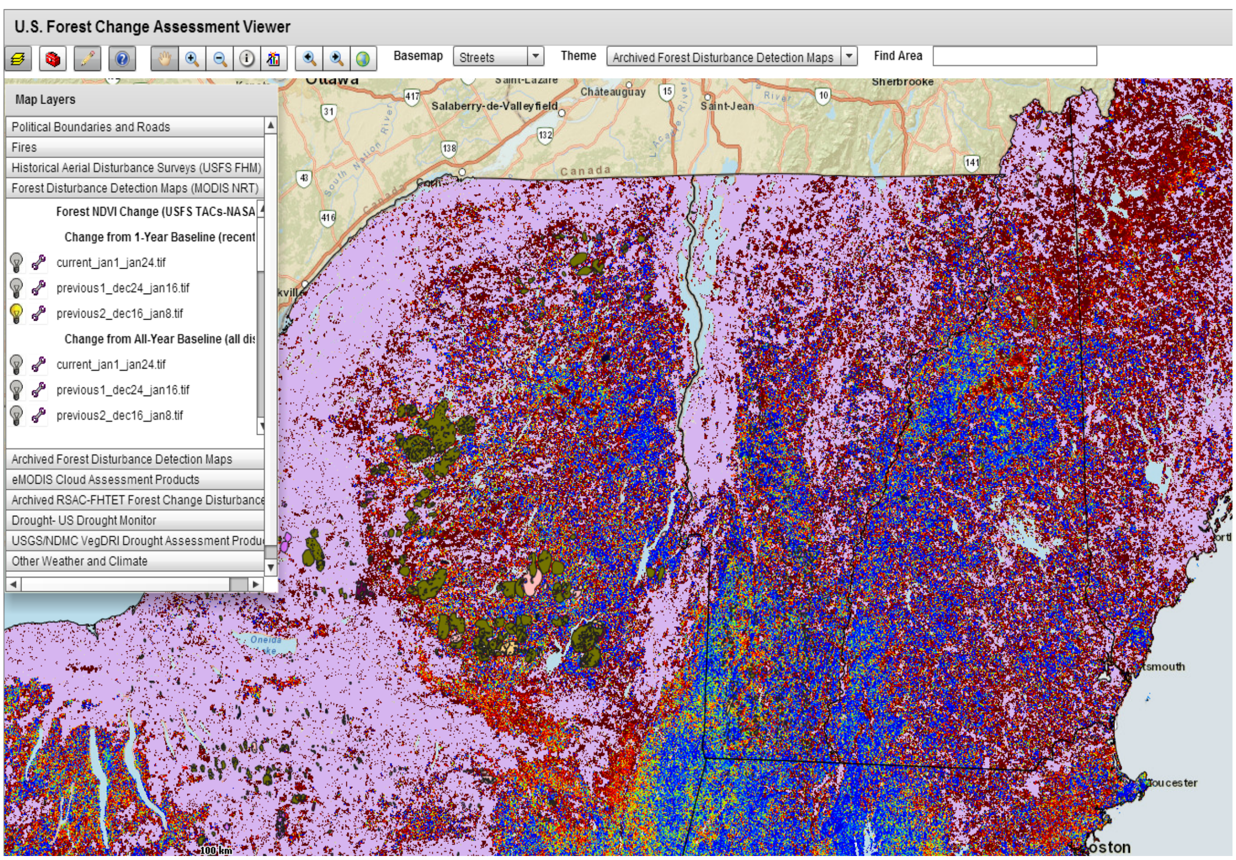

Figure 3. Cumulative disturbance map generated from the Forest Service's ForWarn tool.

the potential impacts of these stressors. The buzzwords are "early" and "rapid" when it comes to forest protection, as highlighted in the US Forest Service Forest Health Protection plan[3].

As part of its mission to provide tools for earlier and more rapid detection, several mapping tools are available through Forest Service efforts. These tools can be used for a wide range of monitoring and management purposes, from facilitating the early detection of invasive pests, to mapping invasive species susceptibility and risk. Such survey and detection efforts across state borders are imperative to help guide policies on the transport of wood products, direct ongoing monitoring efforts, and prioritize treatments in the field to mitigate impacts.

As an example, ForWarn[4], developed by the US Forest Service's Eastern Forest Environmental Threat Assessment Center, is a satellite-based forest disturbance monitoring system for the conterminous United States. It provides near real-time forest change maps for the continental United States that are updated every eight days. These maps show the effects of disturbances such as wildfires, wind storms, insects, diseases, and human-induced disturbances, in addition to departures from normal seasonal greenness caused by anomalous weather.

Similarly, the Forest Insect and Disease Risk Map created by the Forest Health Technology and Enterprise Team adds to this "toolbox" by providing yearly National Insect and Disease Risk Maps (NIDRM) that quantify the potential hazard for tree mortality due to major forest insects and diseases. The goal of NIDRM is to summarize landscape-level patterns of potential insect and disease activity, in order to help direct pest-management resources.

While it became clear that the Forest Service has many tools available to state agencies, academic institutions, planning and conservation organizations, Hanavan stressed the need for collaboration among groups to more effectively monitor the forest resource. He also noted the need to implement new techniques and approaches to maximize our efficiencies and maintain the health and function of the region's forested ecosystems.

[3] http://www.fs.fed.us/foresthealth/publications/StrategicPlan.pdf
[4] http://forwarn.forestthreats.org/

Colleen Madrid, Forest Supervisor, Green Mountain and Finger Lakes National Forests

Colleen Madrid, the Forest Supervisor for the Green Mountain and Finger Lakes National Forests (GMNF), discussed the *Current Issues and Vision for the Future* for the forests she manages. Madrid highlighted the mission of the National Forests branch of the US Forest Service to: strengthen communities by reconnecting people with the outdoors, provide recreation benefits to surrounding communities, and harness the many economic opportunities of our land management activities in a way that supports diverse employment in forest-dependent communities. Madrid also identified challenge areas moving forward, including: budget constraints, political intervention and agency changes, and the need for more natural resource management partnerships.

The biggest budgetary impact to the National Forest System over that last several years has been an increase in spending on fire suppression due to increasingly bad fire seasons. Thanks to more flexible sharing across the Forest Service, during extreme fires seasons emergency funds are pulled from the base budget of various Forest Service branches to cover firefighting costs. While this is often seen as a negative, sharing budgets across branches can also work to benefit local efforts. One example includes policy changes which encourage and provide support for specific management activities such as watershed restoration. Under this new policy, profits from timber sales can now fund restoration projects. In spite of this progress, there remains a cultural science to policy disconnect in the guidelines for such projects as evidenced in the often-imposed requirement for watershed restoration activities to be completed within one year, a feat that is rarely ecologically possible.

> *"The Green Mountain National Forest has been doing integrated resource restoration for about ten years, [putting us] ahead of the pack."*
>
> *~ Colleen Madrid*
>
> *Forest Supervisor, USDA Forest Service*

Madrid also highlighted a shift in emphasis on the National Forests from timber sales to recreation, and the desire for forests to integrate more with the surrounding community. This reflects not only a change in culture, but a change in economics, as more and more revenues are generated from recreational activities on national forest lands (Figure 4).

Madrid emphasized the importance of partnerships to her agency. In the past, this was facilitated by directly funding cooperators on collaborative projects. In the new budget climate this is no longer possible and the National Forests are looking to leverage partnerships to the benefit all parties. While not as attractive as a fully funded project, there was clearly great interest in combining efforts in the room, as

Figure 4. Economic activities on national forest lands, based on USDA Forest Service Fiscal Year 2014 budget.

evidenced by an audience request to expand surface water monitoring within the GMNF during the Q&A period. Ongoing collaborations of particular interest on the GMNF include the maintenance of trails and forest infrastructure, development and implementation of fish and wildlife programs, interpretative programs, education and outreach activities.

Patrick Berry, Commissioner, Vermont Fish and Wildlife Department

Patrick Berry, Commissioner of the Vermont Fish and Wildlife Department, reinforced that often, professionals "silo" into their specific disciplines, organizations or agencies. This is even exemplified by the organizational structure of the Vermont Agency of Natural Resources itself. However, Commissioner Berry recalled a conversation with Forests, Parks and Recreation Commissioner Michael Snyder during which they concluded that forest and wildlife issues are more than just "inextricably linked", they are essentially the "*same thing"* – challenges that require shared, collaborative solutions.

Berry enumerated the many species for which the Fish and Wildlife Department (F&W) are responsible. While much of the funding for F&W comes federally from taxes on the sale of ammunition, guns and fishing equipment, and locally from the sale of hunting and fishing licenses, the Department is responsible for much more than game species. Berry paraphrased Aldo Leopold, "The first rule of intelligent tinkering is to save all the parts", noting that this is especially true when it comes to management issues. While some may consider inclusion of such a broad range of species in the state agency's mission excessive, Commissioner Berry highlighted the link between wildlife and the economic vitality of the state. One example given was the Rusty Patch Bumblebee, a major pollinator that recently "disappeared under our noses" (Figure 5). There had been minimal monitoring of this insect prior to its demise, limiting the agency's ability to understand not only why it disappeared, but also *when* it disappeared. Commissioner Berry highlighted the critical need for monitoring in tracking decline not just for species of greatest conservation need, but many others that we may not even realize are in peril. Monitoring means looking ahead, especially regarding climate change, because it is hard to predict what the needs are going to be. He stressed that through collaboration we must get out ahead of the problem to fulfill his department's mission, "to protect and conserve our fish, wildlife, plants and their habitats for the people of Vermont".

Figure 5. Rusty-Patched Bumblebee (Bombus affinis), a species no longer found in Vermont. Photo credit: http://shadoj.deviantart.com/art/Bombus-affinis-176313018

Fish and Wildlife actively collaborates with organizations such as the VT Audubon Society and the Vermont Center for Ecostudies, as well as the VMC. All of these entities must build upon and expand these efforts in order to keep pace with the increasing rate of change in the natural world. He noted that in times of budget constraints, the role of partnerships becomes even more important. Most recently, grants to state wildlife departments have plummeted due to federal budget stalemates. In order to successfully do the job with which they are charged, the department must capitalize on collaborations to make up for changes in funding.

> *"We have a lot of parts we need to save (and not a lot of funding to do it with), and therein lies the value of these cooperatives and collaborations and partnerships."*
>
> *~ Patrick Berry*
>
> *Commissioner, VT Fish and Wildlife Department*

David Mears, Commissioner, Vermont Department of Environmental Conservation

David Mears, Commissioner of the Vermont Department of Environmental Conservation, spoke directly to participants at the meeting about our collective responsibility to not just focus on the research and monitoring efforts at hand, but to consider how our work might be used to transform public opinion, and ultimately policy. It is only in reaching beyond our traditional audience that we stand the best chance at protecting our forested ecosystems into the future.

> *"We as a community are not doing enough to educate the public how critically important the forested landscape is."*
>
> *~ David Mears*
>
> *Commissioner, VT Department of Environmental Conservation*

Commissioner Mears reinforced the importance of forests in Vermont; economically, recreationally, and environmentally. He pointed out the relationship between healthy forests and water quality, recreation and tourism opportunities, and even Vermont's infrastructure. This latter connection was most clearly demonstrated after Hurricane Irene. Commissioner Mears argued that protecting forests benefits not only the environment, but also communities and economies. While these assertions may be widely accepted by professionals in the forest management communities, he asserted that many in the general public don't understand the importance of our forest resource. It is our job as professionals in the field to inform the public about the importance of forests, and how services provided by healthy forests benefit their daily lives. He enumerated several points to make this happen: 1) continue meetings across organizations and expanding the reach of our current collaborations; 2) make sure to follow up on collaborative efforts to ensure that we move from dialog and planning to "get[ting] to the doing"; 3) get information out in an easily understandable format for a broad lay audience; and perhaps most importantly, 4) be willing to become advocates, with a point of view in spite of the desire for scientific objectivity. Commissioner Mears reinforced that if those of us with the most information are unwilling to make bold statements and express our professional opinions to a larger audience, policy will not change.

Figure 6. David Mears speaking at the Vermont Monitoring Cooperative Conference about the need for experts to engage in policy formulation. Photo Credit: Jim Duncan.

Currently, we particularly need science to inform actions and decisions in regard to adapting to climate change. One example of a policy that could have tremendous impact across the state would include incentives for landowners to manage for carbon sequestration. Such policies would not only work towards mitigating a larger, global problem, but would encourage forest preservation locally.

But without informed advocates, policies such as this gain little traction. On a local level, our expertise could help inform town level planning and management, making it easier for select boards to carry out their duties and responsibilities.

Examples of science in action do exist. For example studies on the Lake Champlain basin have resulted in better infrastructure policies with regard to stormwater management, roads, development, agriculture and forestry. Commission Mears laid down a challenge to VMC collaborators to similarly translate their work into changes on the ground. It is only by putting ourselves out there as advocates that the forested landscape across Vermont can be sustained.

