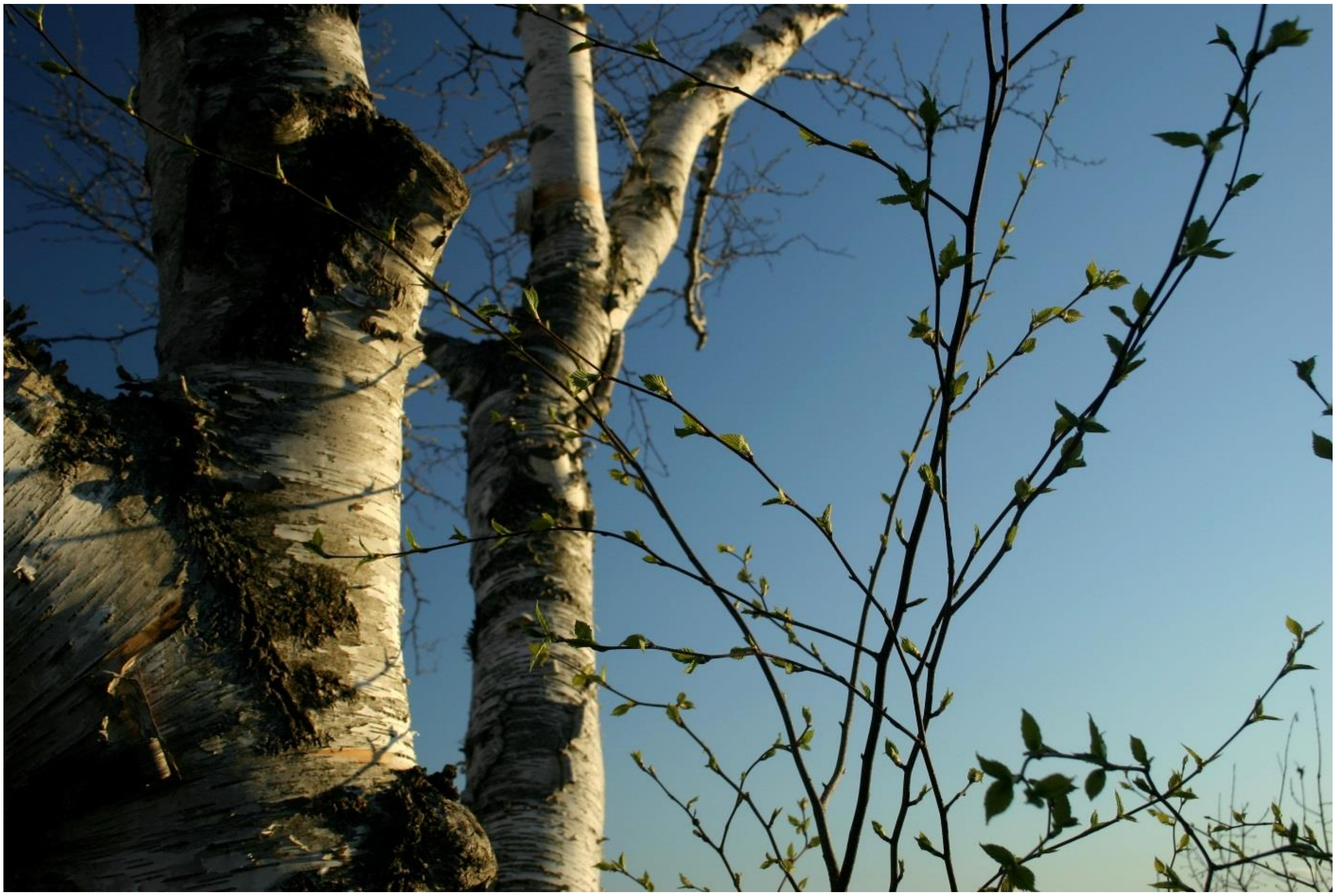
Davis Center • University of Vermont • Burlington, VT, USA



Vermont Monitoring Cooperative

Proceedings of the December 11, 2014

Vermont Monitoring Cooperative and **Mt. Mansfield Science and Stewardship** Conference

Science to Policy: Benefitting from Actionable Science

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

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

VERMONT AGENCY OF NATURAL RESOURCES   The University of Vermont   USDA FOREST SERVICE DEPARTMENT OF AGRICULTURE

Proceedings of the December 11, 2014 Vermont Monitoring Cooperative and Mt. Mansfield Science and Stewardship Conference

Science to Policy: Benefitting from Actionable Science

Published February 27, 2015

From material presented at the Vermont Monitoring Cooperative and Mt. Mansfield Science and Stewardship Conference
December 11, 2014
Davis Center
University of Vermont
Burlington, VT, USA

Contributing Editors: Jennifer Pontius, James Duncan, Miriam Pendleton, Judy 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 Agency of Natural Resources, the US Forest Service Northeastern Area State and Private Forestry and the University of Vermont. Thank you especially to Steve Sinclair, Director of Forests at VT FPR for moderating the morning session, and to Nancy Mathews, Dean of the Rubenstein School of Environment and Natural Resources, and the UVM Planning Office for providing financial support to keep the meeting free and open to the widest audience of stakeholders. This work was produced in part through funding provided by the U.S. Department of Agriculture, Forest Service, Northeastern Area - State & Private Forestry.

Preferred Citation: Pontius, J., J. Duncan, M. Pendleton, J. Rosovsky, and C. Waite (Eds.) 2015. Science to Policy: Benefitting from Actionable Science. Proceedings of the December 11, 2014 Vermont Monitoring Cooperative and Mt. Mansfield Science and Stewardship Conference: Burlington, VT, Vermont Monitoring Cooperative. Available online at http://www.uvm.edu/vmc/annualMeeting/2014/proceedings.

Table of Contents

Introduction

The 2014 Vermont Monitoring Cooperative annual conference at the University of Vermont's Davis Center on December 11, 2014 was cosponsored by the University of Vermont Environmental Program in celebration of the 40th anniversary of the UVM Natural Areas Program. The theme **"Science to Policy: Benefitting from Actionable Science"**, reflects the growing awareness of the important role that science plays in both management and policy arenas. The need for science to reach a broader set of stakeholders in order to maximize its impact has been a recurring topic at VMC meetings throughout the past year. However, bridging this gap is not always easy. While we as researchers, scientists and land managers often include the general public in our outreach efforts, we all-too-often fail to communicate our findings to policy makers and resource managers in an effective way. The challenge to our community is to provide useful information to the appropriate decision makers in a timely manner. Our morning speakers provided expert tips, based on their own successes, on how to engage management and policy makers. Speakers represented a variety of views from federal to state and local government, and included non-governmental and private sector viewpoints. All elucidated that it takes citizen and scientist involvement to incorporate good science into crafting sound policy governing Vermont's forested ecosystems and natural environment.

The meeting also introduced and promoted a vision for a Mt. Mansfield Science and Stewardship Center proposed at the top of the mountain. A "special track" afternoon session was dedicated to bringing together Mt. Mansfield researchers and stakeholders to help inform the development of a research and education program currently under consideration. Engaging potential users of such a center is essential to ensuring its long-term utility and success.

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. Bluebirds in a sugar maple thicket.

Plenary Session: Insider advice on maximizing the impact of our work at local, regional and national scales.

Executive Summary

While diverse in their individual policy arenas, our plenary speakers all agreed that it is critical for researchers, scientists and others who monitor and distribute environmental data to share their information, ideas and expertise with policy makers and resource managers at all levels (local, state and federal). This is a crucial part of ensuring that sound science-based policy is written and implemented. The first step is knowing how to **identify and engage** policy makers at the appropriate level. It is equally important to understand **how information moves** through policy arenas so that our expert advice can be considered at appropriate times for maximum impact. The final piece is knowing how to **tailor information** appropriately. While the process varies across agencies, legislative bodies and jurisdiction, it is always critical that we deliver information as a clear and concise message, using terms and language easily understood by the average Vermonter. Our plenary went on to provide additional tips to maximize our collective impact in ensuring the sustainability of Vermont's forested landscape.

How to engage

There are many levels to natural resource governance. Federal legislation is necessary to affect regional or global environmental issues. But often change is necessary and possible at a more local level. Our plenary speakers encouraged each of us to consider if we can share our findings, or provide our expert opinion by serving on local environmental boards or conservation commissions. Keeping an eye on legislation currently under consideration at the state level also provides an opportunity to provide expert testimony before legislative committees. In small states such as Vermont, we are fortunate to have access to our representatives and governing committees simply by request. When legislation comes up for debate it often takes a simple call to have our testimony included on the committee agenda. Participating in collaborative groups such as the Vermont Natural Resource Council's Vermont Forest Roundtable, or getting involved in scientific technical committees such as Lake Champlain Basin Program's Technical Committee are other excellent ways to make a difference and contribute toward policy decisions based on sound and defensible science.

Most speakers admitted that the legislative process can be long, convoluted and daunting, but assured the audience that the final product is worth the effort. Rep. Rebecca Ellis, in particular, provided tips on how to more easily navigate the state legislative process (Table 1, Page 9). Partnering with other groups, particularly forming seemingly unlikely coalitions can provide added weight to the opinions presented to the legislature. Similarly, engaging and educating the general public provides additional incentive for legislators to address key issues. Working with legislators early on is also instrumental to build support for legislation and facilitate its movement through committee. Mr. Fidel and Secretary Markowitz both cited the Shoreland Protection Act, passed in 2014, as an example of these tactics put into action. A strong coalition was able to present both the public and legislators with sound science, making a clear case that new regulations were needed. Constituents in turn lobbied their legislators to support the legislation in a collaborative grassroots effort that resulted in the passage of the Act.

Current issues for engagement

Fragmentation

Speakers agreed that forest and agricultural land fragmentation and parcelization (subdividing larger parcels into smaller units for the purpose of converting them to housing and other development) continue to constitute the greatest challenge to the resiliency of Vermont's forests. This issue is expected to be a major topic of discussion during upcoming legislative sessions. Continued funding of the Vermont Use Value Appraisal (Current Use) Program, which assesses property taxes at lower rates based on continued forest or agricultural uses, and the recent addition of new wilderness acreage to the Green Mountain National Forest were cited as two ways of addressing this challenge.

Wind

Secretary Markowitz and Mr. Berry pointed to "big wind" development (i.e. Kingdom Wind) as areas where specific knowledge and data about long-term environmental impacts such as effects on wildlife, water quality and forest fragmentation have not been readily available. Mr. Berry identified questions related to big wind development projects that remain unanswered by science, such as "Does ridgeline wind development make sense in the long term?" and "Is this amount of energy generated worth the economic and environmental costs?" Secretary Markowitz remarked that taking 40 years to get answers to some of these questions is not an option when decisions need to be made within weeks or months.

High Elevation Research and Monitoring

While describing the benefits and many contributions of biological field stations (i.e. Proctor Maple Research Center) and high elevation field stations in particular (i.e. Mt. Washington Observatory - focusing primarily on meteorology), Mr. Lambert pointed out there are no alpine biological stations located in the northeast, a critical gap that hinders our ability to understand these complex ecosystems and their potential response to changing environmental conditions. He introduced a collaborative vision for a Mt. Mansfield Science and Stewardship Center to serve as a long-term research, monitoring and education center, building off the wealth of research conducted on the mountain over the past several decades, and the existing infrastructure available for use. This facility would increase our knowledge of ecologically fragile high elevation areas and greatly enhance our ability to inform policy decisions about these sensitive high elevation locations, particularly important in light of the expected increase in development pressures. It would bring together researchers, teachers, and students to stimulate new research and ideas, and provide even more information to help address not only current challenges, but future issues related to changing climate.

Conclusions

Final thoughts shared by our speakers were that Vermont is a small state where "everyone knows everyone else". We can remain passionate about an issue, but need to respect and consider differing views, be willing to compromise and keep the discussion civil at all times.

Researchers and scientists must be willing to move out of their comfort zone and provide high quality, timely information without waiting for absolute certainty or final conclusions. We must weigh-in to help inform, draft and implement sound environmental policy based on the best science available.

Deb Markowitz, *Secretary, Vermont Agency of Natural Resources*

Secretary Deb Markowitz of the Vermont Agency of Natural Resources (ANR)[1] led off the discussion and got to the "nuts and bolts" of transforming science to policy. She explained that decisions and recommendations that she and ANR must make on an almost daily basis need to be grounded in and backed by good, sound science to give credibility to those decisions. This mandate to use science to support regulatory and policy decisions is sometimes slowed by the fact that there is always uncertainty associated with our results, making many scientists reluctant to give definitive answers or recommendations.

Figure 2. Deb Markowitz addressing the Vermont Monitoring Cooperative Conference.

Citing the Kingdom Wind Project as an example, Secretary Markowitz explained how she reached out to her ANR scientists to determine what effects development on this scale would have on water quality and other environmental conditions. She was told it would take *40 years* to find those answers! She also stated that researchers and scientists are often mired down by the "precautionary principle" which says "when in doubt, protect the resource". This problem is compounded by the language disconnect between scientists, and policy makers and the public to whom they are trying to deliver information. As "translator-in-chief", the Secretary tries to bridge that gap, to see that accurate yet understandable information is provided to those in policy making roles within the legislature, and to the public.

Secretary Markowitz believes that scientists can influence successful policy outcomes when they become directly engaged with the public. The "Shoreland Protection" legislation passed during the 2014 session was a success story because scientists engaged in dialogue with the public. Building on public perceptions that clear-cutting a swath to the shoreline was "ugly", scientists provided information on the impacts of land clearing on water quality that was persuasive enough to garner public support. The public in turn, through grassroots efforts, lobbied their legislators to support the legislation.

> *"We really need to lift science but also work with our scientists to understand the context [policy makers] operate in."*
>
> ~ Deb Markowitz
>
> Secretary, Vermont Agency of Natural Resources

The Secretary listed climate change as a critical issue in Vermont that will need sound science to support policy and effect change. Vermont's 4.2 million acres of forests are the foundation of Vermont's ecosystem health, water quality, and economic strength. How can policy be written that can accommodate increased population while preserving forests, 86% of which is privately owned by an aging population? Forest fragmentation and parcelization has a huge impact on forest integrity. Scientists must first explain this to the public and then policy needs to be formulated that prioritizes and provides incentives for forest integrity.

---

[1] http://www.anr.state.vt.us/

Tom Berry, Policy Advisor on Agriculture, Conservation, Energy and Natural Resources to Senator Patrick Leahy

While ANR and Secretary Markowitz are listening to scientists and want to empower them to speak out on and help draft sound environmental policy, the view from the Federal level is more complicated. **Tom Berry, Policy Advisor on Agriculture, Conservation, Energy and Natural Resources to Senator Patrick Leahy[2]**, discussed how funding for various agencies can be politicized with little regard to science. In fact in some cases, riders can be added to bills specifically preventing collection of scientific data or extending protection to certain species. Add to this the seemingly constant threat of government shut-downs, and applying science to guide policy decisions becomes more difficult.

Mr. Berry outlined the funding for various agencies; the EPA funding for Lake Champlain (LC) cleanup and Great Lakes Fishery Commission funding for LC fisheries restoration are up from previous years because of efforts based on sound science implemented by the Lake Champlain Basin Program's (LCBP) Technical Committee. Priorities are established by this group and monitoring and research projects funded using a transparent process. His advice to the audience was to get involved in local technical committees to assure good information is available to develop sound policy. The value of organizations like the Northern Forestlands Council and its more than twenty year record of informing policy championed by Senator Leahy on forest fragmentation, farmland protection and acid deposition was emphasized.

Figure 3. Tom Berry addressing the Vermont Monitoring Cooperative Conference

Mr. Berry also stated the importance of getting your policy-makers out to see for themselves what is happening on the ground. He recounted a trip led by UVM researcher, the late Hub Vogelmann, to the top of Camel's Hump with Senator Leahy, then-Governor Kunin and several federal officials to look first-hand at the devastation to the high elevation forests being caused by acid rain deposition. This experience catalyzed Senator Leahy's interest in atmospheric pollution and he later worked to reduce mercury pollution coming to Vermont from these same sources. Although these one-on-one interactions with legislators are important, it is also necessary to work with other scientists to amass a clear and powerful body of evidence. This ensures that expert opinion is not considered biased, but grounds it a wealth of science that is more difficult to be ignored or discredited.

[2] http://www.leahy.senate.gov/

Examples were given by Mr. Berry of areas where science was either unavailable or insufficient to guide policy decisions. The first was a federal budget vote to extend the tax credit for wind energy development. It was difficult for lawmakers to make an informed decision when several key questions could not be answered: How much energy is being generated? Is it worth the economic and environmental costs? Cormorant and lamprey control on Lake Champlain and the expansion of wilderness in the Green Mountain National Forest were other examples where the science has been ambiguous, lacks consensus or is simply unavailable. Mr. Berry stated that in such cases decisions are often driven more by politics than science.

> *"There are a lot of opportunities to communicate in Vermont… with policy makers… and weigh in on issues."*
>
> ~ Tom Berry
>
> Policy Advisor on Agriculture, Conservation, Energy and Natural Resources to Senator Patrick

Despite these difficulties, Mr. Berry gave some hope by pointing out that because Vermont is such a small place, there are a lot of opportunities to connect with legislators, and scientists should take advantage of this to weigh in on policy decisions.

Rebecca Ellis, *Vermont State Representative and Vice Chair of the House Natural Resources & Energy Committee*

Rebecca Ellis, Vermont State Representative[3] and Vice Chair of the House Natural Resources & Energy Committee echoed that sentiment and gave her local perspective on maximizing the influence of science on policy, while providing concrete examples of the use of science in the judiciary. Her first example used data collected by VMC cooperators to successfully defend a lawsuit brought by fluorescent lamp manufacturers, against Vermont's law requiring labelling of products which contain mercury. In that suit, Dr. Tim Scherbatskoy, former VMC Research Director, presented convincing evidence on the pathways through which mercury enters the environment. The resulting legislation required that products containing mercury sold in Vermont be labelled so they can later be properly recycled. The next example was the American Electric Power (AEP) case brought by Vermont and other northeastern States, and which was settled with the agreement that AEP would clean up several coal-fired utility boilers, which VMC data showed, were sources of emissions that cause "acid rain". The final example was a successful defense of the California air standards rule which sped implementation of greater fuel efficiency in automobiles to help counteract emissions caused by the burning of fossil fuels and linked to climate change. She encouraged continuing with this kind of research and monitoring work, which generates information that can be crucial in the judicial process.

