Proceedings of the December 11, 2015

Vermont Monitoring Cooperative Conference

25 Year of Forest Ecosystem Monitoring: Trends, Patterns and Lessons Learned

Vermont Monitoring Cooperative

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

Vermont Monitoring Cooperative

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

Established in 1990 and ratified in 1996 via a memorandum of understanding between the Vermont Agency of Natural Resources, the University of Vermont, and USDA Forest Service, the Vermont Monitoring Cooperative (VMC) has been conducting and coordinating forest ecosystem monitoring efforts for twenty-five years.

Originally designed to better coordinate and conduct long-term natural resource monitoring and research within two intensive research sites (Mount Mansfield State Forest, the Lye Brook Wilderness Area of the Green Mountain National Forest), VMC efforts have since expanded to capture relevant forest ecosystem health work across the state of Vermont.

Today, Vermont Monitoring Cooperative funding stems primarily from a 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. While VMC funding primarily supports ongoing research, monitoring, outreach and data management, the bulk of VMC activities are accomplished by "in kind" contributions provided by the larger collaborative network.

The current mission of the Vermont Monitoring Cooperative is to serve as a hub of forest ecosystem research and monitoring efforts across the region through improved understanding of long-term trends, annual conditions and interdisciplinary relationships of the physical, chemical and biological components of forested ecosystems. These proceedings highlight some of the VMC activities aligned with this mission and demonstrate the potential of large collaborative networks to coordinate and disseminate the information needed to understand, protect and manage the health of forested ecosystems within a changing global environment.

Online at 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, 2015 Vermont Monitoring Cooperative Conference

25 Years of Forest Ecosystem Monitoring: Trends, Patterns and Lessons Learned

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An Appreciation of Carl Waite

Carl Waite is an unsung hero at the University of Vermont and at the Vermont Monitoring Cooperative, and after 42 years of service in both research and administrative roles, he is retiring. Those who know him and have worked with him can testify to his remarkable set of skills – his ability to build and fix anything, to program recalcitrant data loggers, to balance balky budgets and to maintain his temper and diplomacy at trying times. He is a modest man who accomplishes much and prefers to remain quietly competent while doing so.

More recently, Carl has guided the VMC as the Program Coordinator, keeping this multifaceted organization on a steady course in the face of shrinking funding, increasing administrative complexity and shifting direction. Though Carl would prefer to be out in the field, he is an excellent administrator and the VMC has benefitted from his talent in this arena. He leaves behind a number of programs that would not exist without his stewardship, including the cooperative Long-Term Soils Monitoring effort and a high-quality network of meteorological monitoring stations.

Working for Carl has always been a pleasure. His easy-going demeanor, his light hand as a supervisor and his remarkable work ethic are fine qualities. Yet it is his determination to get things done that is most impressive, as when he single-handedly hauled up 14 sections of a forest canopy environmental monitoring tower.

Carl's efforts are much appreciated by the VMC Steering and Advisory Committees and all of the VMC cooperators with whom he has worked over the years. He has been with the VMC from the beginning and he will be missed. The Cooperative wishes you well, Carl, and thanks you effusively for your time with us.

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Introduction to the Proceedings

The Vermont Monitoring Cooperative's (VMC) annual conference was held on December 11, 2015 at the Davis Center on the University of Vermont campus. This marked the 25th year of coordinated Vermont Monitoring Cooperative activities. Appropriately, the guiding theme was 25 Years of Forest Ecosystem Monitoring: Trends, Patterns, and Lessons Learned.

The morning plenary featured invited presentations from 13 experts in various disciplines to give focused, 10-minute flash-talks synthesizing the long-term trends in their ecological data and implications of these patterns and trends in the future health of forested ecosystems. This synoptic overview of key trends in the long-term data included examples of how the successful translation of research and monitoring efforts to decision makers has informed policies that resulted in marked improvement in environmental quality. Many other plenary speakers noted the importance of long-term monitoring in order to identify changes in ecosystem structure and function, investigate potential drivers of change and develop solutions to mitigate environmental stressors. Some trends, such as a lack of recovery in bat populations and ongoing forest fragmentation in the state, give cause for concern and argue for continued and improved monitoring efforts. This rapid exchange of long-term ecological data across flora and fauna, and the abiotic variables that impact forested ecosystems provided a wealth of information across the disciplinary spectrum, allowing all those who attended to assess the bigger picture and consider the often overlooked interactions and feedbacks among these various projects.

A special Reflections on 25 Years of VMC section brought together key figures from the foundational days of the VMC. Robert Paquin, Vermont State Director, USDA Farm Service Agency and long-time Legislative Assistant and Congressional Aide to U.S. Senator Patrick Leahy, Lawrence Forcier, former Dean of the UVM School of Natural Resources and College of Agriculture and Life Sciences, and Conrad Motyka, former VT State Forester and Commissioner of Forests, Parks and Recreation, reflected on the establishment of the VMC, its evolution and impacts over the years. They also looked forward to some of the major opportunities and challenges for the continually-evolving organization. Thomas Berry, Field Representative for Senator Leahy, delivered remarks on behalf of the Senator that noted the importance of the data and information shared by VMC in the larger context of all the groups working to monitor natural resource conditions in the region.