Michael Snyder, Commissioner, Vermont Department of Forests, Parks and Recreation

Michael Snyder, Commissioner of the Vermont Department of Forests, Parks and Recreation (FPR), began by summarizing the statutory charge of his department. This includes: the encouragement of "economically advantageous management" of forests, and "preservation of forest soils". However, this charge says nothing about the role of science in forest management. Commissioner Snyder noted this omission, pointing out that his agency's charge can't be met without information from science and monitoring efforts. Collaborations through organizations like the VMC are needed to identify, assess and counter the many threats to Vermont's forests, and ensure that such a charge can be met.

> *"Forests are supremely and uniquely suited for integrative, experiential education."*
>
> *~ Michael Snyder*
>
> *Commissioner, VT Department of Forests, Parks and Recreation*

Similar to other departments, FPR has many existing collaborations, and its integral role in the VMC is one of those. But Commissioner Snyder highlighted concrete ideas to increase the impact of these efforts. Specifically this included:

- **Expanding collaborations** to include students of all ages and grade levels. This type of connection to the student population not only provides a broader audience around forest issues, it also serves to make curricular connections stronger, as forests by their nature are great integrators.
- Creating a mechanism for ***two-way*** communications between land managers and those developing best management practices. Because 85% of Vermont's forest lands are owned privately, landowners need to be actively engaged in forest stewardship. We need to be clever and creative to find novel ways to connect people to the land. Similarly, researchers and land managers need to seek input from landowners to ensure that their efforts align with needs on the ground.
- Connecting to those with **quantitative analytical skills** to ensure that efforts on the ground can be integrated and analyzed in a rigorous fashion to best inform decision and policy. This could be facilitated through collaborations with either UVM or the VMC, rather than requiring every organization to hire and support full time staff. Commissioner Snyder

Figure 7. Service-learning creates a mutually beneficial partnership between community groups in need of forest inventory work and students honing their assessment and measurement skills. Photo credit: Elise Schadler.

highlighted the wealth of data out there, but the need for better integration across datasets. One example would be linking FIA data to VMC, state and local forest monitoring efforts.

Commissioner Snyder identified several pressing topics where this need is critical, including: invasive species monitoring and tracking the effectiveness of response strategies; hydrologic resiliency and water quality protection; renewable energy and the role of woody biomass in supply and long-term forest productivity; the ecological and biological effects of increased outdoor recreation, and climate change indicators, impacts, and forecasting. All of this can be accomplished through what Commissioner Snyder called "intelligent tinkering".

Synthesis and Summary of Working Sessions

Executive Summary: Connecting Across Organizations

Problem Statement

The challenges facing forest ecosystems in Vermont are complex, ranging from a changing climate to the pressures of individual land use choices. Because the physical, biological and social systems associated with the forest resource are intricately connected with complex forcing and feedbacks, any efforts to understand, monitor and manage the resource must also be connected. Budget constraints further highlight the need to foster new collaborations and efficiencies across organizational lines. Few dispute the need to transcend both disciplinary and institutional boundaries to synthesize efforts for a more integrated approach to forest land management. Indeed, many groups already facilitate this type of exchange, as evidenced by the existence of the Vermont Monitoring Cooperative itself. However, the development of sustained communication and collaboration, particularly in the early stages of planning, is still cited as a major need in Vermont's forest monitoring community. At its annual meeting in 2013, VMC convened a special working session to identify highly effective forms of collaboration in order to prioritize actions for the coming year and to foster greater communication and collaboration between organizations involved in monitoring the health of Vermont's forests.

Goals and Approach

This session was designed to generate a list and prioritize concrete actions to initiate over the next year to increase communication and collaboration across the broad network of researchers, land managers, professionals, educators and decision makers vested in the sustainable health and function of Vermont's forested landscape. Participants in the working session were asked to:

(1) enumerate specific mechanisms, events, and catalysts that could lead to effective collaboration;

(2) identify those ideas with the highest potential for short term impact; and

(3) design a plan of action to implement these ideas over the coming year.

A pre-meeting survey was used to generate an initial list of existing examples of successful collaborative activities. During the VMC working group session, a mix of 19 participants from state, federal, private, non-profit and university groups came together to expand, refine and prioritize potential activities. What follows is a summary of the recommendations stemming from this discussion.

Session Output

The majority of the discussion focused on how to expand the participation in, and coordination of existing activities, and how to facilitate the development of new collaborative opportunities. Here we summarize the activities that were prioritized for maximum impact relative to effort required (low-hanging fruit), and those that, while more ambitious, may prove worth the additional effort in the long-term (high impact ideas).

Low-hanging fruit

From the process outlined above, the working group identified three top actions that represent 'low-hanging fruit' that should be pursued over the next year to promote greater collaboration across organizations.

1) Connect with local colleges/universities to engage students while providing more labor for monitoring and data analysis needs.

The group identified a number of ways to accomplish this task using existing mechanisms. For example, service-learning courses at St. Michaels College (biotic response to disturbance) and the University of Vermont (urban forest health monitoring) could be better integrated into a larger monitoring framework that would tap student labor for data mining or statistical analysis, as well as addressing the forest monitoring needs of the day. While these courses have been successful over the past several years, they could be better integrated to match the specific needs of the partner group as well as the larger forest health monitoring community. For example, state or federal agencies could be involved in the development of service-learning components of new courses specifically designed to meet current, pressing needs. To accomplish this, lead personnel from both the university and partner organizations would need time specifically dedicated to developing course activities and ensuring their success. At UVM's RSENR, this capacity exists via a service-learning coordinator position (currently Elise Schadler) and internship coordinator position (currently Anna Smiles-Becker). To date, they have met with members of all three ANR departments to explain the internship and service learning options through the Rubenstein School, and identified a point of contact in each department for distributing requests for projects and receiving proposals from within departments. This has led to several new perennial internships being offered through UVM[5] and the incorporation of DEC-proposed projects into the curriculum of an ecological risk class offered this spring[6]. Next steps for this group include identifying the professional skills that those working in the field think students need to develop, the experiential learning environments that would allow them to gain those skills, as well as coordinating graduate education planning with state research needs.

Following this example, one easy way to facilitate connections to service learning and internship activities at local colleges and universities is to solicit and maintain a curated and up-to-date list of partner 'needs'. This list of potential partner projects could include an array of activities, from data collection to statistical analysis and new research. Building off the model being developed at the RSENR, partners could provide a short summary of the project to be completed, required activities, accompanying data, expected products and a desired time table for delivery. As projects are completed, the outcomes can be captured and reported in the listing as an example of what a successful partnership looks like. In this way, student interns or instructors could be connected with an expansive, current database of potential partnerships and completed success stories.

Expanding connections with existing collaborative and interdisciplinary groups was raised as another possible avenue to identify efficient ways to link stakeholder needs to researchers, and increase communication and awareness of what others in the community are doing. Maintaining a list of key activities and contact information for existing formal partnerships, and including them in communication across organizations, would serve to increase general awareness of ongoing efforts and connect those groups and individuals that would benefit from new collaborations. Centralizing information about

---

[5] http://www.uvm.edu/rsenr/?Page=experiential/perennial-summer-internships.html&SM=servicessubmenu.html
[6] http://www.uvm.edu/~wbowden/Teaching/Risk_Assessment/ENSC202_frameset.htm

research, events and activities in digests, newsletters and websites would increase the likelihood that such information reaches the widest group possible. Potential partnerships to include in this effort and forge stronger organizational connections with include the EPSCoR-funded Research and Adaptation to Climate Change Center based at the University of Vermont, the emerging Water Quality Monitoring Council, non-profits such as the Vermont Natural Resources Council and The Nature Conservancy, and private industry such as consulting foresters or managers of ski areas.

2) Provide space and time to learn new skills and connect with others working in forested ecosystems across the state.

There was a surprising level of support for more opportunities to learn new skills pertinent to our field and connect with colleagues across the state in more informal settings. While many of us convene at regional and national meetings, these tend to focus on formal presentations, with little opportunity for training in new techniques, discussion of ongoing projects, or planning of new activities. Unlike traditional workshops and conferences that are narrow in focus, the group suggested it would be better to combine training and meeting opportunities at single events centered on transferring specific knowledge and skills. Such events would give participants the opportunity to gain new skills, be informed of cutting edge work, and network with colleagues in a single venue.

Training opportunities on their own are an enticement to people to attend. However, the ability to connect during and after the training could provide additional benefits, such as brainstorming and planning how new skills could be used in partnership. Participants emphasized the importance of providing broad rather than very specific content. Some ideas included workshops on the use of Google Earth or other online spatial products that might improve monitoring and assessment activities, scientific and 'lay' communication techniques, background and implementation of Act 250, and action research[7] techniques. There are many existing online tools and products that could be integrated into current aerial and field methods and may be of interest to land managers, educators and researchers across the state (e.g. ForWarn[8], Forest Service Pest Portal[9], USGS EROS phenology products[10], GIAM MODIS products[11]). Because of the growing emphasis on data quality, storage, safety and access, interest was also expressed in training partners to use the Vermont Monitoring Cooperative database and web portal. In addition to providing a secure archive for data, upcoming data visualization and integration tools should increase interest in using the VMC database.

Another potential catalyst for increased collaboration included informal settings such as brown bags and lightning talks. While this is not a novel idea, in practice getting people from multiple institutions to attend is difficult. However, there are examples of success in Vermont from other communities of common interest, such as Ignite Spatial events held by the GIS community[12] and meetups held by the technology community[13]. Some ways to encourage broader participation include using new presentation formats such as short lightning talks, offering continuing education credits or collaborating on planning and hosting a themed series held in rotating venues.

[7] http://en.wikipedia.org/wiki/Action_research
[8] http://forwarn.forestthreats.org/
[9] http://foresthealth.fs.usda.gov/portal/Flex/FPC
[10] http://phenology.cr.usgs.gov/get_data_250e.php
[11] http://pekko.geog.umd.edu/usda/test/
[12] http://vcgi.vermont.gov/events/archive#ignite
[13] http://www.meetup.com/VTCode/

3) Improve discoverability of environmental data, and make data available for integration within existing efforts

While we are solidly in the digital age, there still exists a wealth of data that were collected and stored on paper and are currently archived in filing cabinets. These data are difficult to access and combine with other data, and are also vulnerable to catastrophic losses such as the flooding of the State building during Hurricane Irene. Bringing these data into current digital formats is essential to understanding baseline conditions of the state's forested resources, and how those conditions are changing under novel environmental stressors. Combined with increasing requirements to archive and share data collected using federal funding, there is a growing need to organize, archive and disseminate data collected. This sharing of data is the foundation to ensuring the relevance of research and monitoring efforts into the future, and strengthening our capacity to monitor conditions beyond the typical duration of a scientific study. While internal databases are more common among our partner institutions for a variety of reasons related to their organizational structures, a lack of redundant archiving and storage can put both paper-based and digital data at risk of loss. The VMC database has proven to be a secure location to archive data, but in its current form, more advanced data integration and visualization isn't easy to achieve. The participants agreed that improving the structure, access, functionality and volume of data archiving and access services, such as those supported through the VMC, would increase opportunities for collaboration. Use of such a resource could be expanded by highlighting several pilot projects and organizing training sessions (see above) to promote wider use of the resource.

It was also explicitly suggested that forest ecosystem data archiving and dissemination be expanded to better represent spatial data products. While many data layers are available through VCGI, these are typically in formats useful primarily to those with GIS skills. The Agency of Natural Resources is centralizing access and synthesis of its own organizational data with products such as the Natural Resources Atlas[14] and BioFinder[15], though these are still primarily intended for users familiar with GIS software interfaces. Integrating the broader range of forest ecosystem data curated by VMC and others into existing or new interactive geo-portals where data layers could be explored would provide the forest management community with easier access to the vast array of spatial products available.

High-impact ideas

While all the above ideas were selected based on the relative ease of their implementation, they also received a number of votes for their potential to provide significant long-term impact. However, the idea that received the most votes for having potential for high impact was to **build stronger ties to the private sector for monitoring purposes**. Approximately 68% of the state's forests are privately owned by an estimated 87,000 Vermont families, with an additional estimated 12% owned by other private entities[16]. The large land owners and consulting foresters that advise or make land management decisions have an enormous impact on the health of the forest, and collect a wealth of information about the composition and condition of the forest. Engaging the private sector brings in a wider group of stakeholders to help defining forest health and information needs for effective forest management.

While cooperators at state, federal and academic organizations convene regularly to discuss ongoing projects and future activities, the private sector is often absent from the discussion at these events. This was exemplified in the noticeable absence of industry at the VMC Conference. Working session participants felt that rectifying that imbalance, while difficult, could have a substantial impact on

[14] http://anrmaps.vermont.gov/websites/anra/
[15] http://biofinder.vermont.gov/
[16] http://www.nrs.fs.fed.us/pubs/rn/rn_nrs55.pdf

increasing collaboration in monitoring forest health. This could be facilitated by using natural areas such as the Jericho Research Forest to host events that would be tailored for private landowners for a two-way conversation about the needs and knowledge available for forest management efforts.