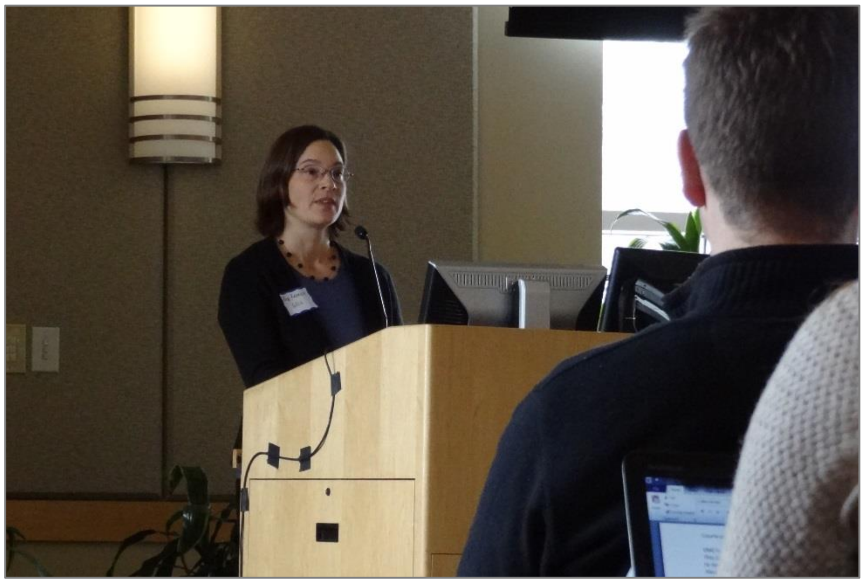


Figure 4. Representative Rebecca Ellis addressing the Vermont Monitoring Cooperative Conference

Turning to the local level, Rep. Ellis also recounted her time as chair of the Waterbury selectboard at a time when high elevation zoning regulations were being developed. The board had benefitted from having members with technical skills and she encouraged those in the audience with specialized skills and knowledge or simply an aptitude toward compromise to serve on local boards, commissions and committees to bring that expertise to bear on local problems and issues. Rep. Ellis cited high elevation zoning as being an important local issue for many towns, including Waterbury and commended VMC cooperators for the wealth of data and information available through the VMC database that can be used by local governments and others to help shape management and policy decisions. She noted that Waterbury is working on resiliency after the flooding caused by Tropical Storm Irene and has used Research on Adaptation to Climate Change (RACC) data to predict future resiliency, which has been very helpful in determining property values of floodplains, for example.

[3] http://legislature.vermont.gov/people/single/2014/16340

> *"It is much, much easier to kill a bill than to get a bill passed... so don't let perfection be the enemy of the good."*
>
> ~ Rebecca Ellis
>
> Vermont State Representative and Vice Chair of the House Natural Resources & Energy Committee

To affect environmental policy through the legislative process, Rep. Ellis presented eight specific tips to ensure that scientific testimony and viewpoints are heard (Table 1, next page). Introducing a bill to the Legislature is easy, but getting it through both houses and passed into law is not. By getting involved early in the process, developing personal relationships with legislators, collaborating and compromising with other interested parties and keeping testimony simple, scientists can help create the best legislation; also keeping in mind that the idea is to reach consensus while being positive and polite. Be flexible and "don't let perfection be the enemy of the good".

The issues that Rep. Ellis predicted would be at the top of the 2015 legislative agenda are the use of forests for generating electricity, a proposed carbon tax, and forest fragmentation. With legislation on Vermont's renewable energy portfolio likely being revisited, and changes to Act 250 that would address forest fragmentation in the offing, the time for involvement in the process is now. The legislature has a website to keep the public informed[4], which she encouraged meeting attendees to use.

[4] http://legislature.vermont.gov/

Table 1. Eight tips for Influencing Policy in the Vermont Legislature.

Define Your Goals	Do you want to comment on a bill that is in a committee? Do you want to express your support or opposition to a bill? Do you want to be part of the process of developing a piece of legislation and its parameters?
Start Early	It's relatively easy to get a legislator to introduce a bill, but what's hard is getting a committee to take an interest in the bill, getting the bill passed out of committee, getting it passed out of the chamber, and then to doing the same thing again in the next chamber. For big pieces of legislation, you should start working on a bill (or an idea) months before the session starts.
Identify Partners	Whether you simply want to comment on a bill, or you want to initiate a new piece of legislation, you will need partners who are knowledgeable about the legislative process (i.e. Vermont Natural Resources Council).
Develop Relationships with Legislators	You should get to know your own legislator, and perhaps a few others, on some of the relevant committees. When the legislature is out of session, you can invite legislators to meet you in your office or research facility, or maybe in a forest, or at a monitoring station. You should seek out the members of the House and Senate Natural Resources Committees, members of the House Agriculture and Forest Products Committee, the House Ways and Means Committee, and the Senate Finance Committee.
Develop Relationships with other Stakeholders	The legislature will be listening to them, and so should you. Do you have areas of common ground? Can you agree to work together on some of parts of the bill, even if not all of it? Odd bedfellows can surprise the legislature and really help a bill move forward.
Remain Flexible	Rarely does a bill get passed without some compromise. You need to figure out ahead of time what is essential to you and what can be sacrificed: Is there enough in this bill to keep fighting for? Is something, even a little something, better than nothing? Remember that it's a lot easier to kill a bill than to get a bill passed. *Don't let perfection be the enemy of the good.*
Keep Your Testimony Simple	Unless you are the lead sponsor of a bill, you will likely have 30 minutes, or maybe only 10 minutes, to explain your position. Your handout should be 2 pages or less. Do you have one or two simple charts that explain the point you are trying to make? Find out in advance from the committee assistant how much time you will have, how far along the committee is in considering the bill, and what the sticking points are in the legislation.
Be Pleasant	Legislators are people too. They are doing their best to resolve differences, balance competing interests, and come up with good law. Getting angry or frustrated is not a good strategy. You live in Vermont. Everyone knows everyone.

***Jamey Fidel**, General Counsel & Forest and Wildlife Program Director, Vermont Natural Resources Council*

After hearing ideas primarily from government insiders on how to translate science to policy, we switched gears and explored this concept from the viewpoint of a non-profit advocacy organization. **Jamey Fidel, General Counsel & Forest and Wildlife Director of the Vermont Natural Resources Council (VNRC)**[5], explained how his organization uses an integrated approach to advance sound environmental policy in Vermont.

Figure 5. Jamey Fidel addressing the Vermont Monitoring Cooperative Conference

Mr. Fidel spoke to the issue of forest fragmentation and reiterated that most of the forestland in Vermont resides in smaller, privately-owned parcels. This ownership pattern yields significant challenges to promoting sustainability and providing continuity in ownership, land use and management practices. Particularly challenging is the statewide pattern of large parcels being broken up into smaller lots and developed, much of it for single family dwellings. In light of these challenges, the VNRC convened the Vermont Forest Roundtable to provide an open forum for people with a wide range of perspectives to exchange information, and where possible, develop recommendations for policy changes. The Roundtable has addressed multiple topics, including trends in Vermont's real estate market and rising forestland values, property tax policy, land use and conservation planning, estate planning, landowner incentive programs such as the Use Value Appraisal (Current Use) Program, and the long-term sustainability of the forest products industry. By focusing on areas of agreement among the participants, policy addressing fragmentation is currently being developed[6].

> *"It's not enough to just talk about it today. We need to keep evolving our understanding how we partner and bridge the science and advocacy."*
>
> ~ Jamey Fidel
>
> General Counsel & Forest and Wildlife Program Director, Vermont Natural Resources Council

In another example, Mr. Fidel demonstrated how a lack of consensus can impede the passage of a bill. Because Act 250 does not

[5] http://vnrc.org/

[6] http://vnrc.org/programs/forests-wildlife/

address forest fragmentation, a bill was introduced to address this issue. However, without widespread support, including the forest industry, that bill was deemed too overreaching and was not passed. This demonstrates the importance of developing consensus with other stakeholders before moving ahead with legislation.

In concluding, Mr. Fidel stated that advocacy groups aren't enough – getting science transformed into policy takes a multi-pronged approach. The basic concept needs to be articulated in plain English and supported by science with the input of other stakeholders. Constituents need to be mobilized to help influence the legislature, because without this support a bill often fails. All of this is necessary to get to policy implementation and on-the-ground action. It isn't enough to just talk about this today, we need to keep working towards bringing science and advocacy together to work toward formulating sound environmental policy.

Dan Lambert, Conservation Project Leader, High Branch Conservation Services

The final morning speaker was **Dan Lambert, Conservation Project Leader from High Branch Conservation Services**[7] and a consultant working with the partner organizations planning a research and education facility on the summit of Mt. Mansfield, dubbed the Mount Mansfield Science and Stewardship Center (MMSSC). Mr. Lambert began by setting the stage for a place-based science and stewardship center as a tool for promoting healthy alpine and subalpine ecosystems. He said that consistent observations at the same location year after year are necessary to inform the severity and impact of current environmental problems, and give us the information necessary to find appropriate solutions. Forests are healthier today because of research conducted at places such as the Proctor Maple Research Center (PMRC)[8], Hubbard Brook[9] and the Bartlett Experimental Forest[10]. As an example, basic and applied research conducted at the PMRC have provided valuable information on sugar maple health, management of the species for maple syrup production and maple sugaring practices of interest to many, including forestry and industry professionals. These are national assets which are necessary to understand our rapidly changing world.

Figure 6. Dan Lambert addressing the Vermont Monitoring Cooperative Conference

Mr. Lambert stressed that mountain environments are particularly sensitive to environmental perturbations and long-term field stations provide the opportunity to monitor changes in climate, biodiversity, species biology, hydrology and many other factors. These high elevation systems can also become agents of positive change - CO_2 concentrations tracked over the past 50 years at the Mauna Loa Observatory[11] in Hawaii are a crucial record showing the rapidly increasing trend in global concentrations - information used by the Intergovernmental Panel on Climate Change to link human actions to climate change. The Sierra Nevada Monitoring Program[12] in Spain, provides an analog to the VMC in that its programs also monitor many different ecosystem components including ecosystem services to measure impacts and benefits of natural areas, and factors specific to management evaluation. Also mentioned were the Japanese Alps Geoenvironmental Reclamation Program, with an integrative focus on the vital connection between forests and waters, and the Rocky Mountain Biological Lab which is known as a "nursery for thought leaders".

Mountain biological research stations are rare, and in the northeast, Mt. Washington Observatory[13] is the only example - focusing primarily on meteorology with little information on biological components. To

---

7 http://highbranchconservation.com/

8 http://www.uvm.edu/~pmrc/

9 http://www.hubbardbrook.org/

10 http://www.fs.fed.us/ne/durham/4155/bartlett.htm

11 http://www.esrl.noaa.gov/gmd/obop/mlo/

12 http://obsnev.es/

13 https://www.mountwashington.org/

better understand how our environment is changing such long-term stations are necessary. But there is also an increasing interest in sharing these data in global networks, providing an opportunity to address issues from local to regional and global scales. VMC has a track record of linking into regional and national networks, with examples such as the long-term work on acid precipitation[14], Mountain Bird Watch[15], ultraviolet-b[16] monitoring, and soil monitoring networks[17]. Contributions from these networks have provided important data and information to inform policy, for example the Mountain Bird Watch program has done work at Mt. Mansfield that has been used in the Adirondacks and the Dominican Republic to inform conservation efforts. A holistic understanding only occurs when we link across scales and disciplines to advance knowledge. This type of convergence happens best over "dinner table" conversations because these discussions lack disciplinary boundaries, and biological field stations provide a conducive venue for these discussions.

> *"Field stations sustain ecosystems and their services by shaping policy and practice."*
>
> ~ Dan Lambert
>
> Conservation Project Leader, High Branch Conservation Services

Mr. Lambert concluded by saying we have a unique opportunity to create such a center on the summit of Mt. Mansfield. The collaborators championing the MMSSC envision a program and a facility that can serve as a hub to bring together researchers, educators and students, and at the same time provide a place to showcase their work, interact with the public and generate information needed and public support to spur ecologically responsible policy and management decisions.

---

14 Vermont Acid Precipitation Monitoring Program - http://www.uvm.edu/vmc/project/vermont-acid-precipitation-monitoring-program, NADP National Trends Network - http://www.uvm.edu/vmc/project/national-atmospheric-deposition-programnational-trends-network.

15 http://vtecostudies.org/projects/mountains/mountain-birdwatch/.

16 http://www.uvm.edu/vmc/project/uv-b-monitoring-station-usda-national.

17 Soil Climate Analysis Network - http://www.uvm.edu/vmc/project/soil-climate-analysis-network-scan, Long-term Soil Monitoring - http://www.uvm.edu/vmc/project/long-term-soil-monitoring.

Summary of Working Sessions

Getting the Most Out of the New Vermont Monitoring Cooperative Website and Database

Organizer: Jim Duncan, Data and Web Coordinator, Vermont Monitoring Cooperative

For over a decade, the VMC has maintained a repository of information about the monitoring and research conducted on Vermont's forested ecosystems. This has ranged from a literal card catalog of paper information to an in-house database to a fully-developed, database-driven website. Following a data management review in November, 2011, several issues were identified that, in total, necessitated a full redesign of the database and web portal. Over the past 2 years, VMC has been working to upgrade the database and website to meet the needs for data access and preservation that its partners have come to expect. At this working session, participants were introduced to the new website and database, including the changes implemented and how to use some of the sophisticated new features of this resource.

Figure 7. The homepage of the new and improved Vermont Monitoring Cooperative website.

VMC Data Management Mission

The redesign of the VMC website and database represent an approach to data management built around three desired outcomes (Table 2). The goal is to centralize as much information as possible relevant to monitoring the long-term trends and conditions in the region's forested ecosystems.

Table 2. Desired outcomes from VMC data management mission, and specific approaches.

Preservation and Integration	Archive data and related information Link content to create an easily traversable web of information
Discovery and Access	Documentation in machine-readable formats Federation to other catalogs Easy download
Use	Promote broad access and distribution of ecological data through the website Contribute to research and monitoring body through individuals and other repositories

These goals are achieved by a paper repository in the VMC office, a digital repository on the University of Vermont servers, a relational database documenting key project and dataset information, and a public-facing website. In addition, VMC provides outreach and a number of services as part of its data management activities.

Improvements in the Database

The first step in redesigning the repository was to improve the existing database structure to reflect the true nature and content of VMC's data. This included activities ranging from cleaning up existing metadata to entirely restructuring relationships between elements to capture the exact nature of projects. All these efforts were geared towards making VMC's archive more understandable and accessible, and implementing industry- and discipline-specific standards for metadata documentation. Some highlights from this effort include:

- The implementation of Ecological Metadata Language to structure and describe VMC's data holdings[18];

  The description of existing taxonomic records using standard taxonomic identifiers from the Integrated Taxonomic Information System[19];
- The addition of spatial coverage and querying for projects and datasets;
- Clearer and more consistent linking between objects such as projects, datasets, people and documents to make it easier to package information and describe our resources;

The new design of the database centers on a ***project*** which is a collection of one or more ***datasets***, and can have people and documents associated with it. In addition, each project is assigned ***tags***, ***themes*** and ***spatial boundaries*** to enable searching and cross-linking with other content. Each dataset in turn is

[18] See https://knb.ecoinformatics.org/#external//emlparser/docs/index.html for more information.
[19] See http://www.itis.gov/ for more information.

linked to detailed ***attribute metadata***, ***methodology*** and ***sampling information***, ***people*** and ***documents***. In addition, each dataset can be assigned ***access restrictions***, ***tags***, and ***spatial coverage***. The new VMC database also utilizes controlled lists of ***species***, ***locations***, and ***custom code lists*** (such as tree age classes) that might not be easily defined elsewhere. This enables the creation and recombination of structured lists for datasets as needed, while adding another way that users can traverse across related items in the database.

The Redesign of the VMC Website

The VMC website has been largely rebuilt to utilize the new database structure and provide a new and improved experience for the user in finding and accessing data and information. This involved a completely new development process, including usability testing from June, 2014 to November, 2014, integration of new libraries, and the creation of new tools and functionality.

Some of the notable new features of the website are:

- Advanced search, including the ability to search by spatial overlap, time ranges, specific taxonomic units, and content type (i.e. projects, datasets, documents) (Figure 2);
- New live data portal for VMC meteorological sites that links side-by-side mapping, table and chart displays (Figure 2);
- Ability to facet search results by people, tags, themes, species and content type (Figure 9);
- A data explorer that enables on-the-fly filtering, subsetting, charting and custom download (Figure 9);
- The website's look and feel are updated, the entire code base is built using free and open source software and libraries, and the latest HTML and CSS standards are in place.

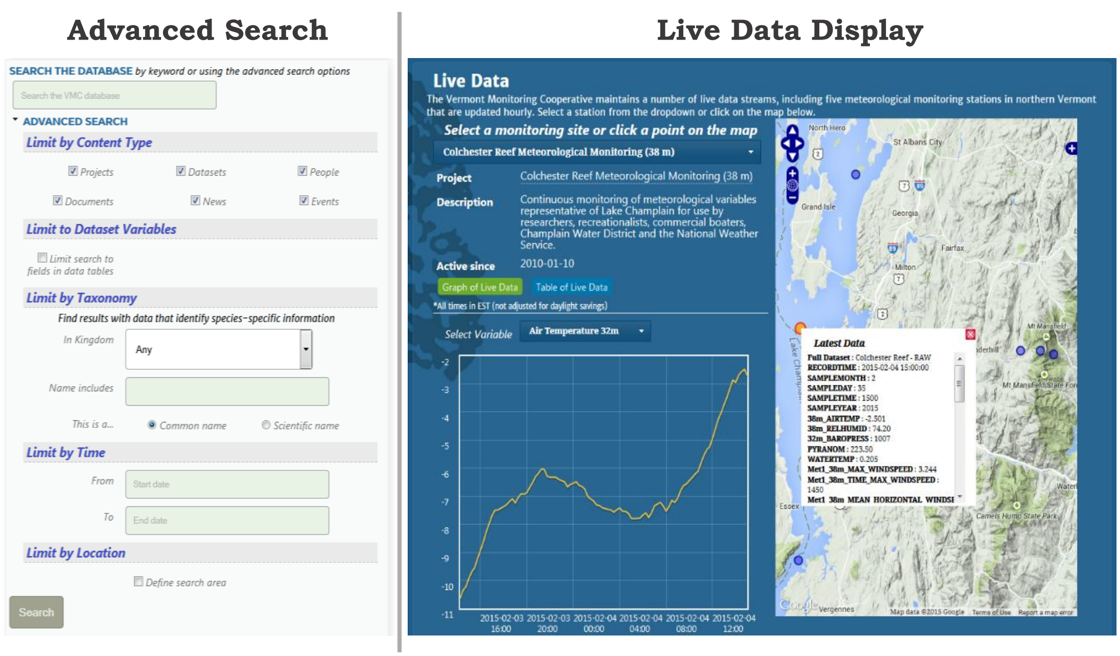


Figure 8. New features of the VMC Website, including advance search functionality including temporal, spatial and taxonomic constraints (left), and a live data interface that includes mapping, charting and tables (right).