As in past years, the afternoon was devoted to concurrent sessions where 15 collaborators from across the region presented their most recent work, followed by eight working group sessions on a wide range of topics that were convened by members of the Cooperative.

These proceedings represent a combination of summaries of the plenary session talks summarized by VMC staff, syntheses and products from a series of afternoon working sessions, and the abstracts submitted by researchers to the concurrent sessions. Additional details, including videos and downloadable PowerPoints of presentations can be found on the meeting home page at www.uvm.edu/vmc/annualMeeting/2015/content.

Plenary Session: Long-term Trends in the Forested Ecosystem

Introduction to the Plenary

Monitoring, research, and modeling are three legs of a stool that provides scientific support critical for adaptive ecosystem management. Monitoring tells us what is happening, research tells why something is happening, and modeling helps us understand what might happen under various scenarios. In conjunction, these three endeavors provide the information necessary to identify emerging forest health issues, determine the drivers of forest decline and evaluate possible management actions in response to those drivers. While all three "legs" are equally important, research, modeling, management and planning activities hinge upon the monitoring data collected. As such, monitoring forested ecosystems is one of the most important components to sustainably manage the forest resource.

Monitoring programs go beyond merely collecting data and documenting disease. Ideally, monitoring activities are designed to integrate research objectives, address compelling management questions, and inform planning and policy. Because forested ecosystems are complex, monitoring should include measurements of potential drivers as well as consequences of changes in forest condition. Because ecosystems typically change slowly, continuous, long-term monitoring is essential. While many long-term monitoring programs have been criticized as "costing too much while delivering too little", this type of information serves a vital role by revealing long-term trends that can lead to new knowledge and understanding as well as evaluation of potential solutions.

With support from the U.S. Forest Service, Vermont state agencies, academic institutions, federal granting agencies and many conservation organizations, there is a broad network of environmental professionals who have been working for decades to monitor the condition of Vermont's forested ecosystems. The 25th anniversary of the VMC provides an opportunity to look back on a segment of this work across a range of forest ecosystem strata to present a more holistic view of Vermont's forested landscape over the past 25 years. It is important to note that while much of this data is archived and summarized within the VMC database and web portal (see www.uvm.edu/vmc/database), this work has been primarily designed and implemented by a network of collaborative partners across the state. No one entity has the capacity to sufficiently monitor the forested resource. The work presented here serves as one example of bringing together these partners for a more holistic assessment of the health and function of forested ecosystems.

Forest Pests and Disease

Barbara Shultz, Forest Health Program Manager, Vermont Department of Forests, Parks and Recreation

Aerial sketch mapping is an efficient and economical way of detecting visible forest change events over large forested areas. These surveys provide much more information than simply identifying the location of stress symptoms. Expert sketch mappers are able include information on the cause, extent, severity and type of forest damages. This type of landscape scale assessment serves as the basis for recommending treatment alternatives. Forest health aerial surveys have been a part of Vermont's overall forest health monitoring program for almost fifty years. Statewide data (over 2.5 million hectares) is collected by the VT Department of Forests, Parks, and Recreation on an annual basis. Digital records dating back to 1995 allowed Barbara Shultz, Director of Forest Health for the Vermont Department of Forests, Parks and Recreation, to summarize the primary stress agents faced by Vermont's forests as well as long term trends in pests and disease over the past 19 years.

Dozens of damage agents have been mapped over the survey record. These can be categorized into chronic (frequent but localized and circled in blue), Figure 1, and episodic (covering a large area, but relatively rare, circled in red), Figure 1, damage agents.

Many pests and extreme climate stress events are episodic, so a number of stressors which have historically occurred in Vermont were uncommon or not detected in this nearly