Additional ideas and discussion

In addition to the top-ranked ideas discussed above, participants discussed several other ideas for fostering collaboration:

- Dedicating a **full-time coordinator focused on building partnerships** could make it easier to establish and maintain collaborations. Because budget constraints often make this infeasible, it may be more likely for organizations to identify specific employees whose responsibilities would include facilitation and coordination of collaborative activities.
- Encouraging supervisors to **use metrics of collaborative activities as a part of yearly performance reviews** could incentivize collaborative efforts among the work force. Such metrics could include attendance at meetings and training sessions, or involvement in projects that cross organizational boundaries. They also stated that having supervisors who encourage collaboration, and who understand the potential time requirements to make such collaborations successful would be helpful, but harder to achieve.
- **Identifying a common physical space for collaborative activities**. This could include locations such as the University of Vermont's research forest in Jericho, as well as the VMC intensive monitoring sites at Mt. Mansfield and Lye Brook Wilderness. Having dedicated space where research, monitoring and education activities are combined creates a melting pot where interdisciplinary collaborations are more likely.
- The **development of an innovation fund** or a cross-organization pooled fund with the charge to support high-quality, cross-cutting collaborations. While such financial structures are difficult to obtain and administer, this has worked in the past. For example, throughout the years the VMC has supported innovative pilot projects. However, the lack of funding for VMC to continue such efforts was noted.
- Participants identified a tension between the benefits of using more **technological tools** (Skype, online documents, webinars and teleconferencing) for working with others, and the pitfalls of losing personal and face-to-face contact.
- While not advocating for their use, participants discussed **the role of negative forces** such as natural disasters and lawsuits as catalysts for collaboration. Such events can force collaboration through mobilization of new resources and rapid setting of priorities.
- Interestingly, traditional mechanisms of collaboration such as MOUs and shared grant-writing were not discussed and received almost no votes from participants in the session.

Next Steps

While many of the suggestions from this working session require effort from multiple parties, there are several activities that VMC could tackle over the coming year. This includes:

- Work with service learning and internship personnel from local academic institutions to create, maintain and disseminate a **database of potential partner projects**.

- Hold a series of **training workshops** (summer 2014) on the VMC database and data management portal. Included in these one day training workshops will be opportunities for partners to share their ideas for using these tools and plan future activities around their use.
- Finalize and **deploy the new VMC database** structure, with pilot examples of data integration and display. This may include partnering with Vermont's Agency of Natural Resources and the Vermont Center for Geographic Information to integrate geospatial and tabular data with data collected and curated by state and federal agencies.
- Organize a **working session** (at the VMC annual meeting Dec 2014) to survey existing spatial data tools for potential integration into ongoing monitoring and geo-portal efforts.
- Develop and/or strengthen and expand a network of individuals to keep "in the loop" about upcoming and ongoing forest health monitoring efforts, and **deliver regular outreach/update materials.**

Conclusion

The interest and energy for new sustained collaboration in monitoring forest ecosystem health was evident in this session, and surely challenges, both familiar and novel, are ahead for increasing communication and collaboration across institutions. However, the ideas and actions generated in a short working session suggest a number of paths to pursue, from creating new networking and training spaces, to integrating student effort into our monitoring work, to increasing the supply, quality and richness of the data we make public. There is great potential for these efforts to lead to more effective and efficient monitoring, and ultimately grow and solidify this network of individuals and organizations committed to improving our understanding and management of the forested ecosystems of Vermont.

Executive Summary: Canaries in the Coal Mine - Identifying Key Metrics for Monitoring Forest Resources

Forests have always faced challenges (e.g., native pests and pathogens, wind and ice storms) but have also evolved biological and ecological mechanisms to respond to such historic stresses in a way that helps sustain their overall structure and function. This natural resilience has allowed temperate forests to persist and provide benefits despite even extreme setbacks (e.g., the extensive land clearing of the 1800s). However, there is growing scientific concern that human activity may be pushing natural systems beyond historic ecological limits, so that they increasingly cannot recover their former structure and function following stress exposure. Accordingly, a range of national and regional organizations have identified active monitoring and management as a paramount endeavor to sustain forest function and to safeguard the welfare of coupled natural-human systems[17, 18, 19, 20].

In response to this pressing need, the Vermont Department of Forests, Parks and Recreation (FPR) has developed its own framework for assessing trends in forest ecosystem health and sustainability in the 2010 Vermont Forest Action Plan[21]. This effort was designed to identify quantitative indicators to serve as measures of the sustainability of Vermont's forested ecosystems. The 2010 Plan builds off of previous state efforts to assess the state's forest resources and guide the department in fulfilling program responsibilities. It also meets the requirements of the 2008 Farm Bill to complete a state assessment and develop resource strategies in order to receive funds from the US Forest Service under the Cooperative Forestry Assistance Act (CFAA).

The 2010 Plan guides assessment and future actions towards the following:

- Healthy and sustainable forest ecosystems;
- A prosperous and sustainable forest products industry;
- Abundant recreational opportunities; and
- A combination of ownership patterns supporting a working forest landscape and large, unbroken forest tracts.

To quantify each of these stewardship goals, the 2010 Plan identified a suite of landscape scale assessments designed to capture baseline condition and trends in five major categories: biodiversity, forest health and productivity, ecosystem services, land ethic, and climate change.

To help inform the development of the State's 2015 Forest Action Plan, a diverse group of forest professionals from state, federal, academic and non-profit organizations met to discuss potential key indicators to include in future forest monitoring efforts. In addition to identification of specific measurements and metrics that might be useful, participants were also asked to identify existing datasets that could be included in monitoring efforts, and the organizations responsible for those datasets. Sticking with the categories identified in the 2010 Vermont Forest Action Plan, the following suggestions are summarized by the state-defined themes of biodiversity, forest health and productivity, ecosystem services, land ethic, and climate change focus areas.

---

17 http://www.safnet.org/natcon12/index.cfm
18 http://www.anr.state.vt.us/anr/envrptsb/envrpt2011.htm
19 http://www.iied.org/forests-resilience-climate-change
20 http://planningrule.blogs.usda.gov/2010/07/23/resilience/
21 http://www.vtfpr.org/htm/for_resourcesplan.cfm

Biodiversity

Current biodiversity indicators included in the 2010 Plan include: area of forest land and percent of forest land in conservation. The group agreed that these were important measures to maintain in the next iteration of the Forest Action Plan. Other ways to quantify the land use/land cover metrics already in use could include the calculation of a fragmentation index and patchiness as indicator of land use change and forest land integrity. The consensus is that metrics related to species composition and richness should be added to these land cover assessments to more accurately assess biodiversity across the state.

Suggested "low hanging fruit" to capture biodiversity at minimal cost to the state and its collaborators could include analyses of the Forest Inventory and Analysis plots across Vermont. Inventory data can be used to calculate species richness metrics (e.g. Shannon Weiner Index) or other metrics of biodiversity in the forest community.

Another common metric of threats to biodiversity include assessments of the extent and severity of invasive species populations. While statewide assessments of invasive species is likely not possible, there exists a strong network of citizen scientists that could be tapped to more aggressively identify current distributions of key invasive species, and map their spread. One such tool is found in the iMapInvasives program (Figure 8) hosted by the Vermont chapter of The Nature Conservancy[22]. The current database lists over 1200 observations of 34 invasive terrestrial plants, with geographic coordinates. If this program were promoted by state officials through existing citizen science efforts (e.g. Audubon winter bird count) a significant source of data could be tapped for yearly monitoring of invasive spread.

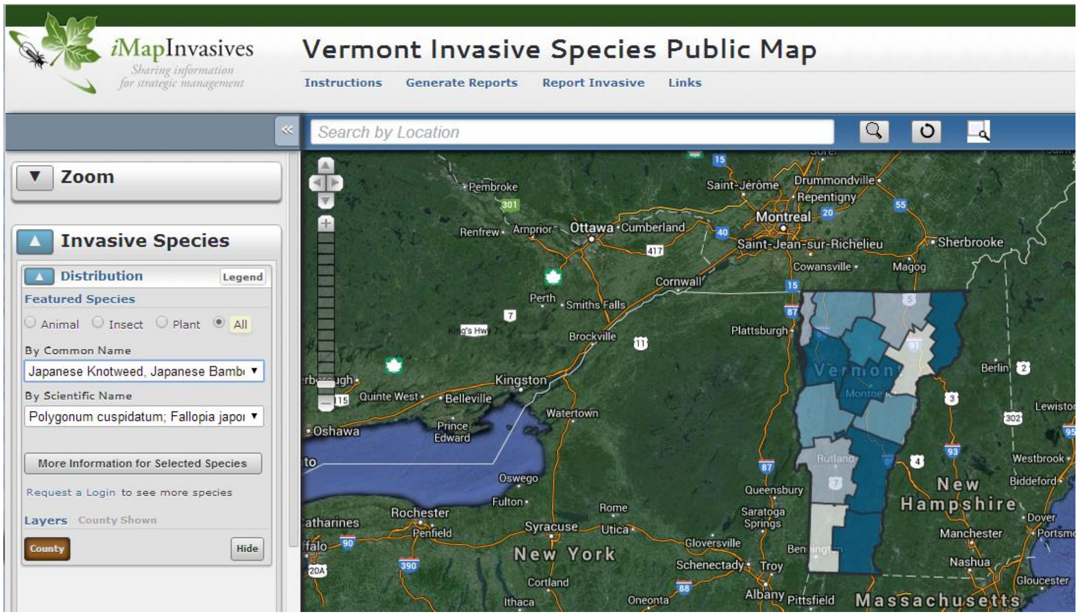

Figure 8. Invasive species mapping portal that allows a wide range of users to report sightings of invasive species in a centralized location.

Forest Health and Productivity

The 2010 Forest Action Plan included a summary of aerial detection surveys to calculate the area of forest land with demonstrated decline conditions. Again, this is an important metric of widespread stress events that impact canopies. However, there was concern that aerial assessments would miss more subtle

[22] http://imapinvasives.org/vtimi/map/

changes in productivity and health that are common from year to year. In particular, this includes variable wood production, regeneration and stocking.

It was suggested that existing data from the Forest Inventory and Analysis plots be "data-mined" each year to compare trends in biomass accumulation, standing biomass and species distributions. As informative as FIA surveys are, repeated measurements on inventory plots span many years. Therefore, another suggested approach to capture yearly productivity, relationships to climate forcing (see below) and potential "winners" and "losers" among species, is to include dendrochronology. In addition to an existing online database of tree cores[23], collaborators across the state have an archive of core data that could be used to examine patterns in historical productivity. This information would provide a useful baseline by which to compare new, yearly productivity measurements. To this end, the group highlighted the importance of ongoing, yearly measurements on a network of permanent plots. Ideally this would include assessments of crown condition (e.g., crown vigor, transparency, dieback, live crown, gap fraction, leaf area index) but also yearly diameter growth (DBH) measurements on permanently tagged stems. Existing long-term plots at the VMC Intensive Study Sites (Figure 9) at Mt. Mansfield and Lye Brook are not representative of other biophysical regions of the state. Results would be more broadly applicable if additional sites were included from the Northeast Kingdom, Southern Piedmonts, and Lake Champlain Basin. This would ensure better coverage across ecotones. Possible "easy access" sites to establish new plot clusters could include: Marsh-Billings-Rockefeller National Park and Sleepers River. Traditional inventories could be conducted on a larger plot network through a consortium of state, academic (service learning courses) and VMC efforts. It was also noted that higher quality measurements of yearly productivity could be achieved through the use of dendrometer bands, as opposed to manual DBH measurements. New methods have been published to create dendrobands "on the cheap" that might enable widespread distribution of these more accurate yearly growth assessments.

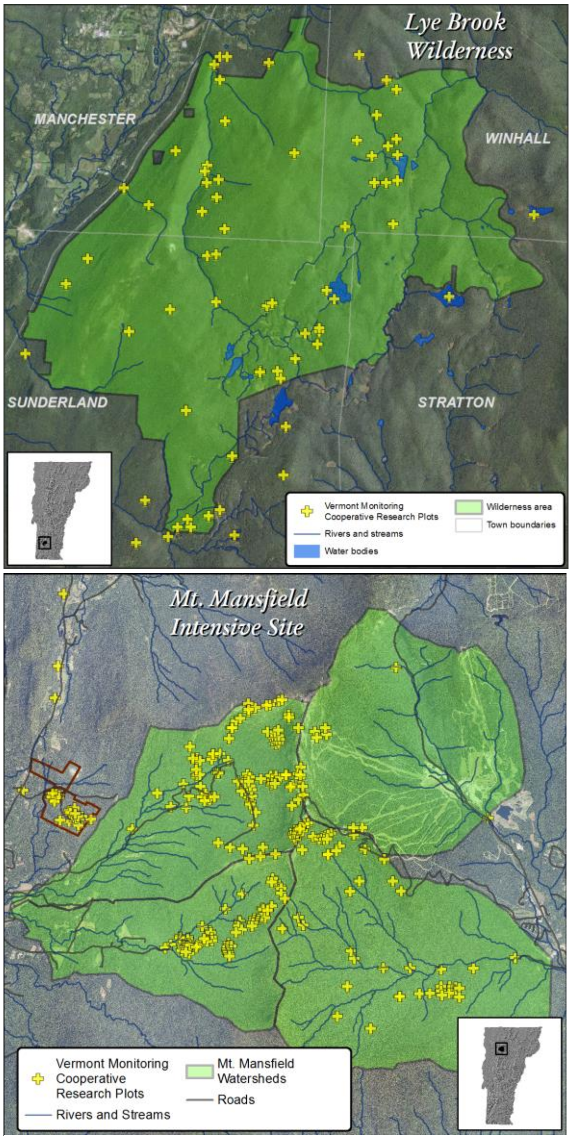

Figure 9. Vermont Monitoring Cooperative intensive sites on Lye Brook Wilderness (top) and Mount Mansfield (bottom). Maps by Jim Duncan.