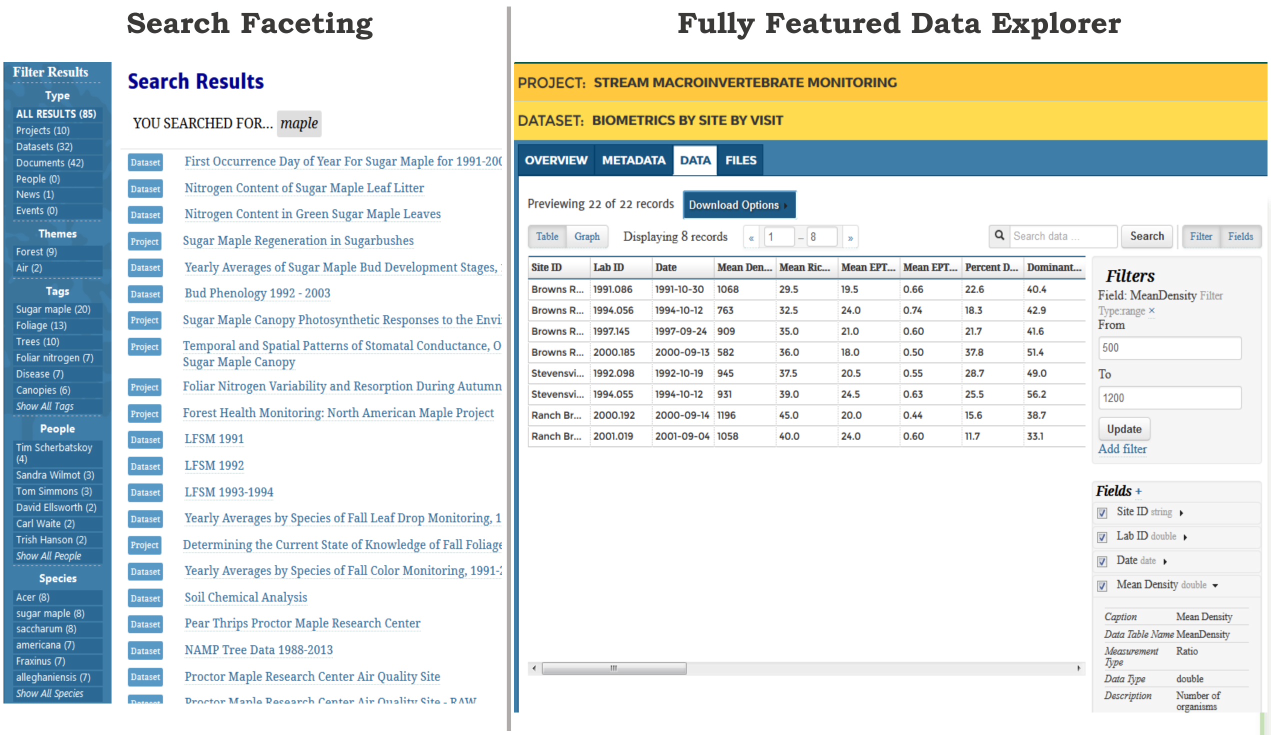


Figure 9. Additional features of the new VMC website, including the ability to facet search results by a number of different attributes (left) and a new data explorer that adds filtering, attribute information and combined charting and table functionality (right).

Coming soon

In the coming year, there are a number of major new improvements planned for the VMC site. These include:

- **Management Portal**. Log-in access will enable people to manage their projects directly, controlling access, content and representation on the site. This will include the integration of an end-to-end data import tool that brings data into the system and helps users create detailed metadata.
- **Federation to Other Data Catalogs**. Through the implementation of Ecological Metadata Language, the content in the VMC database can be automatically ingested into catalog systems such as the Knowledge Network for Biocomplexity[20], which is itself a part of the larger DataOne[21] network of data catalogs. This federation of data descriptions will make the VMC data much easier to find and access alongside other high-quality, national data.
- **Increased support for spatial data**. In addition to refining and increasing the amount of spatial data in the VMC database, the ability to view that data spatially will be implemented.
- **Embedded Live-Updating Indicators and Analysis**. Work is currently underway to create behind-the-scenes scripts to automate the updating and production of key statistics and analysis from VMC data. These metrics can be used to drive dashboards that give regularly updated pictures of the status of and trends in forest condition.

[20] https://knb.ecoinformatics.org/
[21] https://www.dataone.org/

Integrated Forest Ecosystem Assessment to Support Sustainable Management Decisions in a Changing Climate

Organizer: Jennifer Pontius, Rubenstein School of Environment and Natural Resources, UVM, and Northern Research Station, USFS

The McIntire-Stennis Forest Health and Climate Research Group in the Rubenstein School at UVM convened this working session to solicit stakeholder input on the design of a novel forest management spatial decision support tool. To refine our understanding of how climate may impact forested ecosystems, this project combines results from long-term monitoring, manipulative experiments and theoretical models to provide an integrated assessment of the role of climate in forest ecosystem health and function.

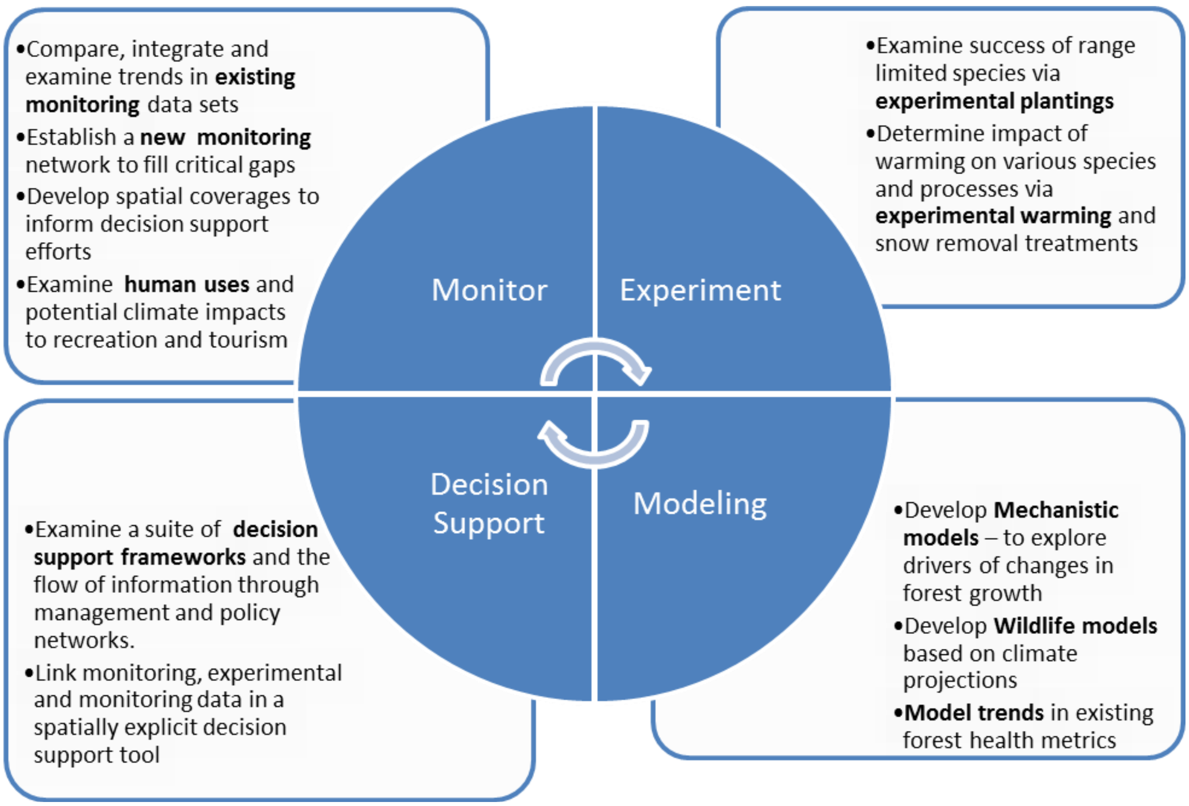


Figure 10. Concept Diagram for the Project: Integrated Forest Ecosystem Assessment to Support Sustainable Management Decisions in a Changing Climate

The overall goal of this five year project, which began in October 2014, is to support more fully informed forest management on a spatial scale that reflects the complexity of the northern forests. The findings from this research will culminate in the development of a spatial decision support framework to inform management and policy decision analysis. Using maps quantifying current and projected forest structure and ecosystem services, land managers can assess the probability of success for specific management objectives and compare the impact of various management alternatives in a spatial structured decision framework on a pixel by pixel basis, reflecting the complexity of the Northeast's heterogeneous landscape. To ensure its success, this decision support tool must be developed in close collaboration with a network of state, federal, private and non-profit natural resource professionals.

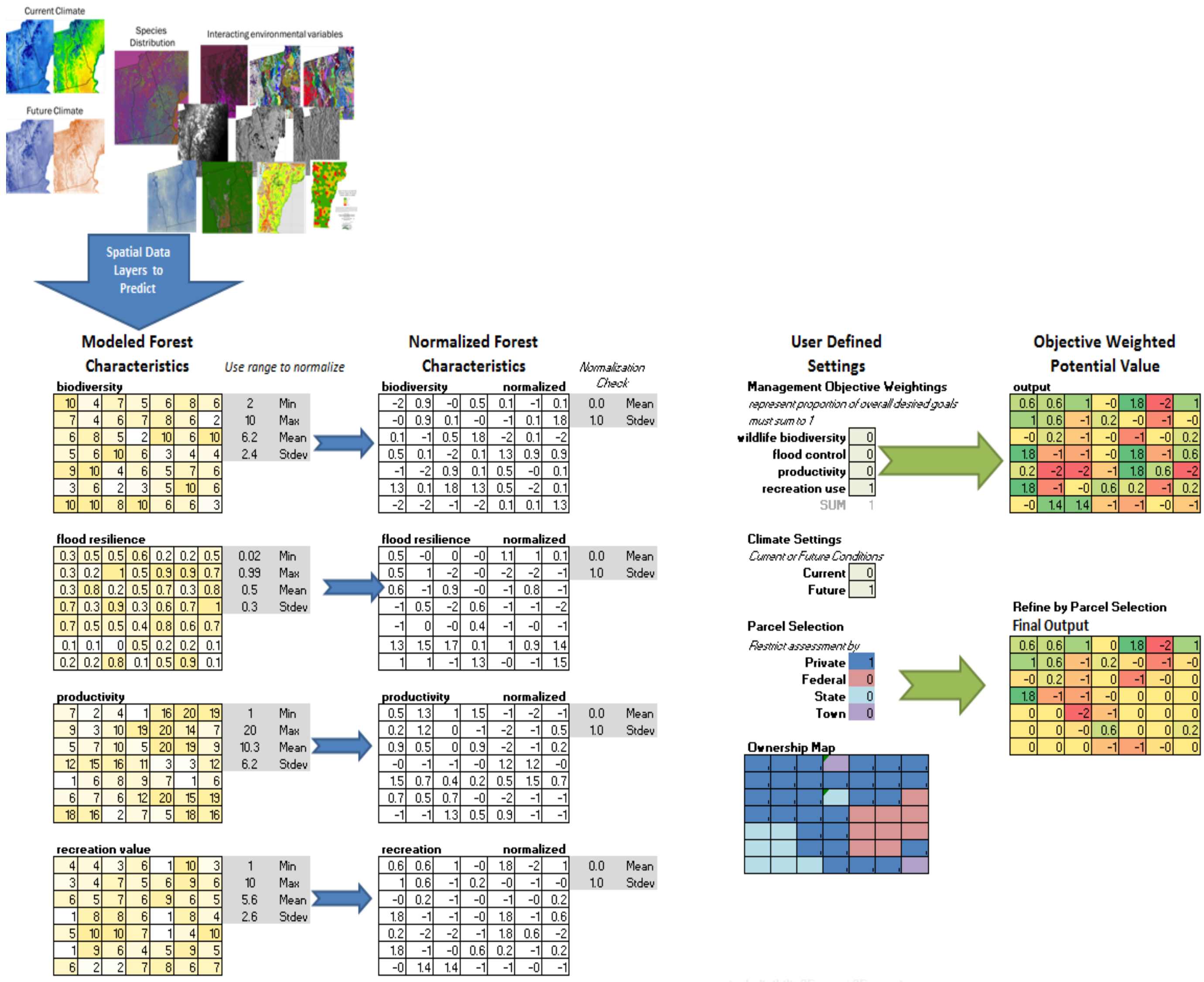


Figure 11. Concept for the structured decision framework.

This workshop represents the first in a series of stakeholder engagement activities. The primary goals were to present the overarching concept and approach of this project, while soliciting feedback on the **current pathways and tools for decision support**. We asked each participant to address the following questions for their institution, agency or organization:

- What are the current pathways for decision making?
- What information is necessary to make those decisions?
- Where does this information currently come from?
- What current decision support tools are used?
- How might this tool duplicate or complement existing tools?

Participants in the working group included over 30 forest resource professionals from a mix of federal, state, private and non-profit organizations. It was noted that the information pathways and needs differ among these organizations, particularly due to the scale of forests under their management purview.

While a statewide spatial tool would be useful for state foresters, consulting foresters working with private landowners can typically inform management prescriptions from traditional forest inventories. However, one of the challenges presented was the overwhelming proportion of forests in private ownership and the trend towards fragmentation of these lands. If we had a tool that could quantify ecosystem services for intact vs. fragmented systems perhaps more private landowners could be convinced to maintain the forest resource. The interface to make this happen is the consulting forester, and thus having a tool that is easily accessible and intuitive in its use could have a tremendous impact across the state.

Currently most participants cite the use of forest inventories and consultations with experts to inform management decisions. However some spatial information is currently available. This includes the VT Agency of Natural Resources Natural Resource Atlas (http://anrmaps.vermont.gov/websites/anra/). This web portal includes a collection of geospatial data layers related to natural resources across Vermont. This includes layers for natural community maps, bedrock geology, elevation, slope, watershed boundaries and many more that can be viewed interactively through the Agency's web portal.

The VT Biofinder project (http://biofinder.vt.gov/) also includes spatial data layers of key natural communities, with a focus on biological, ecological, and natural heritage data. Layers of various sensitive or protected natural communities are overlaid in a co-occurrence analysis to identify locations of greatest overlap for priority ranking at the statewide scale.

What this project would provide in addition to these existing tools is fourfold:

1. The ability to **quantify specific management outcomes** such as forest productivity, carbon sequestration, species composition, recreational value and wildlife distribution that are modeled based on a suite of geospatial data layers which are in turn informed by the foundational monitoring and experimental data of the project.
2. The ability to examine current conditions and distributions of forest resources, but also model them **under future climate scenarios** to see how the forests are expected to change over the next century. This would allow land managers to make informed decisions for longer-term management objectives.
3. The ability to **specify and weight management objectives, which** would allow land managers to identify various locations ideally suited for specific outcomes, maximizing the probability of management success.
4. With a 30-meter resolution, this product would provide **spatial detail** not currently available that would be particularly useful in managing smaller parcels.

While many of the participants were interested in the possibilities of using tools created as a part of this project, the challenge comes in how to develop this tool so that it is easy to use and easily accessible for the widest stakeholder audience. While these appear to be a "quantum leap" over what is currently available, it may take time to get land managers to use it because it is so different from the current way things are done. Many may not trust empirical models that are difficult to understand, or a model whose "cogs" are not transparent. One possible solution to this is to include the option of expert opinion maps to inform or at least validate the spatial products generated by the quantitative models.

Because structured decision making relies on weighting a distinct set of common forest management **goals and objectives**, identifying the possible **management activities** to achieve those goals, and determining a metric to quantify success of **management outcomes**, we also focused groups on the following decision support questions:

- What are the characteristics of an ideal forest?

- What management objectives would be necessary to arrive at the ideal forest described above?
- What management activities can be taken to achieve each of your objectives?
- What information is needed to select alternative activities?

Participants were relatively uniform in their description of an ideal forest and related list of common management objectives to achieve those conditions. Common descriptors included a structurally and compositionally diverse forest with high productivity, resilience to disturbance and provision of ecosystem services. For specific objectives, conserving biodiversity was at the top of the list, as well as minimizing forest fragmentation. Wildlife stakeholders were most interested in managing for specific species of interest or concern. Key areas include the protection of wetland resources and game populations for hunting and fishing activities. Several participants also cited the importance of managing for social or economic outcomes, including recreation or support of the timber industry. The spatial detail provided in this tool could be useful to prioritize areas for conservation, use by recreation enthusiasts or for maximum timber production.

Most participants stressed that moving forward in our understanding of how climate will change the current dynamics of our forested ecosystems is the key to its long-term sustainable management. Management guidelines or target species may need to be updated to reflect how regeneration, competition and mortality change under changing climate conditions. Climate change adaptation is crucial.

Management activities are often limited by parcel ownership, past management plans or policy directives. Setting aside parcels as reserve/conservation areas is one possibility, and the ability to identify the most sensitive or highest potential areas would be useful to direct such efforts. However, the ability to test the potential outcomes of various silvicultural activities would be a tremendous asset, particularly if simulations could be run under future climate scenarios. While this would be difficult to do at the scale and scope of this project, this is perhaps one module that could be informed by expert opinion models combined with the results of the monitoring and experimental components of this study.

While many decision support tools exist for land managers, we believe that this spatially explicit product, based on cutting edge science and designed in collaboration with the stakeholders who will ultimately use them, provides a novel framework to support the sustainable management of forests across the region. We anticipate that a prototype based on feedback from this working group session will be available for continued discussion at the 2015 VMC annual conference.

Lye Brook Working Group

Organizer: Jen Wright and Angie Quintana-Jones, Green Mountain and Finger Lakes National Forests

Present: Jen Wright, Diane Burbank, Angie Quintana-Jones, Judy Rosovsky, Diane Burbank, Scott Machinist, Ralph Perron, Jim Kellogg, Seth Bigelow, Heather Pembrook, Jim Andrews

The Lye Brook Subcommittee met and agreed that a separate venue for meetings would be preferable as the participants would like to attend other VMC work group sessions in this time slot. At a later date budgets and data may be ready, and could be presented and discussed.

Figure 12. Meadow at Lye Brook Wilderness Area.

The group identified topics for further exploration: Jim Kellogg, Heather Pembrook, Jim Andrews and Jen Wright all do research in the LB Wilderness area and recognize that ponds in Lye Brook are being negatively impacted by recreation use. It would therefore be important to continue water quality monitoring, including macroinvertebrates, aquatic plants and amphibians. Heather mentioned the recently passed shoreline bill and possibly applying lessons learned or using that approach to Lye Brook ponds. This might entail developing a public relations strategy for resource protection in Lye Brook – maybe working with a conservation District or other advocacy/resource protection group to develop materials? Jen Wright mentioned that there is no official Lye Brook wilderness group who could serve as advocates for that area.

Other pertinent topics to explore at the next meeting include the tree growth and climate change study in which Seth Bigelow is involved in nearby Landgrove VT. Diane Burbank has a Long-term Ecosystem Monitoring Project (LEMP) update, and an update on the VMC Long-term Soil Monitoring Project would be of great interest. Updates on air quality issues from Ralph Perron or associates are always welcome, too.

Foremost on researchers' minds is the question of funding opportunities (from the Forest Service and elsewhere), and related to that would be a compilation of a list of the future research needs, and the resources needed to accomplish them. This would be a primary goal of the next meeting, in addition to hearing research reports.

Judy Rosovsky noted that the VMC would like to publish the data or findings from studies in Lye Brook and VT forests. The VMC can also summarize results in its annual report.

Next Meeting: The group tentatively decided to meet February 18, 2015 at the USFS Ranger District Office in Rochester, VT to provide brief summaries of the work already done in Lye Brook, identify future research needs, resources needed for the research, and develop a strategy to accomplish the research. Draft agenda with finalized date will be sent to the Subcommittee for review.

Mount Mansfield Science and Stewardship Strategic Planning Workshop

Organizer: Dan Lambert, Conservation Project Leader, High Branch Conservation Services

Background

Mountain forests and alpine zones of the Northeast are sensitive ecosystems that provide valuable opportunities for recreation, commerce, and natural resource management. Because of their distinct biological and cultural attributes, they are important subjects for the study of ecosystem function, effects of natural and anthropogenic change, and the dynamics of social-ecological systems. However, the expense and logistical challenges of remote mountain research have hampered gains in knowledge and integration among academic and professional disciplines. This problem is especially pronounced in the region's montane forests, which lack a permanent platform for investigating climate change, acidification, mercury deposition and other anthropogenic stressors that disproportionately affect high elevations.

A group of VMC cooperators is working to fill this void by establishing a hub of mountain science and stewardship in the Mount Mansfield Summit Station, a 1.5-story, 20 m x 12 m building situated on a forested ridge at an elevation of 1,775 m. Partners in the enterprise include: the University of Vermont Rubenstein School of Environment and Natural Resources, the Vermont Center for Ecostudies, the Vermont Agency of Natural Resources, the Mount Mansfield Company, and the Vermont Ski Areas Association. Once completed, the Mount Mansfield Science and Stewardship Center will help sustain and expand VMC's coordinated investigations of mountain air, water, soil, flora, and fauna, which date back to 1991. As the only field station in eastern North America located in a high-elevation spruce-fir forest, the Mansfield Center will catalyze interdisciplinary studies of woodland and alpine ecosystems across the

Figure 13. Summit of Mt. Mansfield, including a proposed site of a Mount Mansfield Science and Stewardship Center.

northern Appalachian and Adirondack ecoregions. It will also join a worldwide network of mountain-based observatories that is emerging to investigate global environmental issues.

Two recent publications offer fresh guidance for establishing the Mansfield Center: *Field Stations and Marine Laboratories of the Future* (Billick et al. 2013) and *Enhancing the Value and Sustainability of Field Stations and Marine Laboratories in the 21st Century* (National Research Council 2014). These reports document the essential role that field stations play in strengthening research, education, public engagement, and contributions of science to society. As of December 2014, Mansfield Center cooperators have incorporated insights from these publications into an organizing framework for science, stewardship, and education programs. We have also produced a feasibility study and a draft business plan that includes industry and financial analyses, as well as strategies to market and deliver services to Mansfield Center users.

In 2015, we aim to produce a comprehensive, five-year strategic plan to guide program development, infrastructure improvements, and business operations at the Mansfield Center. Members of the VMC community will play an essential role in this work by helping to identify information gaps, programmatic assets, and facility and instrumentation needs. This strategic planning workshop engaged 23 participants from ten organizations in an opening discussion of these topics (See Appendix 1). It was made possible by support from the UVM Environmental Program and from the Dean's Office of the Rubenstein School of Environment and Natural Resources.

Workshop Goal and Objectives

The goal of the workshop was to generate information and ideas for the Mansfield Center strategic plan by seeking input from VMC cooperators and other stakeholders. Specific objectives were to:

- identify planning, regulatory,management, and/or communicationtools for sustaining the vitality of mountain areas of the Northeast;
- identify information gaps that hamper application of these tools;
- synthesize information about contributions of the Mount Mansfield Natural Area and Mount Mansfield State Forest to science and society; and
- document infrastructure, equipment, and instrumentation needs of the Mansfield Center's potential users.

The three discussions summarized below represent the first step in addressing these objectives. Upcoming meetings and online surveys will provide additional opportunities for VMC cooperators to expand on these ideas and shape the Mansfield Center's future.

Identifying and Strengthening Tools for Mountain Stewardship

This discussion focused on opportunities to improve mountain stewardship through science-based conservation practice. Participants identified several tools to enhance the physical, biological, and human components of mountain ecosystems. They also outlined information needed to strengthen these tools (Table 3). Contributed ideas spanned the arenas of policy, management, communication, and informatics. Future planning sessions will build on this preliminary assessment of stewardship mechanisms and data gaps in order to develop new, integrative research initiatives on Mount Mansfield. Ultimately, projects that increase the scientific basis for mountain stewardship will benefit downslope communities that depend on clean water, healthy forests, and opportunities to work and play at high elevations.

Table 3. An assessment of information needed to strengthen tools for mountain stewardship

Issue	Stewardship Tool	Domain	Information Gap / Program Need
Impact on remote areas of transition from winter-only ski areas to four-season resorts	Lease of public lands for commercial recreation	Recreational	What is the effect of year-round resort activity on remote areas?
Group size limits and seasonal carrying capacity of trails	Visitor education	Recreational Biological	How do group size and season of use influence trail impacts? Which communication strategies are effective in reducing hiker impacts?
Biotic effects of mercury and acid deposition	Emissions control policy	Atmospheric Biological	What are benefits of emissions reduction to plant and animal communities?
Availability of data for use in stewardship	Comprehensive data/meta data repository	All	Process and infrastructure for creating and maintaining data clearinghouse
Vehicular impacts along toll road and summit parking lot	Mitigation action or management if indicated by study	Biological, Physical	How do vehicular use patterns (type, speed, air quality impacts) affect wildlife?
Forest pests (e.g., Emerald Ash Borer)	Visitor communication to mitigate spread	Biological	Forest pest monitoring to determine scale of threat and appropriate mitigation strategies
Telecommunications development at high elevation	Mansfield Co-location Committee action	Biological Physical	What is long-term impact of relocation? How do effects of distributed tower placement compare to concentrated tower placement?
Backcountry skiing impacts	Control gates and designation of backcountry routes	Recreational Biological	What are impacts of backcountry skiers on alpine and subalpine ecosystems?
Climate change adaptation/ biodiversity conservation/restoration	Management plans	Biological	Identification and monitoring studies of plant functional traits; genetic diversity studies; high space/time resolution imagery; studies of local adaptations of northeastern alpine populations

Contributions of the Mount Mansfield Natural Area and Mount Mansfield State Forest to Science and Society

To begin this discussion, workshop participants reviewed and added missing information to a preliminary list of ecological monitoring, research, and educational activities that have occurred on the slopes and ridgeline of Mount Mansfield in recent years (Table 4).

Table 4. A selection of recent science and stewardship activities on Mount Mansfield

Activity type	Activity title
Education	UVM course in Ecological Restoration
Education	UVM course in Field Ornithology
Education	UVM course in Landscape Natural History
Education	Natural history exhibits maintained by Green Mountain Club (GMC)
Education	Training of GMC summit caretakers
Education	Hiker outreach by GMC summit caretakers
Monitoring	Temperature, precipitation, and snow depth monitoring
Monitoring	EPA NOx/SOx Field Pilot Program
Monitoring	Fall color and leaf drop monitoring at three elevations
Monitoring	Insect pest monitoring at three elevations
Monitoring	Long-term monitoring of high-elevation stream flow in an undisturbed watershed
Monitoring	Long-term amphibian monitoring
Monitoring	Long-term monitoring of rare plants
Monitoring	Long-term bird population monitoring
Monitoring	Long-term sampling of soil and vegetation at three sites
Monitoring	Alpine restoration / treadway impact monitoring
Monitoring	Forest health, growth, and productivity monitoring
Monitoring	Macroinvertebate monitoring at three streams
Monitoring	Monitoring water quality at two high-elevation lakes
Monitoring	National Atmospheric Deposition Program - Ammonia Monitoring Network
Monitoring	National Atmospheric Deposition Program - Atmospheric Mercury Network
Monitoring	National Atmospheric Deposition Program - Mercury Deposition Network
Monitoring	National Atmospheric Deposition Program - National Trends Network
Monitoring	Ozone bioindicator plant monitoring
Monitoring	Soil Climate Analysis Network (SCAN) operations and maintenance.
Monitoring	Spring phenology of hardwood trees
Monitoring	Sugar maple health monitoring plot
Monitoring	USDA UVB Monitoring and Research Program
Monitoring	Vermont Acid Precipitation Monitoring Program
Monitoring	Telecommunication tower impact monitoring
Research	Assessing the vulnerability of Boott's rattlesnake-root to rapid environmental change

Research	Investigating causes of tree mortality in Vermont and adjacent states
Research	Long-term avian demographic research
Research	Alpine plant genetics and biogeography
Research	Vermont Bumblebee Survey
Research	Plant specimen collection for UVM and other herbaria (since 1805)
Research	Snow accumulation / snowpack studies
Research	Alpine peatland ecology
Stewardship	Alpine zone protection / restoration
Stewardship	Site planning by Mount Mansfield Co-location Committee
Stewardship	Alpine plant seed banking

The wide-ranging and incomplete nature of this information underscores the need for a comprehensive record of past and ongoing activities, including a regularly updated archive that includes both peer-reviewed articles and unpublished student theses. Sources for archive material include: the VMC project and dataset database; the Appalachian Mountain Club's mountain science bibliography (currently in development), and non-UVM researchers and educators who make use of the mountain as a field laboratory (e.g., faculty at Middlebury College, Sterling College, Johnson State College, and the State University of New York).

Beyond the existing information resources, participants identified a variety of other assets that could be leveraged by the Mansfield Center to enhance the site's contributions to science and society, including:

- burgeoning student interest, at UVM and elsewhere, in mountain-based internships and field experiences;
- the demonstrated capacity of some VMC cooperators to design and carry out citizen science projects; and
- ever-advancing "smart forest" technology that allows for continuous measurement and real-time transmission of environmental data.

The Mansfield Center also presents the opportunity to develop place-based humanities programs, as modeled by the artist- and writer-in-residence programs at HJ Andrews and Hubbard Brook Experimental Forests.

The discussion produced few specific examples of how research and monitoring results from Mount Mansfield have guided policy or management decisions. This affirms the need to enhance exchange between science and stewardship, particularly in light of VMC studies that have revealed negative effects of human activity on physical and biological components of the Mount Mansfield ecosystem (e.g., Wemple et al. 2007, Rimmer et al. 2009). One way to generate actionable science is to develop research questions that address the priorities of decision-makers.

When asked to identify research priorities, the group of conservation practitioners and scientists focused primarily on measuring impacts of human activity on the mountain environment and backcountry experience. Important questions include:

- What are effects of foot traffic and backcountry skiing on alpine zone vegetation?
- What are effects of research activity on montane and alpine biota?

- What are effects of research activity, including automated instrumentation, on the recreational experience of visitors?
- What are effects of mountain biking on soils, plants, and animals?
- How do trails cut for glade skiing influence the structure and dynamics of forest communities?
- How has the transition from winter ski areas to four-season resorts affected remote areas, particularly on non-leased state lands adjacent to leased lands?
- What are the local and landscape-level effects of large-scale commercial sugaring on northern hardwood forests?
- How do extreme events influence the structure and function of mountain ecosystems?

These and other questions will receive additional attention at a research planning conference that has been proposed for autumn 2015.

Assessing the Facility, Instrumentation, and Service Needs of the Mansfield Center's Users

In this forum, potential users of the Mansfield Center were asked, "What facilities, instruments, and services would make the Mansfield Center an attractive and productive hub for mountain science and stewardship?" The ideas outlined below show the variety of purposes that could be served by a modern facility and enhanced programs on Mount Mansfield. We plan to incorporate them into a written survey that will be circulated to scientists, educators, and land stewards who may be interested in conducting work from the Mansfield Center. Survey responses will inform the development of facilities, program, and business plans. Ultimately, key actions from each of these plans will form the basis for a comprehensive, five-year strategic plan.

<u>Facilities</u>

Kitchen
Private bathroom
Public bathroom
Shower
Common room
Conference room outfitted with AV equipment
Work stations / computer lab
Wet lab with bench, sinks, cold storage, hood, bisecting and compound microscopes
Library
Bunkroom
Private or semi-private bedrooms
Storage room
Windows
Staffed visitor center with educational exhibits/experiences that use first- and third-person interpretive techniques to showcase science and stewardship activities and educate visitors on topics such as geology, plant identification, mercury deposition and trophic transfer, and human history (including evolution of the Mansfield Center)
Public, educational space intermingled with science and stewardship space (as at University of British Columbia's Beaty Biodiversity Museum and Dinosaur National Monument)
A "mountain dashboard" with monitors that display a live stream of data from automated sensors and provide a video tour of the Mount Mansfield ecosystem
Computers for visitors to enter and retrieve eBird and other crowd-sourced natural history data

Base lodge or camp facility in the valley to provide year-round shelter and absorb surplus of overnight guests from Summit Station

Field Instruments

- Stream, rain, and snow gages stationed longitudinally along major watercourses
- Water quality stations to monitor pH, conductivity, dissolved oxygen, temperature, cations, anions, and nutrients
- Alpine snow gaging stations
- Weather stations to monitor temperature, pressure, humidity, wind, precipitation, solar radiation, cloud ceiling, ultraviolet index, leaf wetness, soil moisture, snowpack (depth and moisture)
- Portable webcam to feed mountain dashboard
- PhenoCam to monitor forest health and phenology

Services

- Facility reservations and management
- Research coordination
- Permit assistance
- Single-point of contact for new investigators
- Trash disposal
- Housekeeping
- Shuttle up and down the toll road
- Information management
- Data archive, including recovered or "dark" data
- Staffing/in-person interpretation for educational exhibits
- Educational programs, such as guided walks, bird banding demonstrations, and short lectures
- Field demonstration of habitat stewardship and restoration methods
- Take-away information for visitors (e.g., annotated checklists, stewardship brochure)
- High-speed Internet connection

Conclusion

Once established, the Mansfield Center will serve scholars, educators, and natural resource managers as they work alongside students and visitors to acquire and apply new knowledge. As a first step in a cooperative planning process, this workshop began to illuminate the needs and priorities of this user community. Input from workshop participants will frame future planning exercises, which are to include a survey of a wider audience, a two-day research planning workshop, and an external review by the Organization of Biological Field Stations.

Figure 14. Black-throated Blue Warbler captured on Mt. Mansfield.

References Cited

Billick, I., I. Babb, B. Kloeppel, J. C. Leong, J. Hodder, J. Sanders, and H. Swain. 2013. *Field Stations and Marine Laboratories of the Future: A Strategic Vision*. National Association of Marine Laboratories and Organization of Biological Field Stations. Available at http://www.obfs.org/fsml-future.

National Research Council. 2014. *Enhancing the Value and Sustainability of Field Stations and Marine Laboratories in the 21st Century*. National Academy of Sciences Press. Washington, D.C.

Rimmer C. C., E. K. Miller, K. P. McFarland and R. J. Taylor. 2010. Mercury bioaccumulation and trophic transfer in the terrestrial food web of a montane forest. Ecotoxicology 19: 697–709.

Wemple, B., J. Shanley, J. Denner, D. Ross and K. Mills. 2007. "Hydrology and water quality in two mountain basins of the northeastern U.S.: assessing baseline conditions and effects of ski area development." Hydrological Processes, 21:1639-1650.

Strengthening the Role of Science at the Vermont Agency of Natural Resources (ANR)

Organizer: Larry Becker, Vermont Geological Survey, Vermont Department of Environmental Conservation

In 2014 the Vermont Agency of Natural Resources (ANR) began a planning exercise designed to strengthen the role of science within that Agency. Larry Becker was asked to lead this effort so Larry decided to organize a working group session around this topic at the VMC Annual Conference. The final product from this exercise will be an Action Plan with recommendations to the Secretary of Natural Resources by June 30, 2015.

The goal of this working session was to stimulate a discussion with external partners to reflect on 20 topics being considered to further strengthen the use of science at ANR. Science is currently employed in ANR for education and to resolve disputes. It informs and influences policy choices through application to specific cases and new rules. As science is multidisciplinary by nature, it requires coordination and collaboration among partners. ANR works with its scientists/data collectors and those that employ science to inform public policy.

The science, monitoring and data functions within ANR and with its partners provide defensible science with sound outputs which are regularly used. Science underpins everything ANR does requiring both vision and practical skills integrated for critical natural resource and environmental thinking and doing to meet protection goals. There is, however, room to strengthen the system by which monitoring, data, scientific studies and analyses are delivered to address these relevant questions.

The process employed by ANR, including the use of a survey questionnaire distributed to all ANR staff, was explained to the group. Examples of results from that questionnaire were presented to the participants. Not all results were presented, but those that seemed most relevant to the working session were discussed. The survey received excellent participation with 167 ANR employees responding.

Again, the focus of the discussion for the working group was the list of 20 topics handed out to meeting participants. The topics were developed through interviews with ANR scientists, managers of science and those who employ science for decision making (Table 5).

Figure 15. Allan Strong of University of Vermont presenting research findings to staff at the Vermont Agency of Natural Resources.

Questions Posed to Meeting Participants

- Are we missing anything?
- What are your thoughts on the topics and how to apply to ANR?
- Do you see any connection to your work and how it can assist?

General Notes on the Discussion - Results of Questionnaire

- The word "public" does not show up in the weighted list of topics.
- The staff answers probably depend on their job description.

Process to Choose Topics

- Need to define what the topics mean.
- Define objectives of this effort.
- Bring in potential partners on the front end.
- Science needs to inform policy.
- Conduct a public survey.
    - Potential questions: How can ANR build scientific credibility? What would make science credible to you?
    - Could "buy a question" from the Center for Research on VT.

Issues and Directions Related to Topics

Within ANR:

- Provide some form of recognition for getting publications completed.
- Institutionalize determining whether management activities are having an impact on outcomes.
- Develop methods to build in cumulative impacts analyses.
- Ongoing databases are key.
- Provide staff education and professional development.

Relationships are key:

- Reach out to UVM. Reach out to academic institutions other than UVM.
- Work with partners to find resources to study emerging issues and to keep up monitoring of issues that are no longer in the news (and funding stream), but which have not gone away.
- Institutionalize the "social capital" that supports what are now ad hoc partnerships (e.g. legislators and scientists meeting together, science advisory boards, VMC).
- Partners are needed to bring cumulative impacts analyses together.
- Need cross-boundary communication to know what information and resources others have.
- May be able to enhance statistical support.

Ensure that outreach to public is occurring on issues with direct scientific implications.

- Public availability of BioFinder is very helpful, and needs to be maintained.
- Strategic teaching of science to citizens at large.
- Ramp up outreach when the public is willing to listen (e.g. T.S. Irene).
- Ensure data is communicated in a way the public can understand.

Table 5. Agency of Natural Results Questionnaire Results for 20 topics – Each participant points were required to add to 100.

Answer Choices	Average Number	Total Number	Responses
SCIENCE QUESTIONS FACING ANR: identify and prioritize	10	732	71
EMERGING ISSUES: develop a process to address the science as a united agency	12	796	69
SIGNIFICANT CUMULATIVE ENVIRONMENTAL IMPACTS: develop science to address	12	1,072	86
ANSWERING NATURAL RESOURCE/ENVIRONMENTAL QUESTIONS: effective targeting of monitoring, scientific studies, data, and laboratory needs	13	1,317	101
MONITORING AND RESEARCH GAPS: identify and address	8	544	70
NATURAL RESOURCE/ENVIRONMENTAL DATABASES: continue to develop, make available, and integrate	13	1,281	99
DATA QUALITY ASSURANCE AND QUALITY CONTROL: improve and document	10	734	74
SAMPLE COLLECTIONS: store, archive and make accessible	7	366	51
ACADEMIA, FEDERAL, COOPERATIVES AND OTHER SCIENCE PARTNERS: roles, objectives, interactions to reach effective outcomes	8	589	71
INTERNS: gain meaningful results	4	163	40
INTERAGENCY COORDINATION OF SCIENCE, MONITORING, DATA MGMT AND POLICY: improve and make effective	10	761	75
SCIENTISTS AND POLICY MAKERS: bring together	11	895	84
SCIENCE ADVISORY BOARDS AND PANELS: support existing and establish new for underpinning decisions	6	319	50
RESULTS BASED ACCOUNTABILITY WITH SCIENCE AS A FOUNDATION: develop	10	549	53
PERSONNEL AND SCIENCE EXPERTISE IN ANR: build and maintain	13	1,190	94
PUBLISHING BY ANR PERSONNEL: mechanisms to foster	7	369	52
SCIENCE COMMUNICATION: build and make effective	9	651	73
CITIZEN SCIENCE: build interaction with groups and assure quality results	8	490	63
SCIENCE ETHICS: understand and insure	9	384	42
FUNDING FOR MONITORING AND RESEARCH: maintain, identify sources, and build	13	1,198	89
Total Respondents: 144			

Vermont Water Monitoring Council

Organizer: Neil Kamman, Program Manager, Watershed Management Division, Vermont Department of Environmental Conservation

The Water Monitoring Council - a joint endeavor of Vermont Department of Environmental Conservation, the US Geological Survey, the US Environmental Protection Agency, and local partners - promotes dialogue about the needs and opportunities for shared development and use of water monitoring data and information. The mission of the VMC is aligned to that of the Water Monitoring Council - sharing and dissemination of data and information. The goal of this session is to strengthen the identity of the Vermont Water Monitoring Council, and to capitalize on the opportunity presented by VMC's organizational structure as one possible unifying entity for the larger Water Monitoring Council community.