[23] http://hurricane.ncdc.noaa.gov/pls/paleox/f?p=518:1:0:::APP:PROXYTOSEARCH:18

Application of remote sensing technologies (e.g. LiDAR, UAV, MODIS and Landsat data products) could also make it feasible to include assessments of forest canopy condition, biomass and structure as a compliment to state and federal sketch mapping efforts. Perhaps easier is the use of remote sensing data products that have already been processed to extract forest related metrics. An example is the ForWarn system, a satellite-based forest disturbance monitoring system developed by the USFS Eastern Forests Environmental Threat Assessment Center. ForWarn delivers new forest change products every eight days and provides tools for attributing abnormalities to insects, disease, wildfire, storms, human development or unusual weather. Archived data provide disturbance tracking across all lands since 2000. Interactive maps are accessible via the Forest Change Assessment Viewer[24] and could be regularly uploaded into a Vermont specific GIS data model to quantify yearly forest condition.

Another potential source of remote sensing assessments of canopy condition and productivity is the USGS EROS MODIS data portal[25] (Figure 10). While primarily designed for phenology applications, 250 meter assessments of the maximum normalized difference vegetation index value (NDVI, or maximum canopy "greenness") could be used to compare canopy condition over years. This quantitative assessment of canopy condition (as opposed to a binary assessment typical of sketch mapping efforts) could allow for more detailed tracking of forest condition over time.

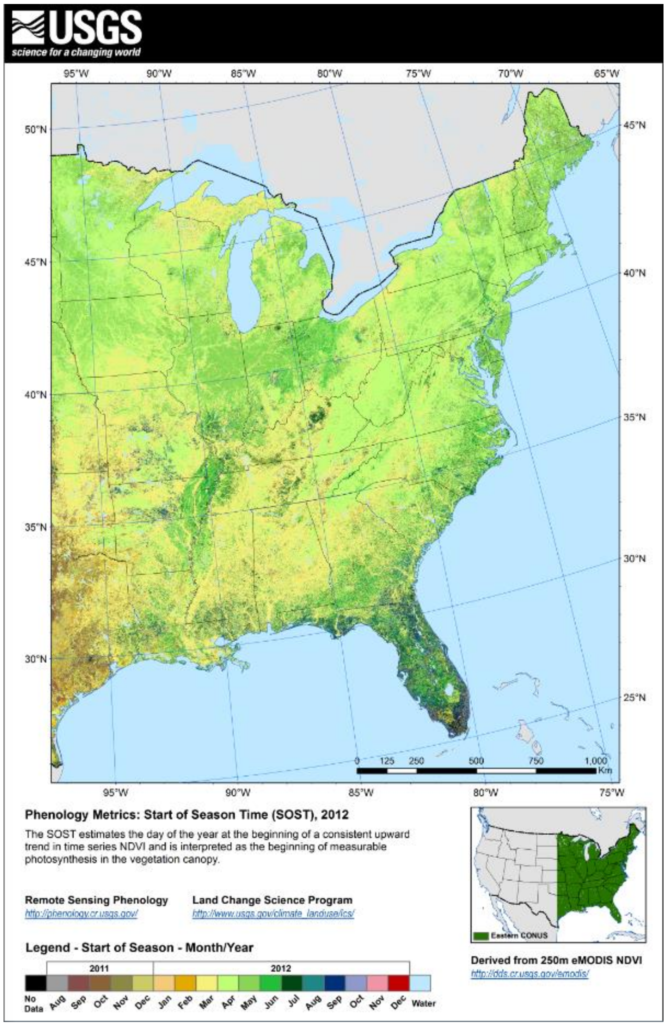

Figure 10. The USGS provides a portal to 250-meter-resolution products derived from MODIS remote sensing imagery, including phenology metrics shown here.

Ecosystem Services

Ecosystems services are captured in the current plan using data on the production of wood and wood products, their consumption and trade. This captures the direct economic benefits of Vermont's forests. Participants suggested that other ecosystem services such as carbon sequestration, surface water quality, recreation and tourism also be included. These ecosystem services could be captured from a wide range of existing data sources, including:

- trail and park usage statistics;
- data from the Department of Transportation during peak foliage;

[24] http://forwarn.forestthreats.org/fcav
[25] http://phenology.cr.usgs.gov/get_data_250e.php

- water flow and chemistry data from the network of steam gauges around the state (VT EPScOR Research on Adaptation to Climate Change program[26], USGS[27], VMC[28], etc.);
- rough assessments of carbon sequestration based on land cover maps (via software packages such as Dinamica[29] and INVest[30]).

While many of these data sets, and their analyses, fall under the purview of other state agencies, their connection to the health and function of forests is undeniable. Strong collaboration across organizations and institutions would benefit all parties, demonstrating the wide reaching impact of their various efforts. Others, such as the products from ecosystem services assessment software, might be accomplished through collaboration with a partner university on a graduate research project.

Land Ethic

Land ethic is an important measure of forest vulnerability, as it captures the will to manage and maintain forests in productive states. Because a land ethic is based on human psychology and behavior, it is difficult to capture. The 2010 Forest Action Plan includes measurements of the number of acres protected as public holdings and the acres voluntarily enrolled in forest stewardship programs.

These are useful metrics, but could be complimented by other existing data to capture values of a wider public audience. This could include dollars donated or volunteer hours logged with Vermont based non-profit organizations focused on forest stewardship (e.g. Green Mountain Club, Trust for Public Lands, The Nature Conservancy).

Climate Change

Climate (temperature, precipitation, wind) is well monitored across the state via established networks (National Oceanic and Atmospheric Administration, National Weather Service, VMC). Of more interest is the impact of climate on forested ecosystems. To this end, yearly assessments of phenology are essential. While the state maintains a long historical record of phenology at the Proctor Maple Research Center, additional locations, representing a wider range of species, elevation and site conditions is necessary. Because phenology assessments are incredibly time consuming, it seems that this may be another appropriate venue to enlist help from citizen scientists (see biodiversity above). Several programs already exist to collect and distribute phenological observations from the public. Project BudBurst data[31] are freely available for anyone to download and use for noncommercial use. The data are provided by thousands of observers from across the country, although only seven observations were currently included for Vermont. The National Phenology Network[32] also includes citizen observations, but a search of current data for the state of Vermont is limited to ornamental and herbaceous species at only two locations. Collaborators within the VMC could also be encouraged to post yearly start–of-spring assessments through the VMC portal, breaking down timing of leaf-out by species, elevational range, county, etc.

More widespread, although less accurate, assessments of phenology can be obtained through remote sensing assessments. Course scale phenology assessments are processed yearly through the USGS EROS

---

[26] http://www.uvm.edu/~epscor/new02/?q=node/30
[27] http://waterdata.usgs.gov/vt/nwis/rt
[28] http://www.uvm.edu/vmc/research/summary.php?id=111
[29] http://www.csr.ufmg.br/dinamica/
[30] http://www.naturalcapitalproject.org/InVEST.html
[31] http://www.budburst.org/results.php
[32] https://www.usanpn.org/data

MODIS data center[33]. Two-hundred fifty meter "start of spring" NDVI products are available from 2001 to the present across region. These could compliment the state's existing field based observations, providing a broader assessment of phenology patterns and trends across the state.

Additional metrics for consideration

The Department of Health is interested in what indicators the state holds that pertain to habitat for vectored diseases. Wetlands and water bodies are of interest from a mosquito/EEE perspective. For Lyme disease, deer populations are of interest. It was also mentioned that there is a correlation between "mast years", which create high mouse populations the following year, and high tick population the year after that. Use of the critical load and exceedance maps developed by Eric Miller under the Conference of New England Governors and Eastern Canadian Premiers might also be useful to identify forests on the edge of nutrient depletion and to focus monitoring efforts in locations where acid deposition stress response is expected.

[33] http://phenology.cr.usgs.gov/get_data_250e.php

Executive Summary: Lye Brook Wilderness Area Working Group

Summary

Lye Brook Wilderness Area is unique in that it is the only Class I Wilderness Area in Vermont, and includes a rich archive of existing monitoring and research data. Historically a subcommittee of the Vermont Monitoring Cooperative connected researchers and land managers interested in Lye Brook. While interest remains high, the activity of the subcommittee has varied over the decades. This working group, moderated by Dianne Burbank of the Green Mountain and Finger Lakes National Forest, was charged with formalizing a plan to bring together key partners in an ongoing collaboration focused at this VMC intensive research site, and to update the list of activities (past, present and planned) at the intensive monitoring site.

The consensus opinion of the working group was that a Lye Brook subcommittee should be formally reinstituted, and potential new partners identified. Jennifer Wright, Wilderness Coordinator for the Green Mountain National Forest, agreed to organize a follow-up meeting in February or March 2014 to solidify an organizational structure and membership. See Table 3 for a list of working group participants and their affiliations.

The working group also successfully compiled a comprehensive list of current and new monitoring and research activities that are or will be occurring at Lye Brook (see Table 1 below). Much of the data from projects conducted at Lye Brook are already in the VMC database, but other datasets might be available and should be pursued for inclusion in that database (i.e. 1984 Spruce Decline Survey, 1991 and 2003 rare plant survey at Bourne Pond, invasive plant survey).

Monitoring and Research Activities at Lye Brook

A review of past and ongoing projects taking place at Lye Brook, and the resulting datasets, was led by Judy Rosovsky. This information is grouped below into established projects with ongoing monitoring taking place now and into the future (Table 1) and projects conducted at Lye Brook that have since ended (Table 2). This information is also summarized on the VMC website[34]. Several new, or previously unrecognized efforts were also identified, providing potential opportunity for collaborations among subcommittee members and integration across projects.

[34] See http://www.uvm.edu/vmc/about/lyebrook/project_list.php

Table 1. Ongoing monitoring and research projects taking place in the Lye Brook Wilderness area. Where available, links to the VMC website project pages are given, and projects with downloadable or linked data are marked with an asterisk.

Project Title	Start Year	Contact
Biological and Chemical Survey of Selected Surface Waters in the Lye Brook Wilderness Area: Water chemistry of water bodies *	1982	Jim Kellogg
Fine Aerosol Monitoring: IMPROVE *	1988	Ben Whitney
Fine Aerosol Monitoring: Partner Network	1988	Ben Whitney
Particulate Matter Monitoring: PM10 and PM 2.5	1988	Ben Whitney
Amphibian Survey and Monitoring *	1991	Jim Andrews
Forest Bird Surveys *	1991	Steve Faccio
Forest Health Monitoring *	1991	Sandy Wilmot
Aerial Surveys for Insects and Disease *	1991	Chris Casey/Dan Dillner
Forest Inventory and Analysis (FIA) *	1983	Randall Morin
Forest Pest Monitoring	1991	Barbara Schultz
Tree Phenology Monitoring: Fall color and leaf drop	1991	Tom Simmons
High Elevation Sensitive Species Monitoring	1994, 2004	Jerry Jenkins
Ozone Bioindicator Plant Monitoring	1999	Jay Lackey
Long Term Soil Monitoring *	1999	Don Ross
Soil Climate Analysis Network (SCAN) Sites *	2000	Thomas Villars
Pond Core Monitoring: Diatom and Chrysophyte Communities for Total Maximum Daily Load	2001	Jim Kellogg
Forest Service Visitor Use Monitoring	2001	Jen Wright
User-made Campsite Monitoring	2004	Jen Wright
Ten-Year Long Term Wilderness Management Challenge Monitoring	2004/2009	Diane Burbank
Lichen Survey	2013	Jen Wright
Recreation Efforts at Bourne Pond: Fishing	2014	Jen Wright
Monitoring Acid Rain Impaired Streams: Bourne Brook and Lye Brook	1982	Jim Kellogg

Table 2. Past monitoring and research projects that took place at Lye Brook Wilderness. Where available, links to the VMC website project pages are given, and projects with downloadable or linked data are marked with an asterisk.

Project Title	Year(s)	Contact
Incidence of Ozone and its Effects on Vegetation in the Lye Brook Wilderness Area	1988	Florence Peterson
Fine Aerosol Monitoring: NePART	1988	Ben Whitney
Fine Aerosol Monitoring: Partner Network	1988	Ben Whitney
Amphibian Survey and Monitoring: Egg mass counts *	1991-2002	Jim Andrews
Amphibian Survey and Monitoring: General inventory *	1993-1995	Jim Andrews
Amphibian Survey and Monitoring: Stream Survey *	1993-2002	Jim Andrews
Lichens and Air Quality in the Lye Brook Wilderness	1993-1993	Clifford Wetmore
Lye Brook Area Ecological Land Type Classification *	1993-1995	Diane Burbank
Clean Air Status and Trend Network (CASTNET) *	1994-2007	Ralph Perron
Effects of Acidic Deposition on Terrestrial and Aquatic Ecosystems of Class I Wilderness Areas *	1994-1996	John Campbell
Lye Brook – Wildlife	1995-1995	Clay Grove
Paleostratigraphy of Mercury in Lakes and Ponds: Branch Pond	1999-1999	Neil Kamman
Biomolecular Indicators of Acid Stress	2002-2002	Mark Bremer
Throughfall Study	2007-2007	Pam Templer

Table 3. Working group participants and their affiliations.