Figure 16. Measuring Stream flow.

Partner organizations delivered “SLAM”-style presentations (Table 6), giving participants a “tasting menu” of water monitoring activities in place across Vermont. These presentations helped set the stage for topically-focused and facilitated discussion regarding the water monitoring topics raised. SLAM talks are like mini “TED talks,” intended to present one or two key ideas, around which participants can engage in further discussion. The set of talks at the session cover all aspects of water monitoring (lake, river, wetland, and groundwater), represent most corners of the State, and contained some very neat ideas.

Table 6. Presenters and the SLAM talks delivered as part of this session.

PRESENTER AND ORGANIZATION	SLAM TALK TITLE AND DESCRIPTION
Kelly Stettner Black River Action Team	**Love that Dirty Water** *Due to weather, Kelly Stettner was not able to attend.*
Danielle Owczarski Wetlands Program Scientist – NW District, VT Department of Environmental Conservation	**No Net Loss: The Conundrum of Protecting Wetlands** *"No net loss" is a mitigation policy goal aiming to prevent and offset the destruction or degradation of wetlands in the United States. The Vermont Wetland Rules extend the no net loss policy to protect wetland function and value in Vermont. This slam talk addresses wetland impact acreage in Vermont in the past ten years, wetland condition studies conducted by VT Department of Environmental conservation, and how we might involve the public in establishing a monitoring program to evaluate the efficacy of the Vermont Wetland Rules.*
Abe Collins Collins Grazing	**Growing Clean Water: Working toward real-time environmental feedback as Best Management Practice**
Kim Greenwood Water Program Director, Vermont Natural Resources Council	**Numbers, Fighters and Doers (Three Good Things That Taste Great Together)** *It takes a wide variety of efforts to move environmental policy. Understand how the Numbers (VMC), the Fighters (VNRC & friends) and the Doers (Watersheds United Vermont & watershed groups) must all push in the same direction to enable meaningful change.*
Ben Copans Watershed Coordinator – NE District, VT Department of Environmental Conservation	**Getting Tactical with Water Sampling - NPS Identification in the Memphremagog Watershed** *The Vermont DEC and Beck Pond LLC and Memphremagog Watershed Association have developed a water quality monitoring and data analysis approach that can be used to identify and prioritize phosphorus reduction actions in the Lake Memphremagog basin. Through an agricultural working group this data has been shared with key partners and has led to priority actions being implemented. Follow-up monitoring has allowed us to determine success (or lack thereof) in reducing phosphorus concentrations in smaller tributaries to Lake Memphremagog which is essential to accountability in achieving phosphorus reductions that will be required though a TMDL for Lake Memphremagog.*

PRESENTER AND ORGANIZATION	SLAM TALK TITLE AND DESCRIPTION
Marty Illick South Chittenden Riverwatch/Lewis Creek Association	**South Chittenden Riverwatch Water Quality Monitoring Program, 2004-2014 - Lessons Learned and Questions Raised** *Our water monitoring program is 10 years old and currently measures nutrient loading from high flows to understand trends and which of our local subsheds are loading nutrients and sediments to Lake Champlain. We are calculating how many tons per acre are involved, and we suggest that our reach or subshed level data results should be used to inform the Lake TMDL implementation plans, budgets, strategies and related policies. We are requesting endorsement and financial support in the TMDL implementation plan.*
Blaine Hastings Division Hydrologist, VT Department of Environmental Conservation	**A municipal-State partnership to conduct flow monitoring in stormwater-impaired streams** *This SLAM talk discusses the flow monitoring program being implemented as part of a recently enhanced NDPES permit for small municipal separate storm sewer systems. Permittees are required to develop a Flow Restoration Plan for any stormwater impaired water to which they discharge, and in partnership with the VTDEC, establish long-term streamflow gaging stations to assess progress towards flow restoration goals.*
Eamon Twohig Environmental Analyst, Wastewater Residuals Program, VT Department of Environmental Conservation	**Diffuse waste management in VT: reducing threats to water quality** *Treated wastewater sludge and/or septage may be applied to Vermont land for agronomic benefits, but only through specific certifications that are designed to protect human and environmental health via permit conditions, pollutant standards and monitoring requirements that go beyond US EPA rules.*

Contributed Abstracts

There were 27 talks contributed to the conference, presented in four concurrent sessions and a special working session centered around the Mt. Mansfield Science and Stewardship agenda. Below are the abstracts submitted for these talks, including author affiliation. The presenting author's name is in bold type.

Amynthas Ante-Portas: Invasive Asiatic Earthworms in New England and Reasons to Monitor Vigilantly

Josef Gorres[1], Korkmaz Belliturk, Ryan Melnichuk and Joseph Schall
[1] University of Vermont

Earthworms in Vermont are exotic and some are invasive. Recently, attention has shifted from earthworms in the Lumbricidae to earthworms in the Megascolecidae family. Species in both families harm forest lands by consuming the O-horizons of deciduous and mixed deciduous forests causing a reduction of biodiversity of the understory and sometimes disruption of canopy species by increased browsing pressure on saplings. Amynthas and Metaphire (Oligochaeta: Megascolecidae) species originating from Japan and Korea are very aggressive invaders whose invasiveness derives from fast feeding, occupying a different temporal niche than other earthworms, wide dietary flexibility, and high population densities. We have found them in five forested locations. But they may be more widespread. We surveyed Master Gardeners in Vermont, New Hampshire and Connecticut. About 20% of respondents in New Hampshire and Vermont reported Amynthas species in horticultural, parkland and natural settings. In Connecticut 90% of respondents reported them. Survey reports of Amynthas species from forests, either on respondents' own property, or in remote or municipal locations, numbered 2%, 4% and 30% in Vermont, New Hampshire and Connecticut. In Vermont we know of 4 Megascolecid species. Three of them have been seen in the wild and one in vermicomposting operation. Greater vigilance is to be exercised when Act 148 requires home owners to recycle garden wastes. Repurposing of garden wastes may become a significant vector. More monitoring and research is required to manage this invasion and to trace the earthworms to potential sources within the USA.

Figure 17. Soil horizons before and after earthworm invasion. From presentation by Josef Gorres.

Effects of Landscape Development on Bobcat Carrying Capacity in Vermont

James D. Murdoch[1], Wendy Cole[1], Therese Donovan[2], and Michelle Brown[3]
[1] UVM Rubenstein School of Environment and Natural Resources
[2] U.S. Geological Survey, Vermont Cooperative Fish and Wildlife Research Unit, University of Vermont
[3] Vermont Cooperative Fish and Wildlife Research Unit, University of Vermont

The bobcat (*Lynx rufus*) is a nocturnal, secretive, and territorial carnivore that occurs throughout Vermont. The species is listed as a Species of Greatest Conservation need in the state and considered susceptible to landscape change. Bobcats require distinct habitats, but little information exists on how changes in the amount and distribution of those habitats, especially due to human developments, affect the population. We examined the effect of housing and road development on the bobcat population in Vermont. We used radio-telemetry data to develop a habitat suitability model for males and females, then mapped suitability across the state and used a technique called maximum clique analysis to estimate the bobcat carry capacity now and under conditions in 2050. We estimated conditions in 2050 using models of projected rates of housing and road development. Our analysis provides a quantitative estimate of how projected changes in development levels affect bobcat carrying capacity. We discuss the ecological and genetic implications of our results, and their impacts on bobcat management and land use planning. We also provide an overview of how our approach can be easily modified to estimate carrying capacity for other territorial species in the state.

Figure 18. Bobcat captured by a camera trap. From presentation by Jed Murdoch.

Experimental Gaps and Biodiversity Responses in the Vermont Forest Ecosystem Management Demonstration Project

William S. Keeton[1]
[1] UVM Rubenstein School of Environment and Natural Resources

Management for late-successional forest structure and function is an important element of sustainable forestry in the northern forest region. The Vermont Forest Ecosystem Management Demonstration Project is testing an approach called "Structural Complexity Enhancement" (SCE) in which variable density horizontal structure, including small gaps (0.02 ha mean), is an explicit objective. SCE is compared against other modified uneven-aged approaches, including single-tree selection and group selection with legacy tree retention within larger gaps (0.05 ha mean). The study is replicated at two research areas in Vermont, U.S.A. Manipulations and controls were applied to 2 ha units and replicated four times per treatment. Vegetation data were collected over two years pre-treatment and seven years post-treatment. Salamander and fungi surveys were conducted several years post-harvest. All treatments were successful in maintaining overall richness and/or abundance of understory plants, salamanders, and fungi. Statistical model results show that over time, understory plant responses were strongly affected by overstory treatment and less influenced by soil chemistry and drought stress. However, diversity for sensitive, late-successional herbaceous plants increased significantly in SCE units and decreased significantly in the semi-open canopied conditions within group selection units. Fungi and salamander responses were strongly associated with microsite characteristics, particularly CWD, and increased significantly ($p > 0.05$) under SCE, but showed no statistically significant decrease in gaps created by group selection in comparison to controls. The results suggest that a variety of small gap and group selection with retention techniques can help maintain a range of biodiversity in managed forests.

Figure 19. Sampling for herbaceous vegetation. From presentation by William Keeton.

Exploring How Silvicultural Management and Genetics Influence the Performance of American Chestnut in Vermont

Paul Schaberg[1], Paula F. Murakami[1], Gary J. Hawley[2], Joshua M. Halman[3], Rebecca L. Stern[3], and Kendra M. Gurney[4]
[1] USDA Forest Service, Northern Research Station
[2] UVM Rubenstein School of Environment and Natural Resources
[3] University of Vermont
[4] The American Chestnut Foundation

Considerable effort is being devoted to the backcross breeding of American chestnut with Chinese chestnut to increase the resistance of resulting stock to chestnut blight. Much of this work has been conducted within central and southern portions of American chestnut's range. Until recently a comparative analysis of chestnut performance in the north (where freezing injury may also limit the species) had not been conducted. In 2009 we established plantings on the Green Mountain National Forest (GMNF) to assess the growth and freezing injury of American chestnuts under three silvicultural treatments (open canopy, partial- and closed canopies) and for 13 genetic sources from across the species' range. First year field results indicated that the open canopy treatment increased growth but also increased shoot freezing injury among seedlings. Seed source also mattered – seedlings from warm and moderate temperature zones (classifications that use winter temperature data to estimate cold hardiness) grew more in height and diameter but experienced greater winter injury than seedlings from colder climates. In this presentation we provide updates of growth and shoot freezing injury data to assess if the apparent tradeoff in growth and cold hardiness has persisted over five years of field performance. We also highlight data on 1) spring budbreak and foliar frost injury (parameters that also influence tree adaptation and survival) and 2) the performance of B3F3 backcross chestnuts (that have about 94% American chestnut and 6% Chinese chestnut genes and are expected to be highly blight-resistant) that were added to the GMNF in 2013.

Figure 20. Experimental plantings of backcrossed American chestnut. From presentation by Paul Schaberg.

Extremes at Elevation - High Flow Events on Mount Mansfield

Jamie Shanley[1] and Beverly Wemple[2]
[1] U.S. Geological Survey
[2] UVM Department of Geography

In September 2000, the U.S. Geological Survey in collaboration with Vermont Monitoring Cooperative started a paired watershed study on the east slope of Mt. Mansfield, Vermont. West Branch (11.7 km^2), the developed watershed, drains nearly the entire expanse of Stowe Mountain Resort. Ranch Brook (9.6 km2) is the forested control watershed. Annual water yield (flow per unit area) at West Branch is consistently higher than Ranch Brook, by an average of 22% (range 11 to 44%). Snowmelt and summer base flow account for most of this differential. Here we summarize the results of the 14 years of monitoring with a special focus on extreme events. The recent large floods of Vermont, including Lake Champlain and Tropical Storm Irene in 2011 had associated high flows on Mt. Mansfield, but most of the highest peaks of record were from isolated storms that had little impact regionally. Although the past two years have been relatively quiet, the incidence of these large storms has generally increased since gaging began.

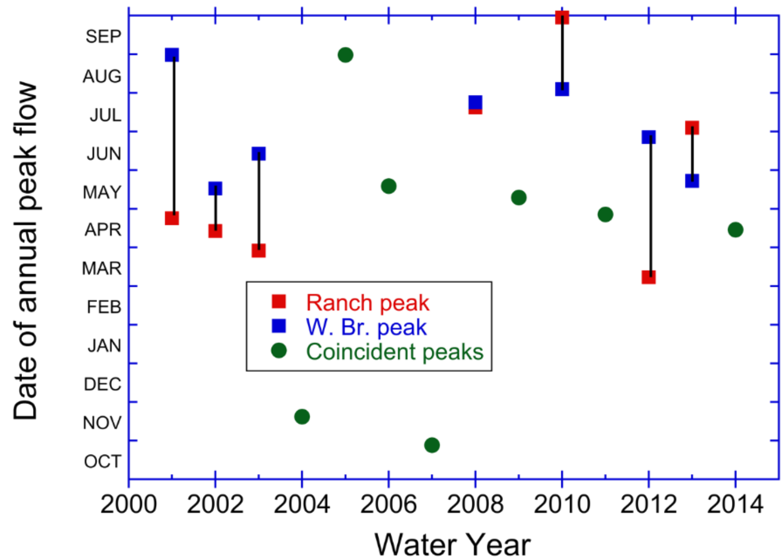


Figure 21. Annual dates of peak stream flow in two watersheds. From presentation by Jamie Shanley.

Geology and Ecology: Building Studies from the Base Map

Laurence Becker[1], **Marjorie Gale**[1]
[1] Vermont Geological Survey, VT DEC

The Bedrock Geologic Map of Vermont (Ratcliffe and others, 2011) shows the type of intact, continuous, solid bedrock at or near the earth's surface and predicts the geology at depth. The rocks record 1.4 billion years of geologic history reflected in rift clastic and volcanic rocks deposited on Proterozoic basement, development of a continental platform marking the ancient margin of eastern North America, Ordovician accreted rocks, and Silurian-Devonian rocks of the Connecticut Valley trough. Rather than continuous stratigraphy as depicted in 1961, the geology represents fault-bounded slices, the result of plate tectonic collisions, which juxtaposed rocks from a variety of geologic settings. Rock geochemistry provided data to discern environments such as rifted continental crust and volcanic island arcs.

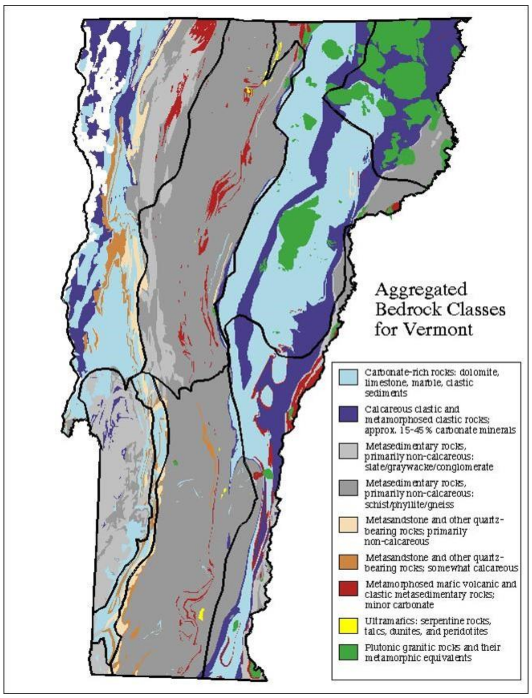


Figure 22. Classes of bedrock in Vermont. From presentation by Laurence Becker and Marjorie Gale.

The map is a fundamental data layer for understanding the landscape and the complex relationship humans have with natural resources. As a base for understanding geochemical, surface and groundwater interaction, and ecosystems, it impacts science policy related to protection of human and ecological health, surface and groundwater quality and quantity, and energy. The Vermont Geological Survey is engaged in projects with state and federal partners related to chemistry and forest health and background geochemistry and mineralogy of bedrock and till. Additional applications of geologic data to policy include acid rain and the lack of buffering capacity on certain substrates and understanding the physical and chemical system that supports biodiversity.

Identifying and Strengthening Tools for Mountain Stewardship

Susan Hindinger[1], Dan Lambert[2], and Rick Paradis[3]
[1] Vermont Center for Ecostudies
[2] High Branch Conservation Services
[3] Environmental Program, University of Vermont

Figure 23. Trail sign on Mt. Mansfield. From presentation by Susan Hindinger.

This participatory session will identify planning, regulatory, management, and communication tools for sustaining the vitality of mountain areas of the Northeast. Following a short presentation, breakout groups will discuss proven and promising methods to support: air, soil, and water quality; plant and animal communities; as well as recreational opportunities and the local economy. Next, each group will designate a subset of tools that deliver crosscutting benefits to the environment and its human inhabitants. Finally, we will identify the major information gaps that hamper application of these tools. This assessment of information needs will guide development of the Mansfield Center's science and stewardship program. Ultimately, projects that strengthen mountain stewardship will benefit downslope communities that depend on healthy forests, clean water, and opportunities to work and play at high elevations.

Incorporating the Next Generation of Water Monitoring in Vermont

Keith Robinson[1]
[1] U.S. Geological Survey

In the past decade a number of new water monitoring and assessment techniques have been developed provide greater temporal, spatial and detailed assessments of water quality and quantity. A number of these new techniques, and examples of how they can be used to address water resource issues in Vermont, will be presented. Continuous water quality monitors, using acoustic technology to measure sediments and other water quality issues and generation of continuous contaminant load estimates to receiving waters, are examples of how water quality measurements are being made in many areas of the Nation. These techniques apply to many critical water quality issues in Vermont. From a water quantity standpoint, use of continuous monitors of river stage, together with mapping technology can arm local emergency management officials with the information they need to prepare for and respond to imminent flooding. Although many of these new techniques require new data collection and data analysis, they may provide enhanced resource data that we find we cannot eventually live without.

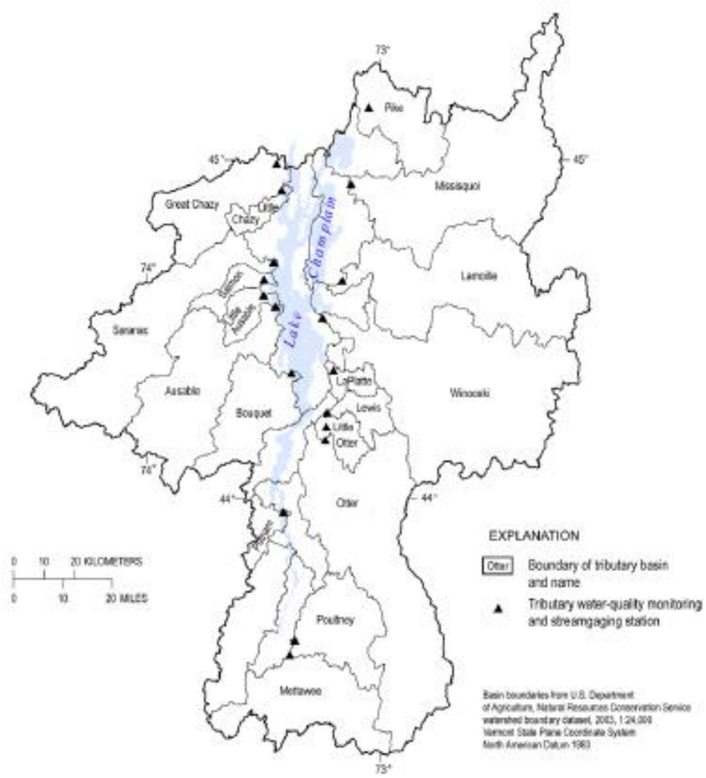


Figure 24. Tributary monitoring stations in the Lake Champlain basin. From presentation by Keith Robinson.

Integrating Science and Stewardship for Healthy Mountain Ecosystems: A Framework for Mansfield Center Programs

Dan Lambert[1], Chris Rimmer[2], and Rick Paradis[3]
[1] High Branch Conservation Services
[2] Vermont Center for Ecostudies
[3] Environmental Program, University of Vermont

A group of organizations from the public and private sectors are working together to establish a hub of mountain science and stewardship in the Mount Mansfield Summit Station, which is located on a forested ridge at an elevation of 3,850 feet. Cooperators in the enterprise include: the University of Vermont, the Vermont Center for Ecostudies, the Vermont Agency of Natural Resources, the Vermont Monitoring Cooperative, the Mount Mansfield Company, and the Vermont Ski Areas Association. During this 45-minute interactive session, we will present the main components of the Mansfield Center's science and stewardship framework, including mission, goals, and guiding question. We will also propose an integrative approach to research, monitoring, and decision-making that involves: measuring natural variability and effects of human activity; modeling processes that sustain ecosystem function and services; evaluating ecosystem capacity to resist, recover from, and adapt to anthropogenic stressors; and incorporating scientific findings into environmental policy and natural resource management. Feedback from session participants will shape programmatic and strategic plans that are currently in development for the Mount Mansfield Science and Stewardship Center.

Figure 25. Hikers at the summit of Mt. Mansfield. From report by Matt Larson.

A Long-Term Examination of Changing Species Assemblages in a Northern Hardwood Forest

Jennifer Pontius[1], Joshua Halman[2], Paul Schaberg[3]
[1] USDA Forest Service, Northern Research Station; UVM Rubenstein School of Environment and Natural Resources
[2] UVM Rubenstein School of Environment and Natural Resources
[3] USDA Forest Service, Northern Research Station

Long-term forest inventories provide a unique opportunity to quantify changes in forest structure, as well as how changes may deviate from historic models of species succession and biomass accumulation. An examination of a 70-year record on mid-late successional stands at the Bartlett Experimental Forest, NH, USA indicated that species abundances have changed as expected under natural succession, with significant increases in shade tolerant species such as American beech (*Fagus grandifolia*) and eastern hemlock (*Tsuga canadensis*), and decreases in early successional species such as paper birch (*Betula papyrifera*). However, interesting deviations were detected, including significant decreases in red (*Acer rubrum*) and sugar maple (*Acer saccharum*) resulting from reduced regeneration rates over the survey period. Other deviations included increases in red spruce (*Picea rubens*) biomass at the expense of sympatric balsam fir (*Abies balsamea*) and hardwoods at upper elevations. We conclude that while natural succession continues to dominate changes in species demographics, the influence of changing climate and the legacy of acid deposition may be altering competitive dynamics, favoring species like red spruce and American beech over their common counterparts in northeastern forests.

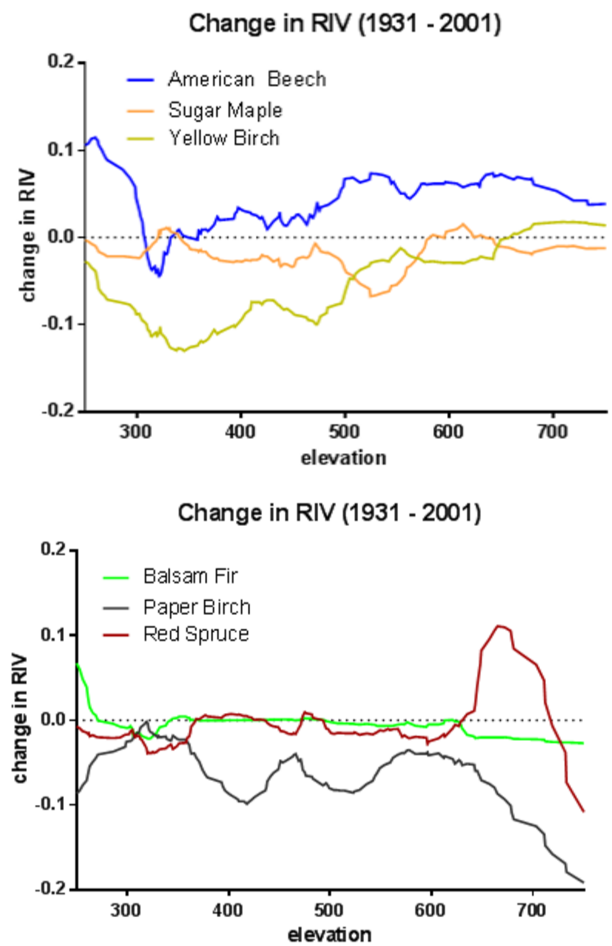


Figure 26. Variation in species composition along an elevational gradient. From presentation by Jennifer Pontius.

Long-term Monitoring Plots on the Green Mountain National Forest

Diane Burbank[1], Marybeth Poli[1], and Nancy Burt[1]
[1] USDA Forest Service, Green Mountain National Forest

Long-term changes are occurring in Green Mountain National Forest (GMNF) ecosystems. Environmental changes such as changes in climate, atmospheric deposition, and the spread of non-native invasive species, are known have effects on forest vegetation and soils. We must better understand these changes and their effects in order to make sound land management decisions in the future. The Long-term Ecosystem Monitoring Project (LEMP) is a 50-year monitoring effort established to characterize and quantify changes to representative ecosystems on the GMNF over time. Site selection criteria were used to locate permanent plots across the geographic range of the GMNF, within the dominant natural communities and soils of the Forest. Plot design is based on a modification of FIA plot design, and plots are intended to be sampled every 10 years for 50 years. Plots are located in areas with minimal evidence of past anthropogenic disturbance. Twenty plots were established between 2008 and 2011. Data is gathered on site characteristics, all layers of vegetation, soil, lichens, and down woody material occurs during each sampling session. Soil samples are collected for analysis of pH, base cations, nutrient status, and mineralogy of the subsoil; soil samples will be archived. The plots are intended to host monitoring of other factors of interest to the research community. Plot data is available to the research community in various forms. It will be used to quantify baseline conditions of soil and vegetation and associated trends, and will contribute to sensitivity models, regional long-term monitoring datasets, and science in general.

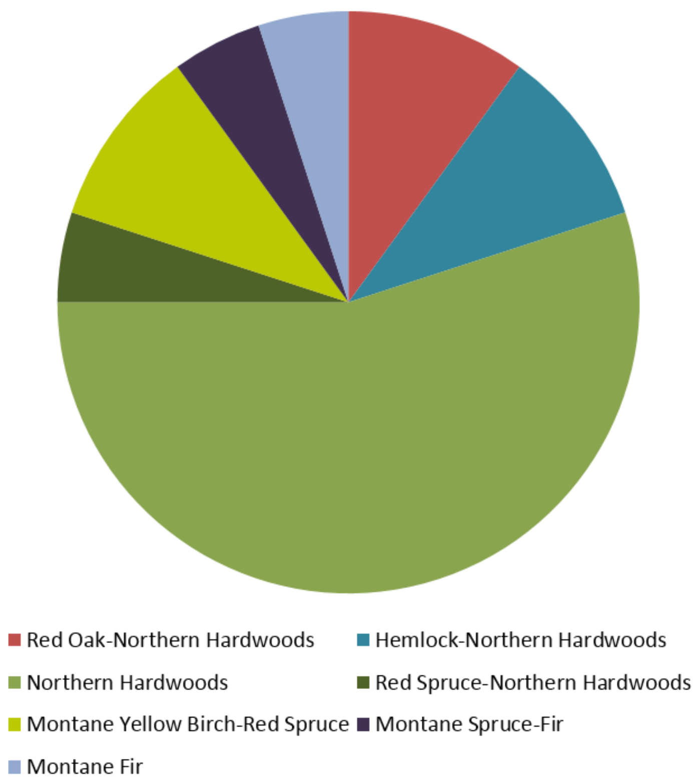


Figure 27. Composition of forest vegetation communities in long-term ecosystem monitoring project. From presentation by Diane Burbank.

Mapping Vermont From Above: Turning Data into Information

Jarlath O'Neil-Dunne[1], Sean MacFaden, Ernie Buford, and Anna Royar
[1] University of Vermont

From multispectral data acquired from satellites to 3D models generated from airborne LiDAR sensors to centimeter resolution imagery taken by unmanned aerials systems – the amount of data acquired for Vermont from above has grown exponentially over the past 5 years. This presentation will explore these remotely sensed data sources and show the types of analyses that are being done to turn these datasets into information to help improve decisions making and drive policy.

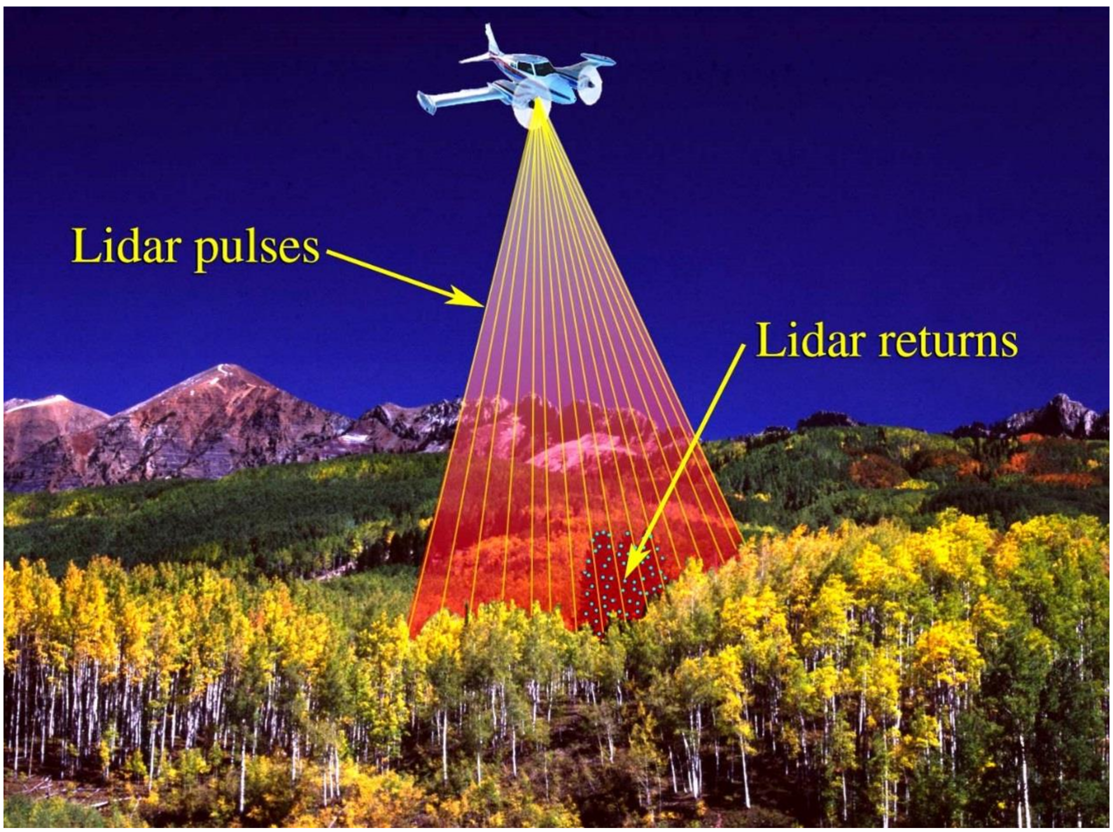


Figure 28. Graphic showing how lidar pulses reflect off of objects and return to the receiver. From presentation by Jarlath O'Neil-Dunne.

Modeling the Impacts of Climate Change on Water Quality in Lake Champlain: Design of an Integrated Assessment Model using Pegasus Scientific Workflow

Ahmed Abdeen Hamed[1], Ibrahim Mohammed[1], Gabriela Bucini[1], Yushiou Tsai[1], Peter Isles[1], Scott Turnbull[1], Asim Zia[1], and Mats Rynge[2]
[1] UVM EPSCoR
[2] University of Southern California, ISI

The Research on Adaptation to Climate Change (RACC) scientists study the Lake Champlain Basin (LCB) as a coupled human and natural system with climate-change and human drivers. In this effort, social scientists and natural scientists collaborate with stakeholders to develop an Integrated Assessment Model (IAModel) for basin management. We present an IAModel scientific workflow to answer the question: "How will the interaction of climate-change, human induced land-use, hydrological processes and public policies alter nutrient transport in the LCB?" The IAModel is calibrated to the observed remote sensing and water quality monitoring systems in LCB.

The workflow is comprised of (1) Climate projections for daily precipitation and temperature for our study area are downscaled to a finer spatial resolution from global climate models (GCMs). The downscaling process adds information to the GCM projections by accounting for topographic and latitudinal differences across our study region. (2) A Land-use transition agent-based model component (ILUTABM): simulates heterogeneity in land use decisions at parcel levels (3) A Watershed Hydrology component to simulate the physical impact of climate and land-use using the Regional Hydro-Ecological Simulation System (RHESSys) (4) Coupled 3-D hydrodynamic and water quality model (EFDC-RCA): simulates the response of multiple biotic and abiotic indicators of Lake Champlain water quality to changes in climate and land-use.

This workflow is designed using Pegasus Workflow Management System, which has been the leading workflow environment for virtually any scientific domains. IAM-Pegasus can run on a local Vermont Cluster and nationwide High Performance Computing clusters (e.g., Yellowstone).

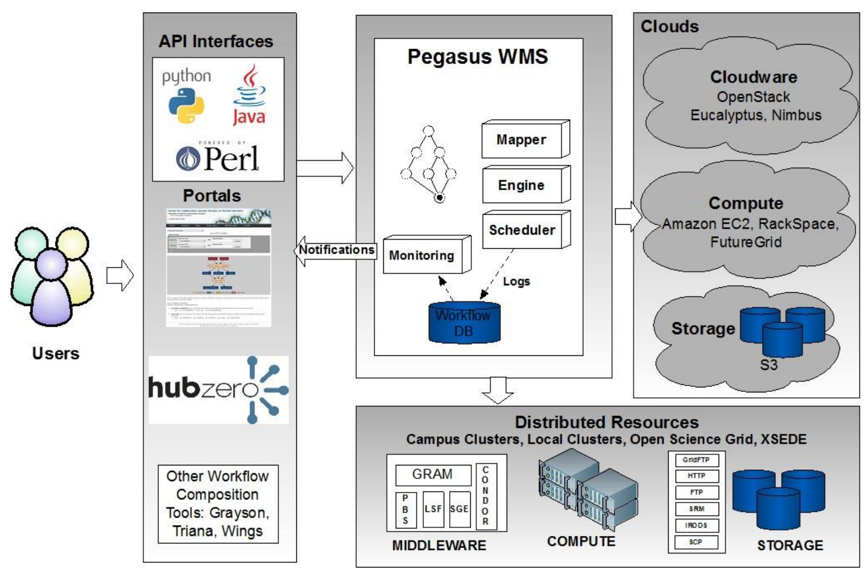


Figure 29. Overview of the Pegasus Workflow Management System architecture. From presentation by Ahmed Abdeen Hamed.

Monitoring Forest Recreation in Vermont

William Valliere[1], Nathan Reigner[1], Jessica Savage[2] and Robert Manning[1]
[1] UVM RSENR Park Studies Laboratory
[2] Vermont Department of Forests, Parks and Recreation

Vermont's forests provide many benefits for states, its residents and visitors. Beyond traditional forest products and ecosystem services, Vermont's forested landscapes are the settings of diverse and exceptional recreational opportunities. Individuals realize health, wellness, and social benefits from forest recreation. Communities realize economic and environmental benefits from forest recreation. While the realization of these benefits is widely recognized, virtually no empirical and representative data exist to quantify participation forest recreation, its distribution throughout the state, or the magnitude of its social and environmental benefits and impacts.

Vermont Forest, Parks and Recreation has started a program of data collection to document the amount and distribution of forest recreation across the state. Their work is based on contemporary approaches to document social and environmental benefits and impacts from recreation developed by the University of Vermont's Park Studies Laboratory. This approach combines automated trail counters and social surveys to describe the amount, distribution, and effects for of recreation.

Automated trail counters monitor the amount of use forest recreation facilities receive. Calibrating trail counters corrects automated estimates and provides numerous additional variables (i.e. activity, behavior, demographics) that expand the utility of counter data. Surveys of recreationists allow the volumes of recreation monitored by trail counters to be attributed with characteristics and behaviors of recreationists. Surveys provide detailed data on recreations, their motivations, expenditures, behaviors, and engagement with forested environments. Applying representative values from surveys to counter estimates allows aggregate benefits and impacts to be calculated.

Figure 30. The multiple dimensions of recreation assessed through survey techniques. From presentation by William Valliere.

Nutrient Dynamics in Streams of Four Land Use Types in the Missisquoi Watershed

Allison Jerram[1], Andrew Schroth[1], Matt Vaughan[1] and Breck Bowden[2]
[1] UVM EPSCoR
[2] UVM Rubenstein School of Environment and Natural Resources

Characterizing the relationships among hydrology, land use, watershed topography, and nutrient export will require quantitative analysis of each of these topics. To investigate some of these links in the Missisquoi watershed, we deployed three in situ sensor suites in streams draining three distinct land use types, as well as one suite in the mainstem of the Missisquoi River from June through November 2014. The land use types represented are suburban, agricultural (primarily dairy), and forested; the mainstem site represents mixed land use. These innovative optical sensors collect hydrological and water quality data at 15-minute intervals, significantly improving on prior research designs that relied on manual sampling. The high-resolution data allow for quantification of storm responses that have historically been difficult to capture. We have found that baseflow nutrient concentrations are elevated in anthropogenically impacted watersheds. During storms, high flow flushes nutrients from each watershed to a different extent. Total exports of nitrate differ across sites: the agricultural watershed exports the most nitrate per square kilometer and the forested site the least. Hysteresis analysis may provide further information on nutrient mobilization within watersheds during storms. “Hysteresis” describes the time lag of nutrient response to rapidly-changing storm flow conditions, observed by plotting nutrient concentration against discharge. The offset results in a loop, the characteristics of which can suggest flowpath separation. Integrating storm data with information on watershed slope and distribution of land cover can improve our understanding of nutrient sources in each watershed.

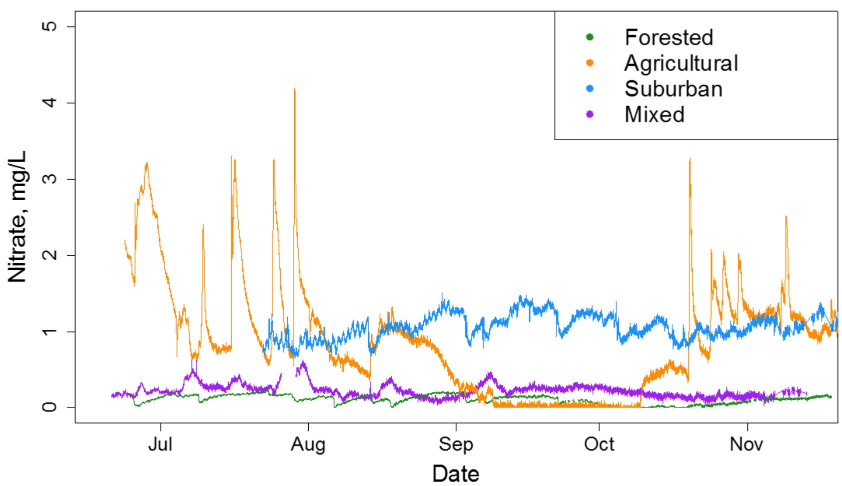


Figure 31. Variability in nitrate across sites in different land uses. From presentation by Allison Jerram.