Participant	Affiliation
Jim Andrews	Vermont Reptile and Amphibian Atlas
Scott Bailey	USDA Forest Service, Durham, NH
Diane Burbank	Green Mountain and Finger Lakes National Forests
Chris Casey	Green Mountain and Finger Lakes National Forests
Charlie Cogbill	Private Consultant
Dan Dillner	VT Department of Forests, Parks and Recreation
Jim Kellogg	VT Department of Environmental Conservation
Bob Manning	Rubenstein School of Environment and Naturel Resources, UVM
Ralph Perron	Green Mountain and Finger Lakes National Forests
Angie Quintana-Jones	Green Mountain and Finger Lakes National Forests
Judy Rosovsky	Vermont Monitoring Cooperative
Carl Waite	Vermont Monitoring Cooperative
Jen Wright	Green Mountain and Finger Lakes National Forests

Contributed Abstracts

There were 15 talks contributed to the conference, presented in three concurrent sessions. Below are the abstracts submitted for these talks, including author affiliation. The presenting author's name is in bold type.

Vermont's Disappearing Reptiles and Amphibians: Boreal Chorus Frog, Fowler's Toad, and North American Racer

James Andrews[1]
[1] Vermont Reptile and Amphibian Atlas

The Vermont Monitoring Cooperative has supported both intensive amphibian monitoring at Mt. Mansfield and Lye Brook Wilderness and extensive monitoring of reptiles and amphibians throughout the state. Without this effort we would not know what species were once found in Vermont and as a result would not know which species are increasing or decreasing in numbers or the extent of their range. Three of our native herptiles have not been reported in recent years. The Boreal Chorus Frog was last heard in Alburgh in 1999. The Fowler's Toad was last seen in Vernon in 2007 and the North American Racer was last seen in Guilford in 2008. These are all edge of range species in Vermont. Two are at the northern extreme of their range (Fowler's Toad and North American Racer), and one is at the southeastern extent of its range. We do not know what has caused the apparent disappearance of these species. I will present what we know about these three species in Vermont and nearby areas.

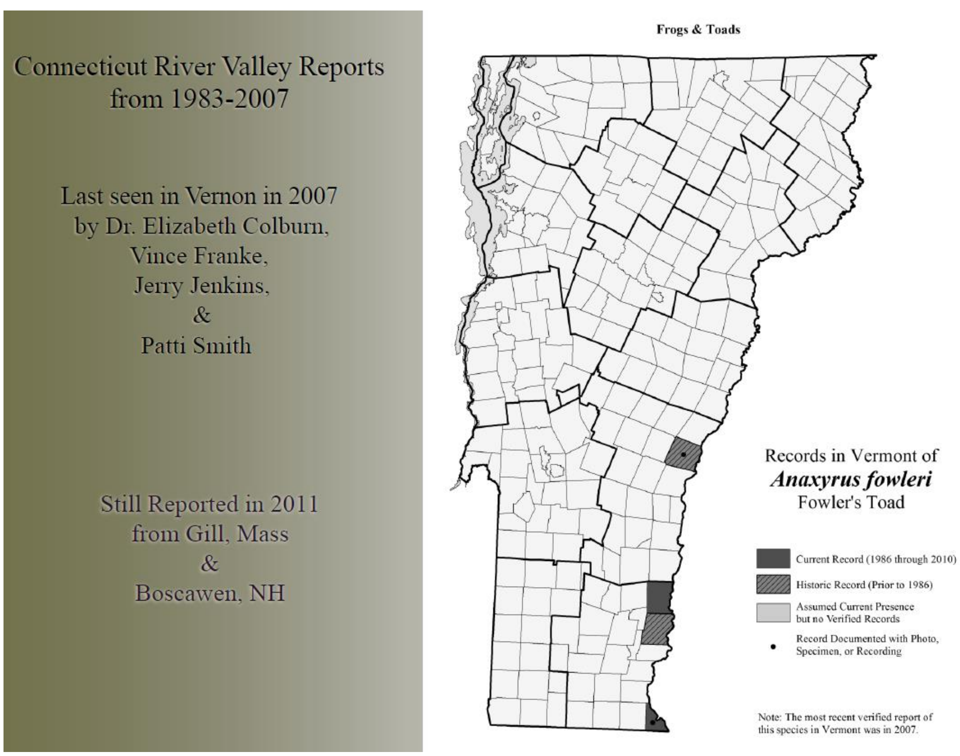

Figure 11. Records of Fowler's Toad (Anaxyrus fowleri) in Vermont. From presentation given by James Andrews.

Peeking Beneath the Canopy: Insights from Using i-Tree Eco to Monitor Burlington's Urban Forest

James Duncan[1], Aswini Cherukuri[2], and Emily Van Wagoner[2]
[1] Vermont Monitoring Cooperative
[2] Rubenstein School of Environment and Natural Resources, University of Vermont

The urban forest in Burlington, VT, provides diverse benefits to residents in the city and the surrounding area, including ecosystem services such as air and water filtration, temperature moderation, and carbon sequestration. But maintaining these services into the future will depend, in part, on careful monitoring of the forest's condition over time for early warning signs of decline. In 2011, the Vermont Monitoring Cooperative used i-Tree Eco, a USDA Forest Service software suite, to design a monitoring framework for the city's urban forest using 200 randomly located permanent plots throughout the city. Over a three year period, students from the University of Vermont's Natural History and Field Ecology class worked with the VMC to survey 159 of these plots, gathering data on land use, ground cover, species, size, height, and crown condition. Using the i-Tree analysis services, preliminary estimates suggest that Burlington's urban forest is in good condition overall, though certain species such as eastern white pine fall into poorer condition classes, and invasive species such as Norway maple and buckthorn are quite common. The forest is also providing substantial benefits, with estimates including sequestration of 730 metric tons of carbon per year, and roughly $200,000 saved in avoided health impacts from air pollution. Future work will focus on surveying the remaining plots in Burlington and substituting more locally appropriate valuation rates for certain services. Despite some challenges, there is significant potential to use the i-Tree Eco suite to monitor forest conditions in Burlington. Beyond the city, opportunities to utilize i-Tree for broader-scale monitoring of Vermont's forested landscapes will also be discussed.

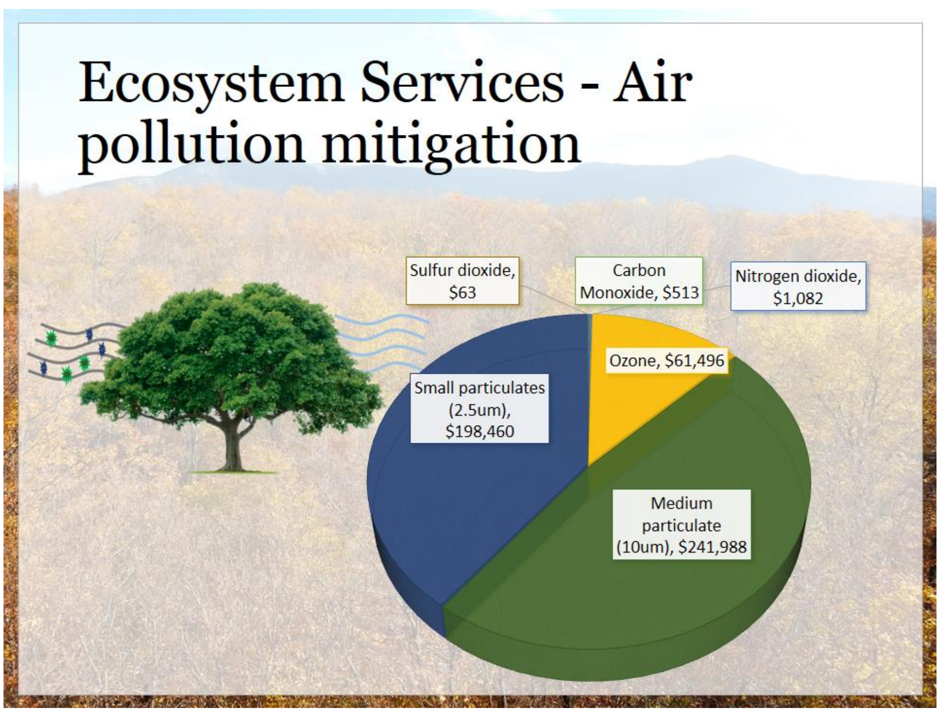

Figure 12. Air pollution removal ecosystem services provided by Burlington urban forest. From presentation given by Jim Duncan.

The Vermont Vernal Pool Mapping Project: Using Aerial Photo Interpretation and Field-verification to Map State-wide Distribution of Vernal Pools

Steven D. Faccio[1], Michael Lew-Smith[2], and Aaron Worthley[2]
[1] Vermont Center for Ecostudies
[2] Arrowwood Environmental

Vernal pools are typically small, shallow wetlands characterized by alternating flooded and dry phases. Yet, despite their small size and ephemeral nature, they support a rich assemblage of invertebrates and breeding amphibians. Many of these species are considered High and Medium priority Species of Greatest Conservation Need (SGCN) in the Vermont Wildlife Action Plan, including *Ambystomid* salamanders, Odonates, Fairy Shrimp (*Eubranchipus spp*.), and freshwater snails. However, due to their small size and seasonal nature, most vernal pools do not appear on National Wetland Inventory maps and their location and distribution across Vermont was largely unknown. We used color infrared aerial photo interpretation to map the location of "potential" vernal pools statewide, and trained citizen scientists to help field-verify a proportion of mapped pools. A total of 4,856 "potential" vernal pools were mapped statewide. Of these, 636 (13%) were field-visited; 54% of which were confirmed to be vernal pools. However, 71% (*n* = 207) of sites that were not pools were other types of wetlands (e.g. beaver ponds, shrub swamps, seeps, etc.), while only 13% were artifacts of remote mapping, primarily shadows from conifers. Among field-verified pools, the most commonly detected species were *Lithobates sylvatica* and *Ambystoma maculatum*, found breeding in 78% and 73% of confirmed pools respectively. *A. Jeffersonianum* was found in 10% of confirmed pools, *A. Laterale* in 3% of pools, and *Eubranchipus spp*. in 5% of pools. At least 115 volunteers participated in field-verification of vernal pools, submitting data from 301 field visits.

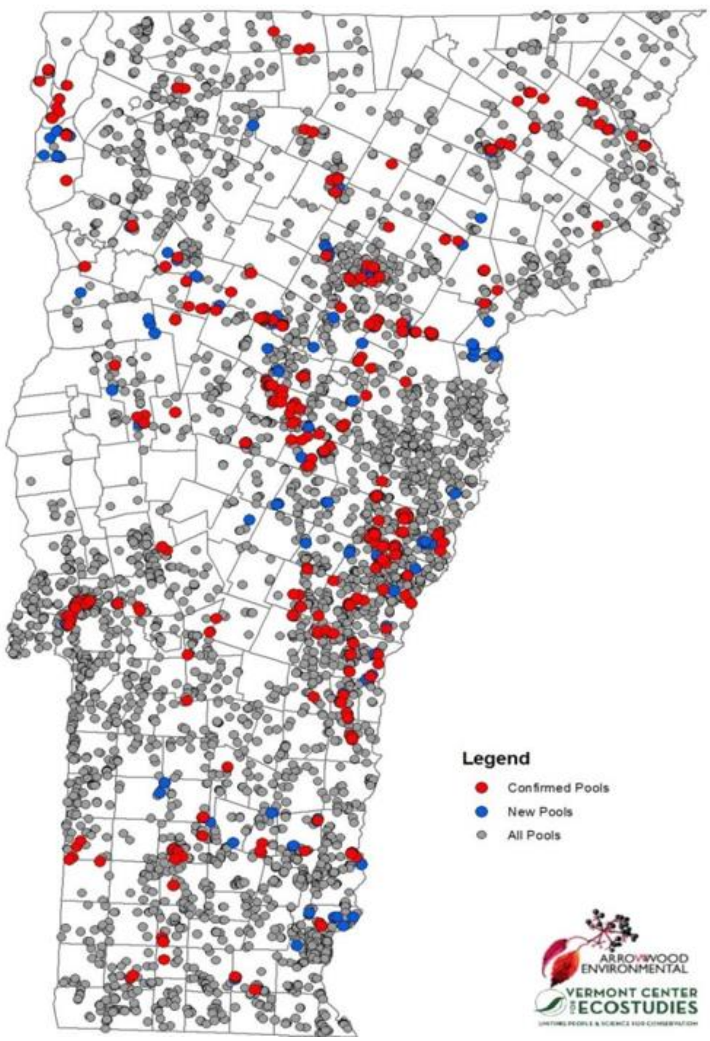

Figure 13. Potential and confirmed vernal pools identified across the state of Vermont. From presentation by Steve Faccio.