Optimizing Climate Datasets for Use in Forest Health Research

Evan M. Oswald[1], Lesley-Anna Dupigny-Giroux[2]
[1] University Corporation for Atmospheric Research, UVM Department of Geography
[2] Vermont State Climatologist

Typically raw climate datasets are not optimized for direct analysis with forest health data in a topographically complex region such as Vermont. For instance, forest health plots are point locations, often situated on the sides of mountains, making coarse resolution climate information unrepresentative of the actual site-level meteorological conditions. This adds noise to the analysis and potentially depresses the strength of signals between climate and forest health data. A relatively light-in-resources-required method of spatially refining gridded climate information will be discussed; the gains and limitations will be illustrated using meteorological data from the VMC.

Another common disconnect between climate data and forest health investigations lies in the role of temporal consistency. Tree ring analyses, in particular, need climate data that can span numerous decades. The bulk of high resolution datasets are not suited for long term analyses, and thus will again add noise and depress climate-forest signal strengths. A process, called homogenization, applied to the climate data can potentially improve these issues. Homogenization in Vermont will be discussed; the improvements will be illustrated using meteorological data from the USHCN network.

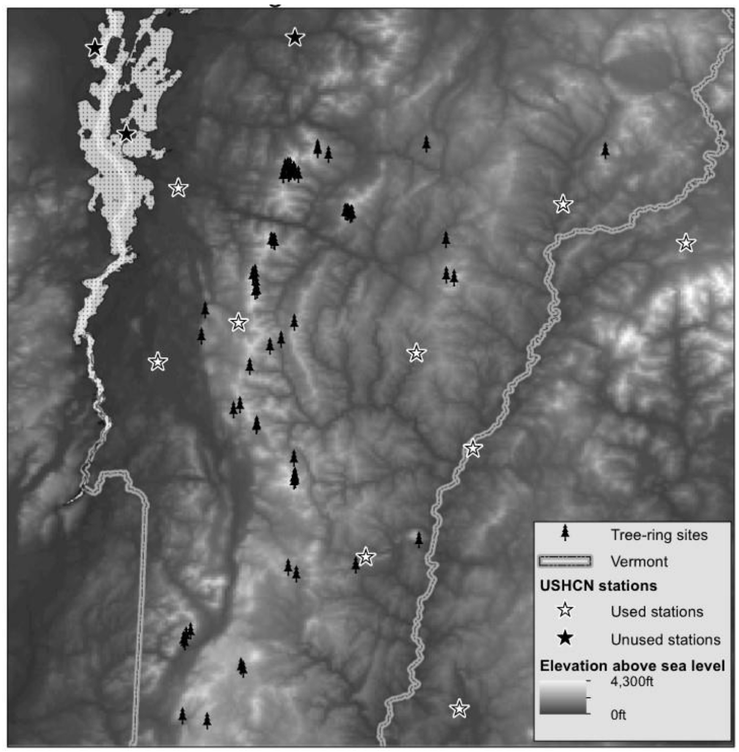


Figure 32. The locations of tree ring observations and US Historical Climatology Network stations. From presentation by Evan Oswald.

Photo-Monitoring in Mt. Mansfield's Alpine Zone

Elisabeth Fenn[1] and Kevin Hudnell[1]
[1] Green Mountain Club

Mt. Mansfield's alpine zone is one of only three areas in Vermont where arctic alpine tundra thrives today. As it is also one of Vermont's most popular hiking destinations, this rare ecosystem faces potential extirpation. In 1969, the Green Mountain Club, along with the Vermont Department of Forests, Parks, and Recreation, Stowe Mountain Resort, and University of Vermont, created the Ranger Naturalist Program, a new effort to educate hikers and combat the increased trampling along hiking trails above tree line in Vermont. This program has grown into the current Summit Caretaker Program, which watches over all of the alpine summits in the state.

We plan to re-launch a photo-monitoring program in the 2015 field season, which will continue work started by Matt Larson in 2004. Preliminary comparisons of sites documented in the 2004 study suggest that revegetation efforts in the alpine zone are succeeding. By analyzing photographs of multiple sites on a time frame separated by 11 years, we can make more informed decisions about the relative efficacy of our trail management techniques in order to strengthen our stewardship program. A large part of the Mt. Mansfield Caretaker Program is educating visitors who may have little previous experience with such a unique natural area. Having photographs that illustrate the progress we have made in protecting alpine vegetation, and emphasize the work that still needs to be done, will increase the effectiveness of our educational efforts.

Figure 33. Ridgeline of Mt. Mansfield. From report by Matt Larson.

Putting Tree Inventories and Canopy Assessments to Work: Translating data into actionable plans

Daniella Fitzko[1] and **Elise Schadler**[1]
[1] VT Urban & Community Forestry Program: A joint initiative between the Vermont Department of Forests, Parks and Recreation and UVM Extension

The Vermont Urban & Community Forestry Program is strategically working with communities to complete tree inventories and canopy assessments. In this session, we will share how communities are putting these inventories and assessments to work to create policy, secure funding, prepare for invasive pests, develop management strategies and engage the community.

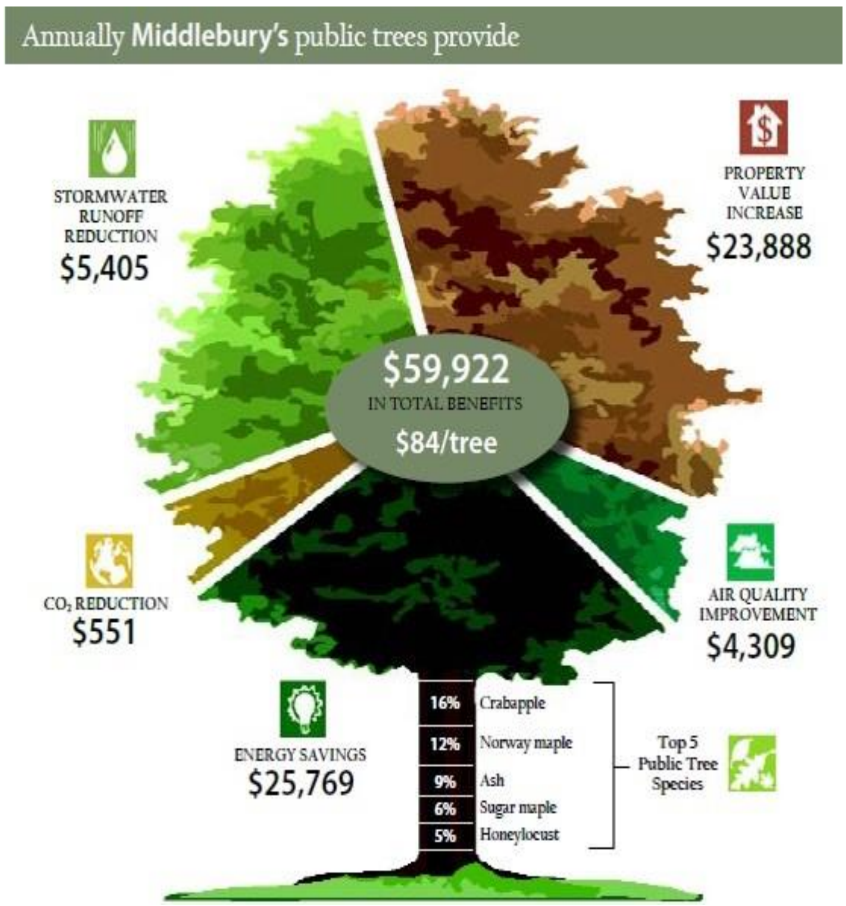


Figure 34. Ecosystem services provided by Middlebury's public trees each year. From presentation by Elise Schadler.

Stream Macroinvertebrate Responses to Landscape Variables; an Evaluation of Rapid Bioassessment Techniques Using a Statistical Modeling Approach

Declan McCabe[1], Philip A. Yates[1]
[1] Saint Michael's College

We calculated 14 benthic macroinvertebrate metrics from kick net samples taken from 56 Vermont streams as part of the Vermont EPSCoR Streams Project. Geographical information system (GIS) layers were used to measure 26 quantitative landscape response variables from the subwatersheds upstream from each macroinvertebrate sampling site. A generalized additive model used landscape variables to predict macroinvertebrate responses. The following 10 response variables were successfully modeled using this approach: number of Ephemeroptera taxa, number of EPT taxa, taxonomic richness, clinger richness, % EPT, % filterers, % Clingers, dominance, % grazers, and % tolerant organisms. We did not successfully fit models for number of intolerant taxa, Plecoptera richness, or Trichoptera richness. Bedrock classification, elevation, catchment area, and site aspect were the most influential landscape variables in our models. Of the land use variables used, % agricultural land and % forested land in the watershed were influential components of the model response. These results are valuable in comparing the relative importance of landscape parameters and on macroinvertebrate responses.

Figure 35. Obtaining kick net samples of stream macroinvertebrates. From presentation by Declan McCabe.

Subdivision and Land Use Change at the Municipal Level: An Analysis of Trends and Strategies for Maintaining Intact Forests in Vermont.

Jamey Fidel[1]
[1] Vermont Natural Resources Council

This presentation will explain the relationship of subdivision and land use change at the municipal level in fourteen case study towns Vermont. Recent research focused on subdivision trend analysis, case studies, and conclusions about effective and problematic zoning approaches for maintaining viable tracts of forestland in Vermont. Research results demonstrate that a majority of subdivision activity is not being reviewed by Act 250, Vermont's development review law, which means local municipalities are left to shape subdivision through local regulations. The presentation will discuss where subdivision is occurring, and whether certain municipal zoning approaches are more effective in controlling subdivision in forestland. Furthermore, the presentation will explain how subdivisions are lowering the amount of land that is eligible to be enrolled and conserved in the Current Use Program. Project partners coordinated with regional and local planning entities to discuss the research results and develop replicable strategies for planning and zoning to reduce the parcelization of forestland. This outreach effort resulted in a technical assistance manual and an online community planning toolkit showcasing effective planning and zoning techniques and non-regulatory strategies for maintaining forestland. Project partners also solicited input to develop a Forest Fragmentation Action Plan, which outlines nine of the most "effective" strategies to maintain forests in Vermont. The results of these efforts will be shared at the presentation.

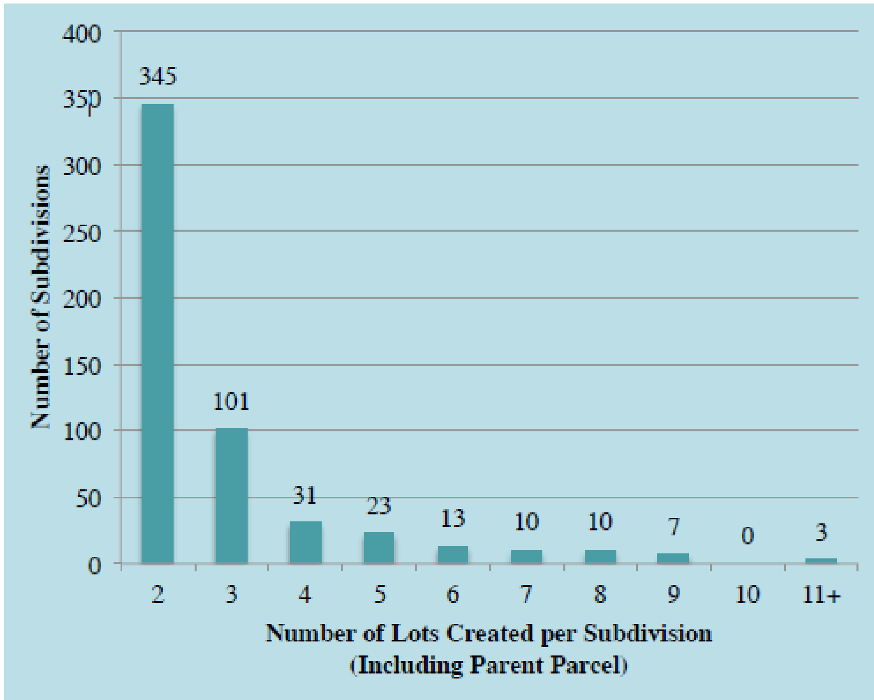


Figure 36. Count of lots created in the process of subdivision. From presentation by Jamey Fidel.

The Tree-Ring Perspective: How Dendrochronological Techniques Enhance Study of Environmental Change in New England

Shelly A. Rayback[1], Paul Schaberg[2], Andrea Lini[3], Gary Hawley[4], Joshua Halman[4]
[1] UVM Department of Geography
[2] USDA Forest Service, Northern Research Station
[3] UVM Department of Geology
[4] UVM Rubenstein School of Environment and Natural Resources

The study of tree rings provides a direct measure of stem growth in response to multiple environmental conditions and represents the principal above-ground carbon accumulation pool that can be measured over time, at high resolution and at site-specific and landscape scales. The greatest strength of dendrochronology lies in its ability to place current and future changes and events in a long-term perspective, allowing us to examine observed trends and cycles, their rates and magnitude of change and even extremes in a context that temporally exceeds observational data. Tree-ring-based time series offer multiple variables (e.g., ring width, cell density, light reflectance, $\delta^{13}C$) that serve as proxies for a variety of environmental information and provide information on tree function and physiology. Dendrochronology also offers reciprocal benefits with other research communities when tree ring time series are integrated with other datasets (e.g., climate, pollution, stream flow and flux tower measurements, remote sensing data, forest inventories) to provide greater insight into the magnitude and variability of forest C balance, climate change and related environmental research. The UVM Forest Ecology Lab Group has used dendrochronological techniques, alone and in tandem with other scientific approaches, on trees sampled at sites across Vermont, New England and northeastern North America. Recent tree-ring-based research has focused on reconstructing past stream flow, detecting changes in tree growth over the 20th century, identification of the influence of pollution deposition on tree recovery, and quantification of how rising carbon dioxide may be influencing water use and carbon storage in trees.

Figure 37. Cross-section of tree showing tree rings used in dendrochronological analysis. From presentation by Shelly Rayback.

Twelfth-year Update on a 200-yr Soil Monitoring Study

Don Ross[1], Scott Bailey[2], Therese Quintana-Jones[3], Jamie Shanley[4], Thomas Villars[5], Deane Wang[1] and Sandy Wilmot[6]
[1] University of Vermont
[2] USDA Forest Service Northern Research Station
[3] Green Mountain National Forest
[4] U.S. Geological Survey
[5] USDA Natural Resources Conservation Service
[6] Vermont Department of Forests, Parks and Recreation

Ongoing monitoring of unmanaged forest soils can play a valuable role in detecting, predicting and addressing environmental change. In cooperation with the Vermont Monitoring Cooperative, we have established a long-term soil monitoring study of five forested plots, three in the Mt. Mansfield State Forest and two in the Green Mountain National Forest Lye Brook Wilderness. Elevation ranges from 590 to 1140 m, with forest type changing from Northern Hardwood Forest (*Acer saccharum*, *Betula alleghaniensis*, *Fagus grandifolia*) to Montane Spruce-Fir Forest (*Picea rubens*, *Abies balsamea*). Each 50 x 50 m plot is sub-divided into 100 5 x 5 m subplots, with sampling dates assigned randomly to each subplot. Ten subplots are sampled per sampling date, allowing for a total of 10 sampling dates. The initial sampling of the five plots took place in 2002, with subsequent sampling occurring in 2007 and 2012. Small pits were dug in the center of each subplot, and soils were then 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. We will present data from the first three sampling dates, review the variability within and among plots, and discuss implications for our ability to detect temporal changes. Challenges of the monitoring study include within-site variability, continuity of sampling efforts, and difficulties in sustaining support. Continued monitoring and sampling will allow detection of environmental change in response to atmospheric deposition and a changing climate.

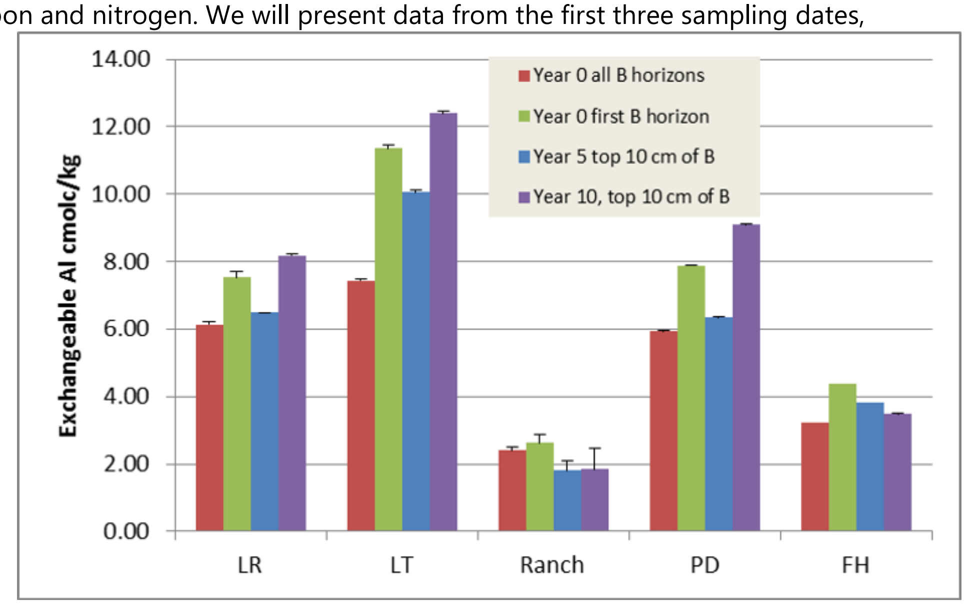


Figure 38. Long-term comparison of exchangeable Al in the B horizon at each sampling site. From presentation by Don Ross.

Using Dendroecological Techniques to Interpret the Response of Trees to Environmental Change at VMC's Mount Mansfield Study Site

Alexandra Kosiba[1], Paul Schaberg[2], Gary J. Hawley[1], Shelly A. Rayback[3],
[1] UVM Rubenstein School of Environment and Natural Resources
[2] USDA Forest Service, Northern Research Station
[3] UVM Department of Geography

A number of tree species in Vermont have undergone documented decline in the 20th century, most notably red spruce and sugar maple. However, there is also varied and conflicting evidence about how these trees are responding to more recent changes in climate and atmospheric deposition. We examined the growth, relative growth rates, and vigor of five key tree species in the Northern Forest growing in Mt. Mansfield State Forest: sugar maple (*Acer saccharum* Marsh.), red spruce (*Picea rubens* Sarg.), red maple (*Acer rubrum* L.), yellow birch (*Betula alleghaniensis*, Britton), and balsam fir (*Abies balsamea*, [L.] Mill.). We found baseline differences in past as well as present growth; with red maple and yellow birch having the highest mean basal area increment (BAI) growth, and sugar maple and balsam fir, the lowest. When growth was converted into a Z-score that compares recent growth (2008-2012) to mean growth since 1980 for each species, red maple and red spruce had growth above, yellow birch and balsam fir had growth that was indistinguishable from, and sugar maple had growth below their respective means. Although many year-to-year declines in growth were likely associated with specific (often localized) stress events, protracted patterns in growth (e.g., the recent increases in red spruce and red maple growth) were more likely associated with broader climate or deposition trends. Based on our assessments with other chronologies, growth at Mt. Mansfield for these species aligns with regional trends and may indicate that patterns assessed here are indicative of the broader region.