Predicting Calcium Content and Lithology of Glacial Till in the Green Mountain National Forest

Gus Goodwin[1]
[1] Field Naturalist Program, University of Vermont

For many forest soils in Vermont, the availability of nutrients, such as calcium, is determined by the lithology of glacial till, not bedrock. Till composition is variable and can differ dramatically from the underlying bedrock, but is largely unmapped. For both land managers and researchers, such a map would be valuable, as it would provide insight into nutrient cycling, spatial patterns in species diversity, and buffering of soils and streams against acidification.

I applied a source-area model to predict till lithology and calcium content across the Green Mountain National Forest (GMNF). The model identifies bedrock sources in the geographic area where the till likely originated and computes their relative contribution to the till. By tying these predictions to geochemical analyses of bedrock units, the model can estimate the concentration of individual elements in till. In my initial model, I used a wedge-shaped source area defined by a 32km radius and 60º arc centered along the mean direction of ice flow during the last glacial maximum (148º). Using a database of 550 geochemical analyses, I assigned estimates of calcium content to all rock types that could be found in till in the GMNF.

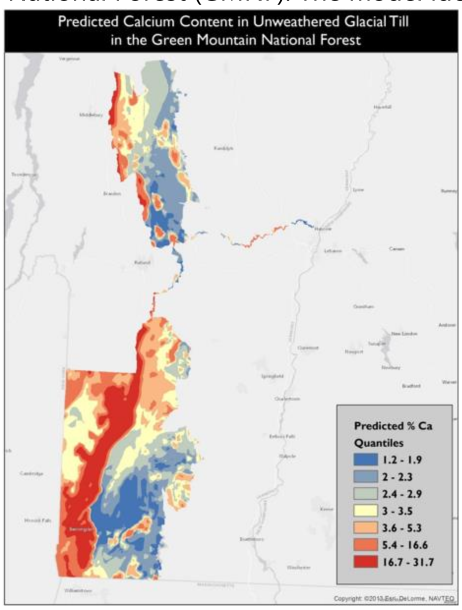

Figure 14. Glacial till calcium content on the Green Mountain National Forest. From presentation by Gus Goodwin.

With this, I generated a map of calcium content in till, that shows strong gradients in calcium availability across the GMNF, with the highest values reported for the Taconic Mountains and western Green Mountains and the lowest values in the central and eastern Greens. Sampling of till exposures and soil pits is being used to test the validity of the model predictions.

Products of my research, to date, include 1.) a comprehensive database of VT bedrock chemistry; 2.) a statewide map of calcium content in bedrock; and 3.) a preliminary map of calcium gradients in till within the GMNF.

A Proposed Vermont Water Monitoring Council – Results of a Needs Survey, and Next Steps

Neil Kamman[1], Keith Robinson[2], and Steve Gillespie[2]
[1] Vermont Department of Environmental Conservation
[2] US Geological Survey

During 2013, the VT Department of Environmental Conservation and US Geological Survey, in collaboration with the Vermont Monitoring Cooperative and several stakeholder organizations, pursued investigation of a statewide Water Monitoring Council. Through a series of meetings and outreach, the organizing partnership established a draft set of goals and objectives for a Statewide Council, consulted with other state water monitoring agencies, and considered the benefits conferred by these efforts to water management efforts in Vermont. As a result of this work, organizers developed and deployed a web-based survey to determine the interest, needs, and initial priorities of a Vermont Water Monitoring Council. A total of 113 survey responses, representing a 57% response rate, were received. This presentation will summarize the results of the survey, then propose next steps.

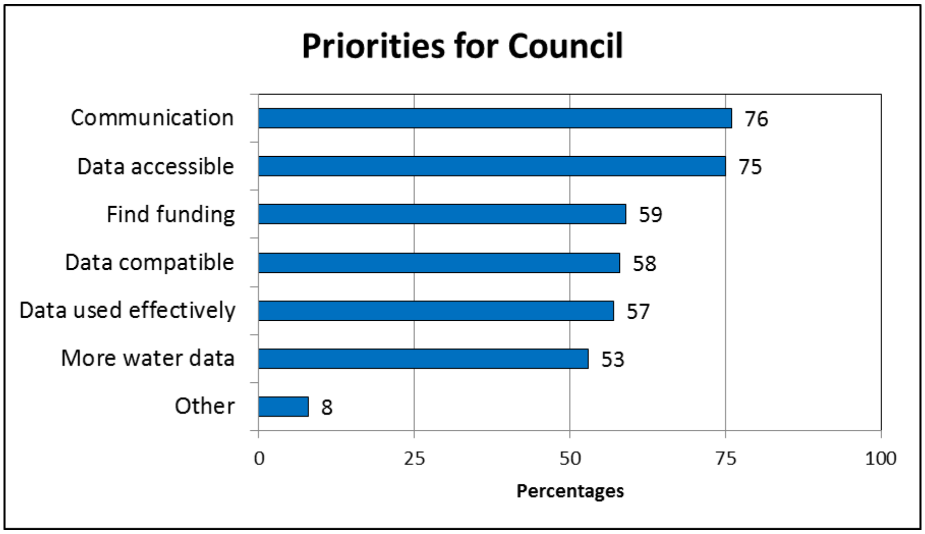

Figure 15. The most important priorities for a new Vermont Water Monitoring Council emerging from a recent survey. From presentation by Neil Kamman.

Emerging Remote-sensing Technologies for Studying the Vermont Landscape

Sean MacFaden[1], Jarlath O'Neil-Dunne[1], James Sullivan[2], and Adam Zylka[1]
[1] Spatial Analysis Lab, University of Vermont
[2] Transportation Research Center, University of Vermont

Remote-sensing techniques have long been used to monitor and characterize landscapes, providing important information on the structure and function of forests and component ecosystems. Specific applications include tree-canopy mapping, change detection, wildlife-habitat analysis, and forest-health assessment. Nationally, this work has been materially aided by the increasing availability of high-resolution remote-sensing data and improved processing methods, permitting efficient mapping and analysis of extensive landscape areas. Given the often substantial costs of acquiring high-resolution imagery, however, some of the newer remote-sensing data types have not been widely used to map and monitor landscapes in Vermont. Fortunately, this data gap is now being addressed. This presentation describes two of the most exciting and useful high-resolution remote-sensing technologies that are emerging in the state: Light Detection and Ranging (LiDAR) imagery and Unmanned Aerial Vehicles (UAV). LiDAR captures landscape features in both the horizontal and vertical planes, meaning that it offers the potential to map not only forest cover but also structural complexity, making it useful for stand delineation, canopy-volume calculations, and carbon stock estimation. Additional applications include assessment of vernal pools and other landscape features that are heavily dependent on topography. Meanwhile, UAVs offer near real-time color imagery and 3D representation of ground features, providing rapid assessment of individual forest stands, streams, wetlands, and anthropogenic features. This capability could be especially helpful in the immediate aftermath of storm events, providing damage estimates and highlighting areas where mitigative action is required. It will also be very useful to site-specific monitoring efforts for which acquisition of traditional, extensive remote-sensing imagery would be cost prohibitive.

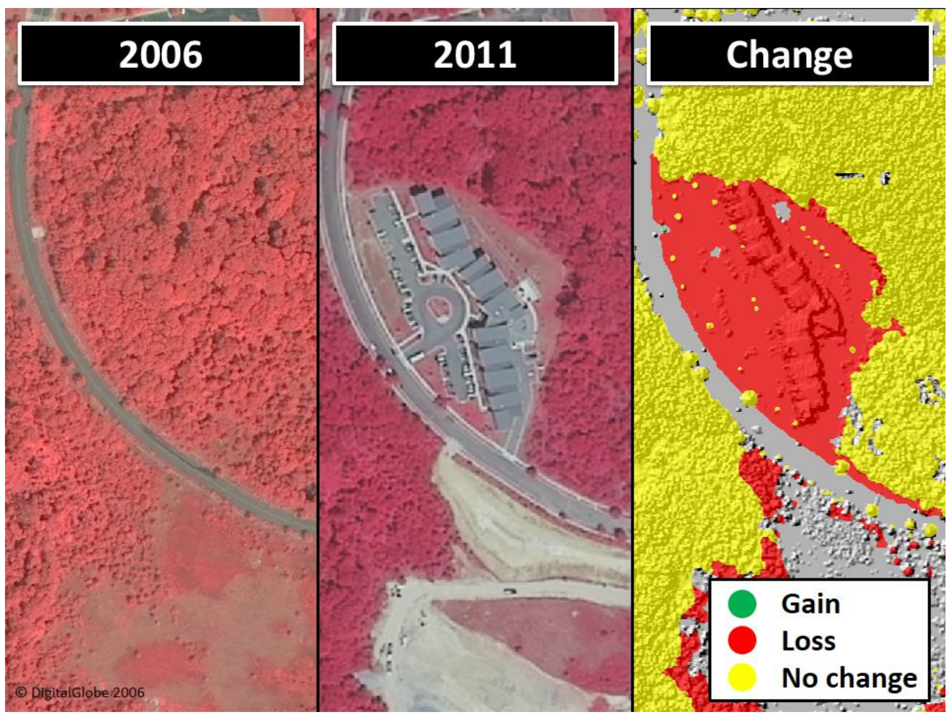

Figure 16. Mapping land cover change using LiDAR and emerging remote sensing analytical tools. From presentation by Sean MacFaden.

Collaborative Study and Management of the Camp Johnson Sandplain Forest

Denise Martin[1], Peter Hope[1], Valerie Banschbach[1], Doug Green[1], Declan McCabe[1], and **Doug Facey**[1]
[1] Department of Biology, Saint Michael's College

Camp Johnson, located in Colchester and controlled by the Army National Guard (ANG), contains one of the few remaining sections of sandplain forest habitat in Vermont. These forests are characterized by pitch pine (*Pinus rigida*) which require well drained, sandy soils and regular disturbance by fire. To maintain the sandplain forest community on the Camp Johnson property, controlled burns were conducted in 1995 (8 acres) and 1998 (the same 8 acres, plus an additional 6.5 acres).

Saint Michael's College is located adjacent to Camp Johnson, and beginning in fall 2006 the Biology Department restructured its introductory biology program to include semester-long student projects studying plants and invertebrates of the sandplain forest. Class projects from 2006 to 2011 focused on comparisons of trees, shrubs, and arthropods in burned and nearby unburned areas. In addition, several independent student research projects have focused on the Camp Johnson forest. Sharing of information obtained through these studies led to additional discussions between the SMC Biology Department and ANG, and resulted in a decision to implement additional burns and gather pre- and post-burn data.

In spring of 2012, areas to be burned were cut, with some wood left in place to provide fuel. That summer, students and faculty from SMC gathered data on the vegetation and arthropods in some of these areas, as well as nearby areas that were not to be burned. In May of 2013, 4 acres were burned, and pitch pine seedlings were subsequently planted in this area. Post-burn data are now being gathered; and more area may be burned in 2014.

The SMC Biology Department intends to continue this collaboration with ANG through future courses and research projects. Examples of some of the questions asked and data gathered will be presented at the conference.

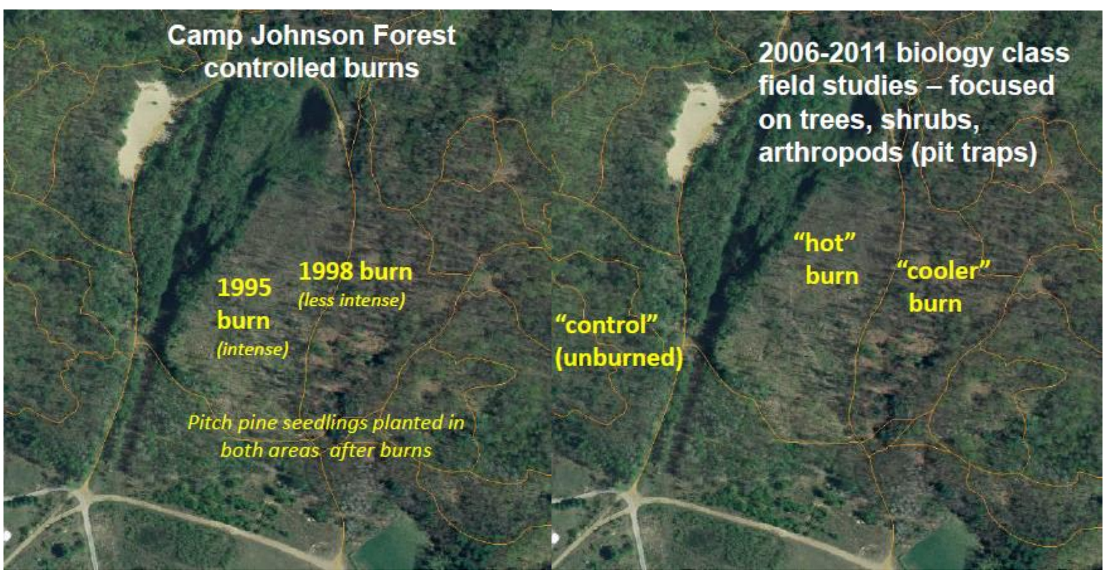

Figure 17. Student field surveys of sandplain forest regeneration following controlled burns at Camp Johnson, Vermont. From presentation by Doug Facey.

Remote Sensing of Spring Phenology in Northeastern Forests

Jennifer Pontius[1, 2], Katherine White[2], and Paul Schaberg[1]
[1] Northern Research Station, USDA Forest Service
[2] Rubenstein School of Environment and Natural Resources, University of Vermont

The timing of vegetation development is one of the most clearly observed terrestrial responses to changing climate. Current remote sensing studies of foliage emergence have been limited to coarse spatial resolution and often lack a direct link to field measurements. To address this gap, we developed remote sensing techniques to assess start of spring using Landsat TM 30m imagery and extensive field measurements. This allows us to compare trends and patterns on a landscape scale in order to better understand how climate is impacting forested ecosystems. However, because of widespread cloud cover during the spring season, Landsat (16-day return) estimates of the start of spring were complimented by MODIS (250m, 8-day nadir return) to compare trends and patterns in historical phenology.

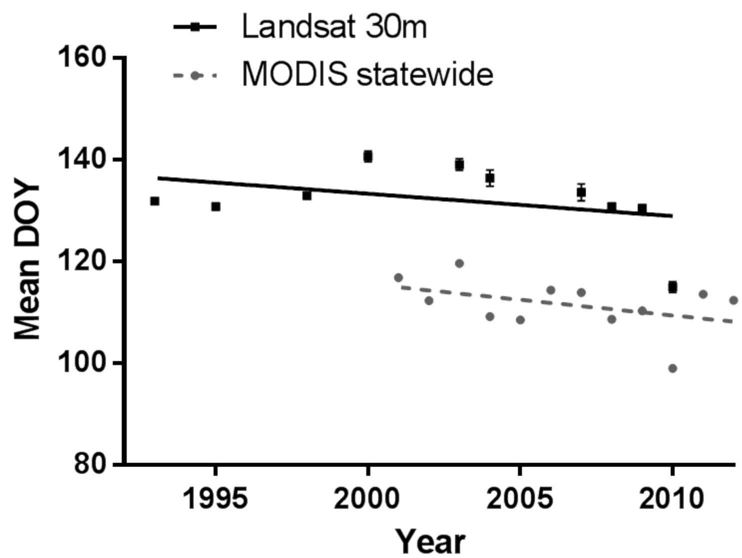

Figure 18. Long-term trends in forest phenology based on two satellite assessments. Both sensors show a significant trend towards earlier spring ($p < 0.0001$) over the past several decades. From presentation by Jen Pontius.

While year to year variability is high, our initial analyses of both Landsat and MODIS products indicate that spring is trending a half day earlier each year (Figure 1). In our Vermont study area, this change to earlier spring is most severe in lower elevation forests, closer to Lake Champlain, indicating that naturally warmer locations may be most sensitive. An examination of the larger MODIS coverage across the state shows that change to earlier spring is also more severe at higher latitudes.

These results suggest that climate change is impacting forest phenology over the past two decades, and that this change varies across our heterogeneous landscape. These changes likely have cascading impacts across forested ecosystems, from wildlife population dynamics to the economic vitality (sugar industry, tourism) of Vermont.

Maple Syrup Production Declines Following Masting

Joshua Rapp[1] and Elizabeth Crone[1]
[1] Department of Biology, Tufts University

Flowering and seed production are energetically costly, which is hypothesized to play a role in driving masting dynamics. For spring-flowering species, energy is drawn from non-structural carbohydrate (NSC) stored in woody tissues. We hypothesized these same NSC stores provide the sugar in xylem sap that is tapped to produce maple syrup, and that maple syrup yields and seed production should be coupled. Specifically, we expected that in sugar maple, a masting species: 1) carbohydrate stores as measured by soluble sugars in xylem sap would be depleted after masting; and 2) seed production would increase after a resource threshold is reached. We tested these predictions at the landscape scale using monitoring data on seed production from the North American Maple Project provided by the Vermont Monitoring Cooperative, and maple syrup production from the United States Department of Agriculture National Agricultural Statistics Service. Maple syrup production data, detrended to remove a decade-long increase in syrup production reflecting greater harvesting effort, declined in the year following a mast year, demonstrating a cost of reproduction to trees, and maple syrup producers. We also found evidence for a resource threshold beyond which trees attempt reproduction, and a positive relationship between seed and syrup production in the same year. In addition, even though weather during the sugaring season is a strong predictor of sap flow, seed production was a stronger predictor of maple syrup production than climate alone, although a model containing both seed production and climate best predicted syrup production. Our results show that reproduction-driven internal resource dynamics of trees can have impacts on economic activity, and the importance of long-term monitoring data for testing ecological theory.

Figure 19. Masting can affect levels of non-structural carbohydrate resources in sugar maples. From presentation by Joshua Rapp.

Integrated Social and Ecological Recreation Monitoring for Vermont's Forests

Nathan Reigner[1], Kelly Goonan[2], Carena van Riper[3], Jeremy Wimpey[4], Robert Manning[1], Chris Monz[2] and William Valliere[1]
[1] Park Studies Laboratory, University of Vermont
[2] Utah State University
[3] Texas A&M
[4] Applied Trails Research

Outdoor recreation is an important use of and contributor to forest health. It is a primary mechanism by which communities benefit from and individuals develop relationships with forest resources. Recreational use can have deleterious impacts to forest resources including wildlife disturbance, vegetation damage, soil erosions, and water quality impairment, among other impacts. Additionally, the quality of recreation experiences is dependent in many ways on the character and quality of forest resources that provide the setting for recreation.

While environmental impacts from recreation and the quality of recreational experiences are often studied independently, they are less frequently understood in a coupled systems context. Innovative spatial and social research conducted on Vermont's Camel's Hump mountain demonstrates an approach to monitoring and analyzing the quality recreational experiences and forest resource quality in an integrated way.

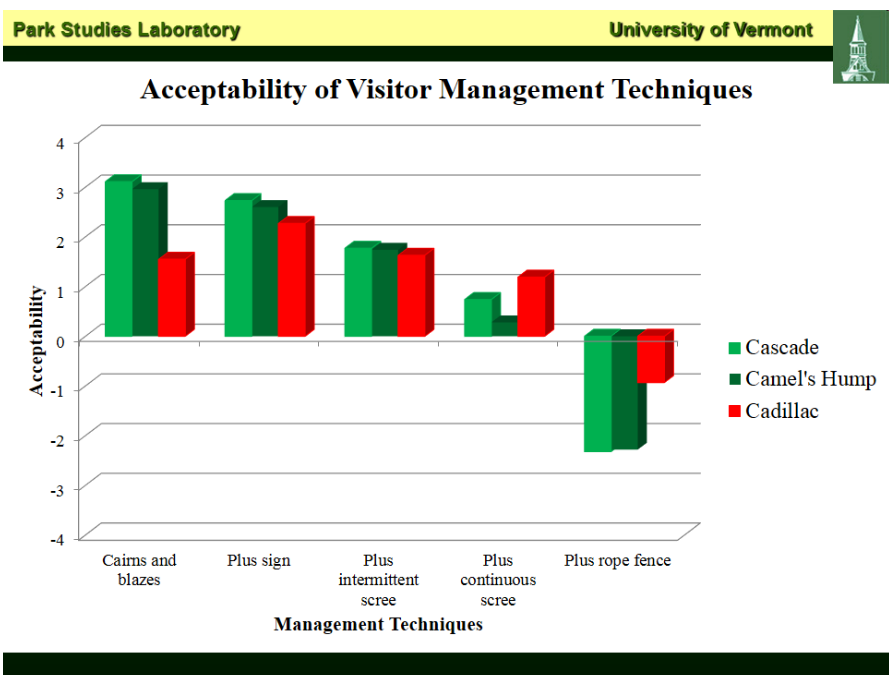

Figure 20. Different trail user management techniques vary in their acceptability to recreationalists on three northeastern mountains. From presentation by Nathan Reigner.

The study monitors: 1) recreation related environmental resource conditions on Camel's Hump, 2) recreationists' perceptions of environmental quality and recreation related impacts, and 3) recreationists' support for a range of management actions to mitigate impacts and enhance environmental quality.

The study demonstrates an integrated and repeatable method for monitoring environmental and recreational conditions, quantifies social and ecological indicators of quality, identifies potential standards of quality for social and ecological conditions, and evaluates the acceptability of a range of management actions. This study illustrates an approach that could be adopted at a spectrum of recreation sites throughout Vermont to establish an integrated social and ecological recreational monitoring network.

Long-Term Monitoring of Forest Soil Mercury by the Vermont Monitoring Cooperative

Don Ross[1], Jamie Shanley[2], Scott Bailey[3], Thom Villars[4], Sandy Wilmot[5], Nancy Burt[6], Neil Kamman[7]
[1] Department of Plant and Soil Science, University of Vermont
[2] US Geological Survey
[3] US Forest Service
[4] Natural Resources Conservation Service, US Department of Agriculture
[5] Vermont Department of Forests, Parks and Recreation
[6] Green Mountain and Finger Lakes National Forests (retired)
[7] Vermont Department of Environmental Conservation

Ongoing monitoring of mercury concentration in soils is essential for detecting, predicting and addressing environmental change. In cooperation with the Vermont Monitoring Cooperative, we have established a long-term soil monitoring study in five forested plots, three on Mt. Mansfield and two in the Lye Brook Wilderness Area. Elevation ranges from 590 to 1140 m with forest type changing 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 and 2012. Small pits were dug in the center of each plot and the soils were sampled both by genetic horizon and depth increments. These samples have been analyzed for a suite of chemical parameters, including exchangeable cations, carbon and nitrogen. Separate samples of the uppermost humified horizon (Oa or A) were taken for total mercury analysis using appropriate protocols. Average mercury concentration at each site ranged from 162 to 444 ug/g (standard error 7-56 ug/g). The average carbon concentration in these horizons varied between 97 and 417 g/kg. There was clearly a positive gradient of mercury concentration with elevation, consistent with greater deposition (and with other studies). The highest concentration was found near the 'forehead' of Mt. Mansfield and may pose a threat to high-elevation species, such as Bicknell's thrush. Challenges of the monitoring study include within site variability, continuity of sampling efforts and difficulties in sustaining support. Continued sampling at 5-year intervals will allow detection of environmental change in response to both a changing climate and changing mercury deposition.

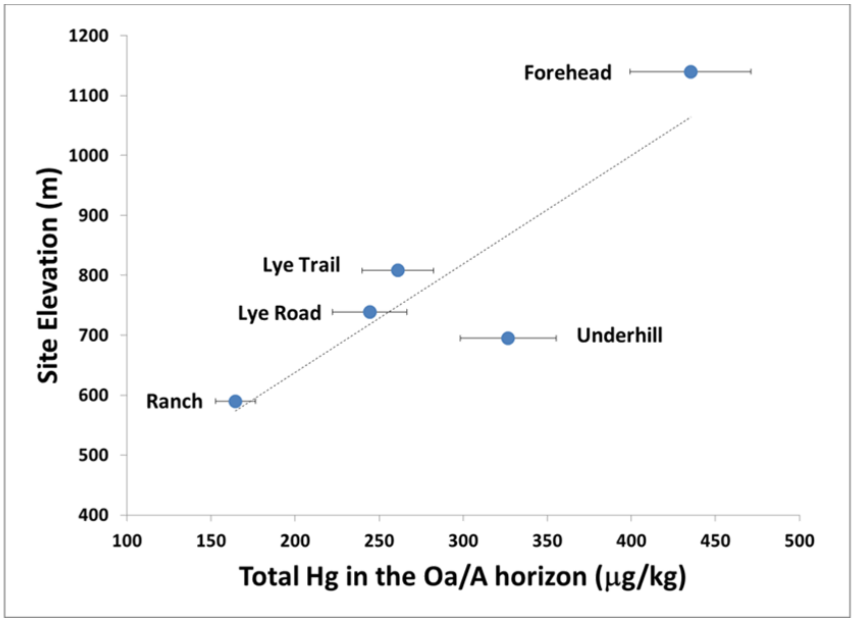

Figure 21. Concentration of mercury in the top soil horizons at different sampling elevations on Mount Mansfield and Lye Brook. From presentation by Don Ross.