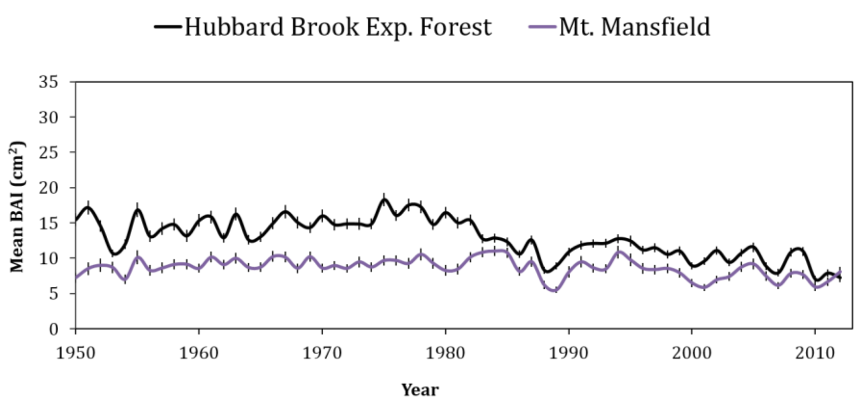


Figure 39. Sugar maple chronologies from specimens sampled from Hubbard Brook Experimental Forest and Mt. Mansfield. From presentation by Alexandra Kosiba.

The Vermont Reptile and Amphibian Atlas, Highlights from the 2014 Season

Jim Andrews[1]
[1] The Vermont Monitoring Cooperative, the Vermont Reptile and Amphibian Atlas, Vermont Family Forests

Figure 40. North American Racer. From presentation by Jim Andrews.

During the 2014 field season the Vermont Monitoring Cooperative continued to support both intensive amphibian monitoring at Mt. Mansfield and the extensive monitoring of the Vermont Reptile and Amphibian Atlas. We have not yet processed the intensive monitoring data for 2014; however, for our extensive monitoring efforts we have developed a new "hit list" of needed reptile and amphibian documentation and made it available on our website. Visits with survey teams to some of our least-well surveyed areas filled in many documentation gaps. Reports from the public included rare potential breeders such as the Eastern Box Turtle as well as reports of the North American Racer. The racer had not been documented in Vermont since 2008.

What Are Forest Health Indicators Telling About Future Forests?

Sandy Wilmot[1]
[1] Vermont Department of Forests, Parks and Recreation

It has been 40 years since the first Vermont sugar maple health survey, 30 years since the first Vermont Hardwood Health Survey, 26 years since the start of the North American Maple Project and 24 years since the first forest health plots were established as part of the Vermont Monitoring Cooperative. Trends in overstory tree health has ebbed and flowed with insect defoliators, ice storms, wind storms and other forest disturbances. Recent trends suggest regeneration failures that may have important ramifications for future forests. This "tell all" presentation will include statewide and site-specific trends in a suite of forest health indicators.

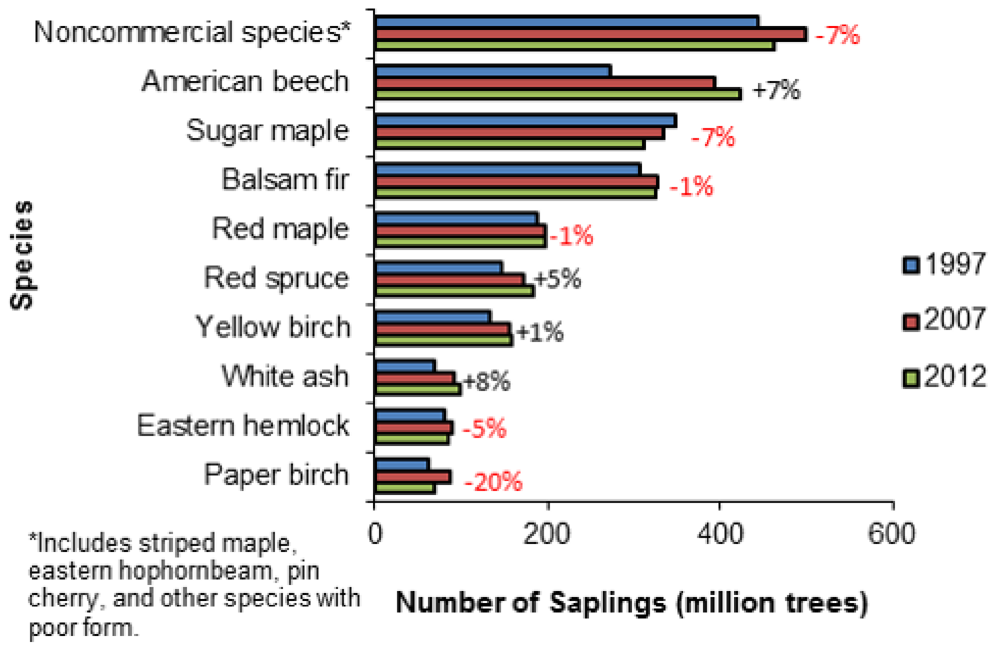


Figure 41. Trends in sapling abundance on long-term forest health monitoring plots in Vermont. From presentation by Sandy Wilmot.

When One Tugs on Mount Mansfield, You Find it Attached to the Rest of the World: Discoveries in Songbird Population Connectivity.

Kent McFarland[1] and **Chris Rimmer**[1]
[1] Vermont Center for Ecostudies

Not available.

Wilderness Streams in the GMNF: Creating a Chemical Baseline

Heather Pembrook[1] and Jim Deshler[1]
[1] VT Department of Environmental Conservation

Wilderness streams were sampled by the GMNF and the VTDEC 3 times in 2014 to establish a baseline of water chemistry values, as recommended in the 2013 USFS Air Quality Value Monitoring Plan. This information will be used by both the State of Vermont and the GMNF to determine the status of flowing waters in Vermont's wilderness areas across a geographic range, from the West Branch of the Deerfield in the George Aiken Wilderness area in Stamford to the North Pond Outlet in the Bristol Cliffs wilderness area. Preliminary results and beautiful photos of these hidden treasures will be presented. This work was funded in part by the Green Mountain National forest through a cost share Agreement with the State of Vermont.

Figure 42. Sampling stream chemistry at Lost Pond Brook, Danby, Big Branch Wilderness. From presentation by Heather Pembrook.

Image and Photo Credits

Cover Photo

New Leaves. By Flickr user Adam Franco. Online at https://www.flickr.com/photos/adamfranco/484497004 and reproduced under a Creative Commons BY-NC-SA 2.0 License (www.creativecommons.org/licenses/by-nc-sa/2.0/)

Introduction

Bluebirds in sugar maple. By Flickr user Putneypics. Online at https://www.flickr.com/photos/38983646@N06/6313449145/ and reproduced under a Creative Commons BY-NC 2.0 License (www.creativecommons.org/licenses/by-nc/2.0/)

Plenary Session

All photographs by Jim Duncan, Vermont Monitoring Cooperative.

Summary of Working Sessions

Lye Brook Meadow. By Flickr user Chris Morris. Online at https://www.flickr.com/photos/79666107@N00/6306277208/ and reproduced under a Creative Commons BY 2.0 License (www.creativecommons.org/licenses/by/2.0/)

Mansfield Summit buildings. By Flickr user Jimmy Everson. Online at https://www.flickr.com/photos/auvet/2601328362/ and reproduced under a Creative Commons BY-NC-ND 2.0 License (www.creativecommons.org/licenses/by-nc-nd/2.0/)

Black-throated Blue Warbler on Mt. Mansfield. By Flickr user Kent McFarland. Online at https://www.flickr.com/photos/vtebird/3919596968 and reproduced under a Creative Commons BY-NC 2.0 License (www.creativecommons.org/licenses/by-nc/2.0/)

Stream flow measurement. By Flickr user msmornington. Online at https://www.flickr.com/photos/msmornington/2388677565 and reproduced under a Creative Commons BY 2.0 License (www.creativecommons.org/licenses/by /2.0/)

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at 202–720–2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, or call 800–795–3272 (voice) or 202–720–6382 (TDD). USDA is an equal opportunity provider and employer.

Appendices

Appendix 1: Attendees at Mount Mansfield Science and Stewardship Strategic Planning Workshop

Table 7. Workshop participants.

Name	Affiliation
Jim Andrews	Middlebury College
Tom Berry	Senator Leahy's Office
Charles Cogbill	
Jon Erickson	University of Vermont
Elisabeth Fenn	Green Mountain Club
Steven Fiske	VT DEC Biomonitoring
Susan Hindinger	Vermont Center for Ecostudies
Ryan Horvath	VT Forests, Parks & Recreation
Kevin Hudnell	Green Mountain Club
Thomas Hudspeth	University of Vermont
David Kaufman	University of Vermont
Stephen Keller	University of Vermont
Dan Lambert	High Branch Conservation Services
John Lloyd	Vermont Center for Ecostudies
Nancy Mathews	University of Vermont
Kent McFarland	Vermont Center for Ecostudies
Ed O'Leary	VT Forests, Parks & Recreation
Rick Paradis	University of Vermont
Bob Popp	VT Fish and Wildlife
Chris Rimmer	Vermont Center for Ecostudies
Don Ross	University of Vermont
Paul Schaberg	USDA Forest Service
Beverley Wemple	University of Vermont
Sandy Wilmot	VT Forests, Parks & Recreation

Appendix 2: Agenda for the 2014 Conference

For informational purposes, the agenda from the conference is reproduced on the following page. It is also available online at http://www.uvm.edu/vmc/annualMeeting/2014/agenda.

The annual Vermont Monitoring Cooperative conference provides an important opportunity for communication, exchange of ideas, and expanding collaboration on forest ecosystem management, monitoring and research in Vermont.

About the 2014 Conference

This year, VMC is partnering with the University of Vermont Environmental Program to present a joint conference in celebration of the 40th anniversary of the establishment of the UVM system of Natural Areas and to deliver an agenda around the theme ***Science to Policy: Benefitting from Actionable Science.***

As environmental professionals we are well trained in studying and protecting natural resources, but may be less informed on how to translate our findings into actionable change. While the general public is often included in our outreach efforts, we all-to-often fail to communicate our findings to policy makers where these results can be considered for maximum long-term impact. The challenge to our community is to provide useful information to the appropriate decision makers in a timely manner. This year we are offering a program to provide our community with insider advice on maximizing the impact of our work at local, regional and national scales.

Special track on Mt. Mansfield Science and Stewardship

As part of the celebration of the 40th anniversary of the UVM Natural Areas, there is a dedicated track at the Conference for those interested in moving forward the science and stewardship agenda for the Mount Mansfield Natural Area, including a special presentation in the morning, a set of longer concurrent sessions in the early afternoon, and a working group session at the end of the day. Special sessions are denoted in the agenda with a ♦ symbol

New from the Cooperative in 2014

This year, the Vermont Monitoring Cooperative released several exciting new products.

New Vermont Monitoring Cooperative Database and Website

New digital infrastructure making it easier than ever to discover and access key ecosystem data

Newly launched at www.uvm.edu/vmc

The Vermont Monitoring Cooperative Long-Term Monitoring Update – 2013

A 2013 review and comparison to long term trends in nine key areas affecting regional forest ecosystem health

Available online at www.uvm.edu/vmc/about/annual_report/2013

The Vermont Monitoring Cooperative Strategic Plan – 2015-2020

A fresh update to VMC's goals and objectives with the strategic activities to get us there

Available online at www.uvm.edu/vmc/about/strategic_plan/2014

Agenda

8:15 – 9:00 **Registration**

Refreshments and poster setup.

9:00 – 9:10 **Welcome, Introductory Remarks**

Jen Pontius, Principal Investigator, Vermont Monitoring Cooperative
Rick Paradis, Director, University of Vermont Natural Areas

9:10 – 12:00 **Plenary Session**

Invited speakers include:

9:10 – Deb Markowitz, Secretary, Vermont Agency of Natural Resources

9:40 – Tom Berry, Policy Advisor on Agriculture, Conservation, Energy and Natural Resources to Senator Patrick Leahy

10:10 – Rebecca Ellis, Vermont State Representative and Vice Chair of the House Natural Resources & Energy Committee

10:40 – 11:00 Coffee break

11:00 – Jamey Fidel, General Counsel & Forest and Wildlife Program Director, Vermont Natural Resources Council

11:30 – ♦ Dan Lambert, Conservation Project Leader, High Branch Conservation Services

12:00 – 1:00 **Lunch**

Provided by the Vermont Monitoring Cooperative and UVM Rubenstein School of Environment and Natural Resources

1:00 - 2:30 **Contributed Presentations: Forest ecosystem science and monitoring, conservation, resource management, and public policy.**

Learn about new and ongoing research, monitoring, conservation and outreach initiatives through several concurrent sessions of presentations.

2:30 – 2:40 **Coffee Break**

2:40 - 4:00 **Concurrent Working Sessions**

Proposed, organized and run by meeting participants, this time allows for more structured networking and communication among current and potential collaborators. Participation may be primarily by invitation only, at the discretion of the group organizers, but most are open to everyone.

Confirmed working sessions include:

1) **Vermont Water Monitoring Council** (Open to All)
This session will focus on further improving coordination among the VMC and other Vermont organizations that undertake water monitoring activities. Partner organizations will be offered the opportunity to deliver "SLAM" style presentations, which will set the stage for topically-focused and facilitated discussion regarding the water monitoring topics raised. The goal of this session is to strengthen the identity of the Vermont Water Monitoring Council, and to capitalize on the opportunity presented by VMC's organizational structure as one possible unifying entity for the larger Water Monitoring Council community.
Organizer: Neil Kamman, VT Department of Environmental Conservation Watershed Management Division

2) **Integrated Forest Ecosystem Assessment to Support Sustainable Management Decisions in a Changing Climate (**Invitation only)
The McIntire Stennis Forest Health and Climate Research Group plans to convene stakeholders in the forest management community to present the concept for a novel spatial decision support tool, and solicit feedback on management objectives, alternatives and outcomes on which to base decisions.
Organizer: Jennifer Pontius, UVM, USFS, VMC

3) **♦ Mount Mansfield Science and Stewardship Center: Strategic Planning Workshop** (Open to All)
A group of VMC cooperators has formed to establish a hub of mountain science and stewardship in the Summit Station, located at the top of the Mount Mansfield Auto Road. This workshop will engage participants in the

development of a strategic plan for the proposed Mansfield Center.
Organizer: Dan Lambert, High Branch Conservation Services

4) **Strengthening the Role of Science at the Vermont Agency of Natural Resources (ANR)** (Open to All)
Vermont Agency of Natural Resource's science is employed for education and to resolve disputes. It informs and influences policy choices and supports implementation of policies through application to specific cases and new rules. As science is multidisciplinary in nature, it requires coordination and partner collaboration. For ANR to continue to be a trusted natural resource and environmental science advisor and decision maker, in cooperation with others, a number of topic areas need to be addressed. This workshop seeks a discussion with external partners to reflect on topics that are under consideration for targeted focus to strengthen science at ANR. ANR is currently working with its scientists/data collectors and those that employ science to inform public policy. A committee will meet to develop, for targeted areas, recommendations to the Secretary of Natural Resources by June 30, 2015. The science, monitoring and data functions in ANR and through our partners work to provide defensible science with sound outputs regularly used. Science underpins what we do and is an endeavor that requires both vision and practical skills integrated to develop critical natural resource and environmental thinking and doing to meet protection goals. There is room to strengthen the system by which monitoring; data; scientific studies and analyses are delivered to address the relevant questions.
Organizer: Larry Becker, Department of Environmental Conservation Vermont Geological Survey

5) **Lye Brook Working Group** (Open to All)
Discuss possible projects to pursue in Lye Brook Wilderness.
Organizer: Jennifer Wright, Green Mountain National Forest

6) **Getting the Most Out of the New Vermont Monitoring Cooperative Website and Database** (Open to All)
Participants will take a guided tour of the new VMC website and database, learn about some of the new and exciting features now available, and identify ways to expand and cross-link VMC data with other data catalogs and repositories.
Organizer: Jim Duncan, Data and Web Coordinator, Vermont Monitoring Cooperative

4:00 – 5:00 **Posters & Social Hour**
Enjoy conversation, posters and a cash bar at the end of the day

Contributed Presentations Schedule

Time	Session A	Session B	Session C	Session D	♦ MMSSC Session
1:00 to 1:15	**Long-term Monitoring Plots on the Green Mountain National Forest** *Diane Burbank*	**Incorporating the Next Generation of Water Monitoring in Vermont** *Keith Robinson*	**Effects of landscape development on bobcat carrying capacity in Vermont** *James D. Murdoch*	**Mapping Vermont From Above: Turning Data Into Information** *Jarlath O'Neil-Dunne*	**♦ When One Tugs on Mount Mansfield, You Find it Attached to the Rest of the World: Discoveries in Songbird Population Connectivity.** *Kent McFarland and Chris Rimmer*
1:15 to 1:30	**A long-term examination of changing species assemblages in a northern hardwood forest** *Jennifer Pontius*	**Wilderness Streams in the GMNF: creating a chemical baseline** *Heather Pembrook*	**The Vermont Reptile and Amphibian Atlas, Highlights from the 2014 Season** *Jim Andrews*	**Subdivision and Land Use Change at the Municipal Level: An Analysis of Trends and Strategies for Maintaining Intact Forests in Vermont.** *Jamey Fidel*	**♦ Photo-Monitoring in Mt. Mansfield's Alpine Zone** *Elisabeth Fenn*
1:30 to 1:45	**What are forest health indicators telling about future forests?** *Sandy Wilmot*	**Paired Watershed Monitoring** *Jamie Shanley*	**Modeling the Impacts of Climate Change on Water Quality in Lake Champlain: Design of an Integrated Assessment Model using Pegasus Scientific Workflow** *Ahmed Abdeen Hamed*	**Monitoring Forest Recreation in Vermont** *William Valliere*	**♦ Integrating Science and Stewardship for Healthy Mountain Ecosystems: A Framework for Mansfield Center Programs** *Dan Lambert*
1:45 to 2:00	**Optimizing climate datasets for use in forest health research** *Evan M. Oswald*	**Nutrient Dynamics in Streams of Four Land Use Types in the Missisquoi Watershed** *Allison Jerram*	**Stream macroinvertebrate responses to landscape variables; an evaluation of rapid bioassessment techniques using a statistical modeling approach.** *Declan McCabe*	**Putting Tree Inventories and Canopy Assessments to Work: Translating data into actionable plans** *Danielle Fitzko and Elise Schadler*	
2:00 to 2:15	**The tree-ring perspective: how dendrochronological techniques enhance study of environmental change in New England** *Shelly A. Rayback*	**Twelfth-year Update on a 200-yr Soil Monitoring Study** *Don Ross*	**Amynthas Ante-Portas: Invasive Asiatic Earthworms in New England and Reasons to Monitor Vigilantly** *Josef Gorres*	**Experimental gaps and biodiversity responses in the Vermont Forest Ecosystem Management Demonstration Project** *William S. Keeton*	**♦ Identifying and Strengthening Tools for Mountain Stewardship** *Susan Hindinger*
2:15 to 2:30	**Using dendroecological techniques to interpret the response of trees to environmental change at VMC's Mount Mansfield study site** *Alexandra Kosiba*	**Geology and Ecology: Building Studies from the Base Map** *Laurence Becker and Marjorie Gale*		**Exploring how silvicultural management and genetics influence the performance of American chestnut in Vermont** *Paul Schaberg*	