A Preliminary Analysis of Relationships between Red Spruce Woody Growth and High-Resolution Pollution Critical Loads and Exceedance Values for Vermont and New Hampshire

Paul Schaberg[1], Benjamin Engel[2], Gary Hawley[2], Shelly Rayback[3], Alexandra Kosiba[2], Jennifer Pontius[1, 2] and Eric Miller[4]

[1] Northern Research Station, USDA Forest Service

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

[3] Department of Geography, University of Vermont

[4] Ecosystems Research Group

Acidic deposition depletes cations such as calcium (Ca) from forest soils and has been linked to the decline of red spruce trees in the northeastern United States. To better understand the spatial nature of the connection between Ca depletion and tree health and productivity, we used data from an existing geographically-referenced, steady-state model for New England and New York that produces fine scale (30 m) maps of critical loads (the capacity of a site to tolerate pollution) and exceedance (amounts to which incoming pollution exceeds the critical load) estimates for forests. We examined how woody growth (i.e., xylem basal area increment) of dominant and co-dominant red spruce trees within Vermont and New Hampshire is related to modeled estimates of critical loads and exceedance. This comparison was done by examining patterns of growth in red spruce xylem increment cores from sites with a wide range of modeled critical loads and exceedance levels. Exceedance was associated with average growth for the study period (1950-2010) overall, and for the 1970s and 1980s when acid deposition was at its highest, whereas critical load was associated with growth only for the most recent decade (2001-2010). An analysis of the rebound in growth from the region-wide 2003 red spruce winter injury event found that exceedance was linked with growth rebound both overall (2003-2010) as well as annually from 2006-2010, while critical load was not related to this rebound. Regression analyses found similar results, and may indicate potential linear relationships between exceedance and tree growth. Overall, our analyses suggest that modeled critical load and exceedance estimates can help account for tree growth variability and rebound from injury in the field, and that dendrochronological analysis may help infuse a temporal component to steady state critical load models that otherwise lack this context. Recent growth for red spruce exceeds average growth over the dendrochronological record – including growth decades before peak acid loading in the region. The cause of this recent surge in red spruce growth is currently unknown.

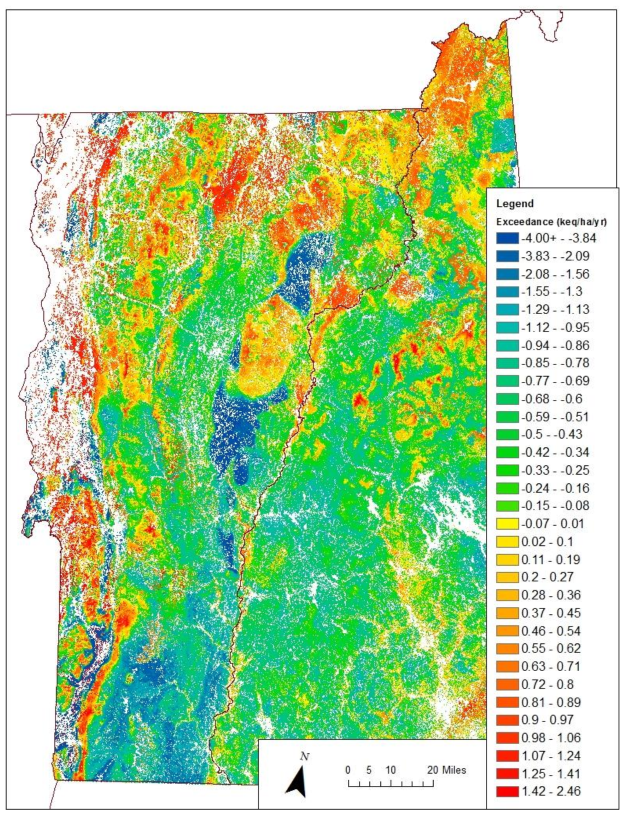

Figure 22. Exceedance of modeled ecosystem critical loads of pollutants for Vermont and New Hampshire. From presentation by Paul Schaberg.

Engaging Students in Resource Management & Monitoring through Experiential Education

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

The Rubenstein School of Environment and Natural Resources (RSENR) at UVM has identified community engagement as one of three core focus areas in its recent strategic planning efforts, highlighting experiential education (internships, service-learning courses, and applied research) as an integral component. Service-learning is a High Impact Practice[35] that gives students the opportunity to both apply what they are learning in the classroom in real-world settings and reflect in a classroom setting on their service experiences. In RSENR, service-learning courses such as *NR 1: Natural History and Field Ecology*, *NR 25: Measurements & Mapping*, *FOR 235: Forest Ecosystem Health*, *NR 140: Applied Environmental Statistics*, and *NR 206: Environmental Problem-solving & Impact Assessment*, students are engaged in diverse projects that help a variety of community partners better understand and monitor forest resources, from rural to urban, parcel-level to landscape-level. In 2012 RSENR entered into a partnership with the Vermont Urban & Community Forestry Program to fund a position that would both support service-learning courses in RSENR and align UVM students with municipal and volunteer forestry needs statewide; in the first year and a half of partnership, 21 service-learning projects and 3 internships specifically focused on urban and community forestry have been completed. This presentation is intended to inform VMC stakeholders of opportunities to engage in service-learning and internships in RSENR to achieve forest management and monitoring goals, how RSENR's Office of Experiential Learning can facilitate partnerships, and to present the value of these partnerships have for students, faculty, and community partners.

Figure 23. Rubenstein School students participating in an ecological restoration service learning course combine academics with community work. From presentation by Elise Schadler.

Forests and the Vermont Tourism and Recreation Economy

William Valliere[1], Lisa Chase[2], Robert Manning[1], and Greg Gerdel[3]
[1] Park Studies Laboratory, University of Vermont
[2] Vermont Tourism Research Center
[3] Vermont Department of Tourism and Marketing

Tourism and recreation are primary pillars of Vermont's economy. Much of this tourism and recreation is based in and on Vermont's forests and forest resources. Prominent examples include skiing, hiking, camping, maple and leaf-peeping. Indeed, from the "Green Mountain" moniker to the logos of successful Vermont brands, forests are essential to Vermont's identity.

Healthy and productive forests are intimately and necessarily connected with healthy and productive communities and individuals in our state. By providing settings for recreation and tourism, forests infuse communities with economic, ecological and cultural resources. Likewise, communities and individuals seek to satisfy their economic, ecological and cultural needs via recreation and tourism in and around forests.

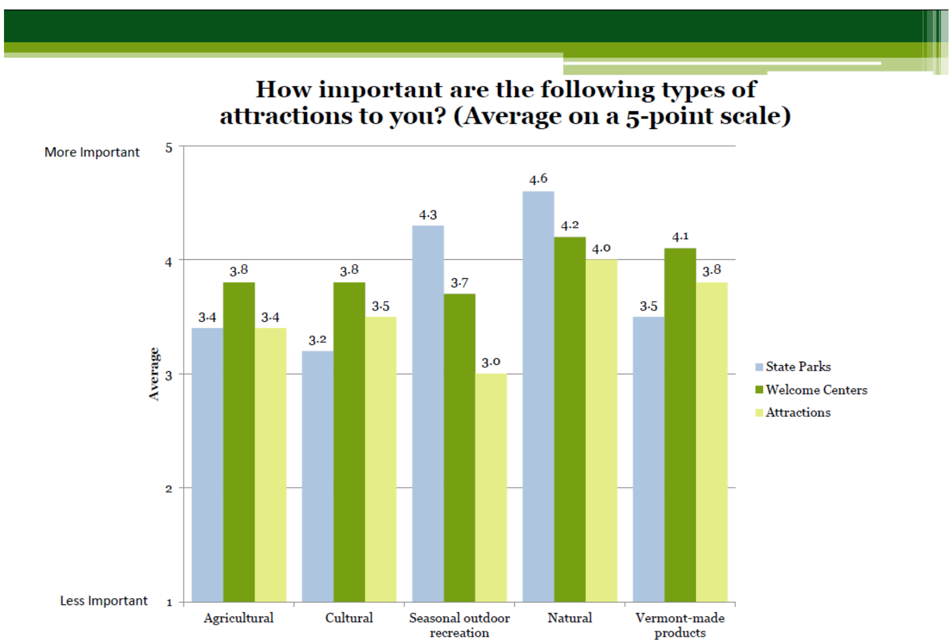

Figure 24. Tourists to Vermont value different natural resoruce amenities based on whether they were interviewed at a state park, a welcome center or at a state attraction. From presentation by William Valliere.

Understanding the social, economic and geographic impacts of Vermont tourism and recreation is an important of forest and natural resource management. A coordinated effort to understand these issues began in the spring of 2012 by surveying people who vacation and recreate in Vermont. Survey administration began in the summer of 2012 in selected state parks and selected attractions that are members of the Vermont Attractions Association. In October 2012, eight of Vermont's Welcome Centers were included in the survey procedure. This report presents interim findings from the survey. These findings demonstrate the connections between Vermont's forests and the state's tourism and recreation, and suggest how understanding and managing tourism and recreation can complement forest resource science and management.

Vermont's Soil Climate Analysis Network (SCAN) Sites at Lye Brook and Mount Mansfield – 10 Years of Soil Temperature and Soil Moisture Data Collection

Thomas Villars[1]
[1] Natural Resources Conservation Service, US Department of Agriculture

The Soil Climate Analysis Network (SCAN) of the USDA Natural Resources Conservation Service (NRCS) is designed to collect soil moisture, soil temperature, and local climate information on a real-time basis. In September 2000, the Vermont Monitoring Cooperative (VMC) partnered with NRCS to install SCAN stations at the two VMC research and monitoring sites. Above-ground sensors provide the information required for climate analysis and evapotranspiration calculations and below-ground sensors provide soil temperature and soil moisture at five depths (2 inches, 4 inches, 8 inches, 20 inches, and 40 inches).

The soils at the two SCAN sites have similar temperature characteristics. Based on 2000-2010 data, the mean annual soil temperature is 7.3 deg C at Mount Mansfield (2235 feet elevation) and 6.9 deg C at the Lye Brook shaded site and 7.2 deg C at the open, less shaded site (both at 2435 feet elevation). There is very little change in soil temperature between the months of December and April, with the soils appearing to "hibernate" through the winter months. Temperature gradually drops to near 0 degrees C, with deeper layers being slightly warmer than surface layers. The coldest daily soil temperatures are in late March to early April. On an average monthly basis, March is the coldest month.

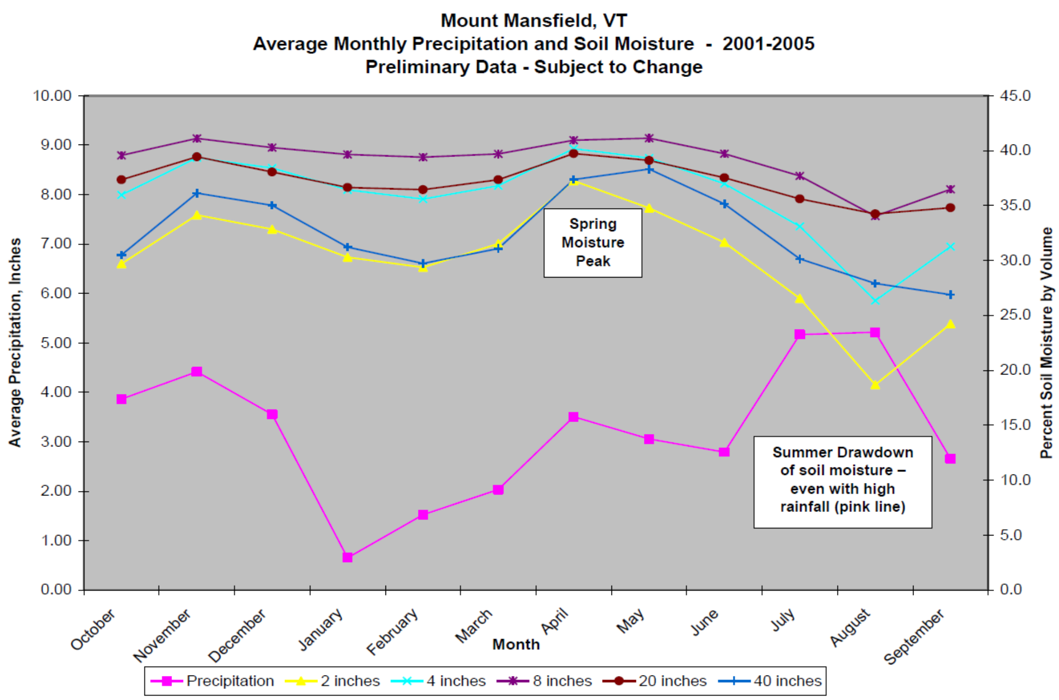

Figure 25. The connection between precipitation, soil depth and soil moisture shows some dependence on season. From presentation by Thomas Villars.

Similar to the Lake Turnover that occurs on large northern lakes, soils in northern climates undergo a spring and fall temperature turnover. In the summer, the upper layers of soil are the warmest, and in the winter, the deeper layers are warmest. Using SCAN data, a seasonal turnover in soils is defined as: *the date* *at which the temperature of the 2 inch surface layer sensor crosses over (or under) the temperature of the 40 inch sensor for the season.* The ten-year average date for the spring and fall turnover at the Vermont SCAN sites is mid-April and late September.

The soils at the two SCAN sites have similar moisture characteristics. The soils have the highest moisture content in the spring, typically in April. This seems to be more attributable to snowmelt than increased precipitation. All soils exhibit a drying-out in the summer months, regardless of precipitation levels. The 8-inch soil depth has the highest moisture levels – this is consistent in virtually all months of the year at both sites. There is a smaller moisture peak in the fall as trees start losing their leaves and evapotranspiration rates go down. Although not as distinct as in summer, there is a noticeable drop in soil moisture in winter.

Data is placed on the NRCS National Water and Climate Center SCAN website[36]. The website contains current and historical data for each SCAN site in the country.

[36] http://www.wcc.nrcs.usda.gov/scan/