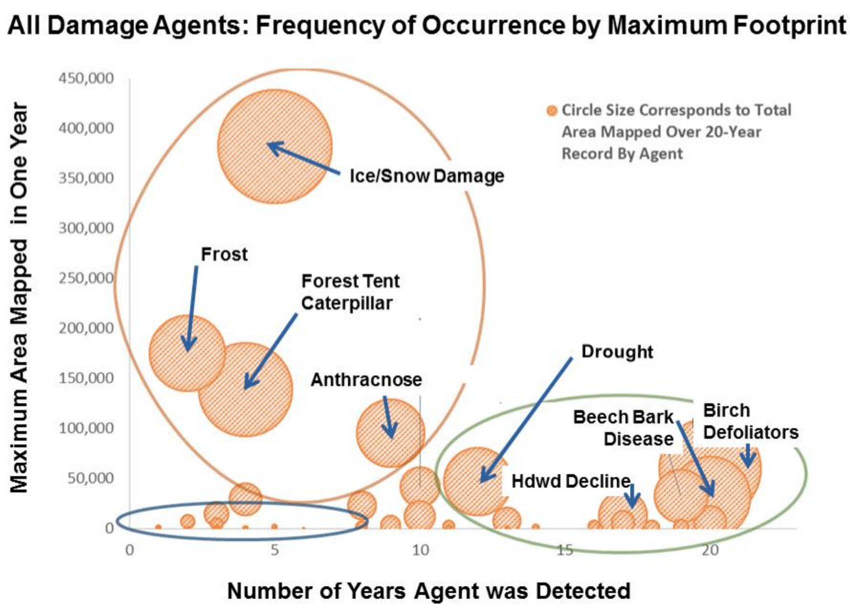

Figure 1. Frequency and extent of damage agents observed on Vermont forests. Adapted from the VMC 2014 Long-Term Monitoring Update.

twenty-year-long analysis period. Many of these (e.g. hurricanes) have the potential to cause widespread damage and leave the state's forests vulnerable to decline and mortality, should they reemerge or become more frequent and severe in nature.

Summary findings from the Vermont Aerial Detection Surveys:

- Surveys have detected dozens of types of forest damage, although widespread dieback and mortality are rare
- Damage occurs every year but the damage agents and extent of damage vary widely
- Beech bark disease, birch defoliators and hardwood decline are the most commonly mapped damage agents, but the ice storm of 1998 caused the most widespread damage
- Weather is a common driver or contributor to forest decline (most symptoms are consistent with dry conditions)
- Over the past 25 years the total mapped damaged area has been generally declining but the yearly variability and episodic nature of many stressors indicate that high damage years are still likely

Moving forward, maintenance of long-term metrics will be essential. Several invasive insects and diseases have been detected close to Vermont's borders. Under a warming climate, increases are expected in extreme weather events, such as ice storms, wind, drought, and flooding, and in defoliator outbreaks. Continued annual aerial surveys will provide critical information about the impact of these stressors on the forest and help inform resource management.

Lessons Learned

"We are documenting significant impacts on some species..." but we are fortunate in that "... we are not seeing disturbances that affect a lot of Vermont's land."

-Barbara Shultz

Tree Growth Trends

Paul Schaberg, Research Plant Physiologist, U.S. Forest Service Northern Research Station and UVM Dendrochronology Lab

Examining yearly growth in tree core measurements allow the investigation of historic long-term changes in tree growth, the impact of damage events on forests and recovery from such events over time. Tree increment core analysis also allows species-to-species comparisons of how well trees are growing relative to each other, and how different species respond to environmental stress agents.

Paul Schaberg and his team from the UVM Dendrochronology Lab collected increment cores along three transects and within three elevational zones at the VMC Mt. Mansfield intensive site, where forest canopy health measurements have been collected for over 25 years. These transects capture multiple tree species across three different watersheds, allowing for robust growth comparisons over the past 80 plus years. Analysis of these cores provide the "big picture" trajectory that overall, trees are growing faster over the historical record, with a particularly notable increase in growth in recent years.

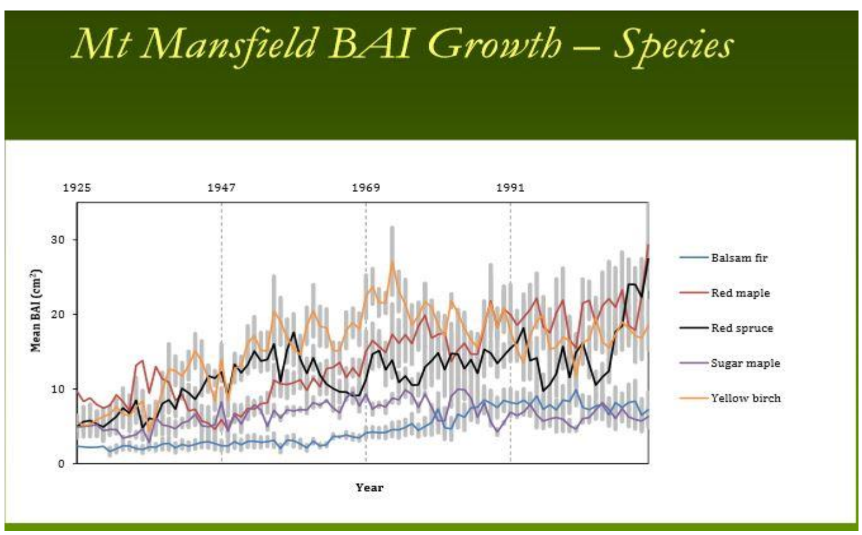

Figure 2. Basal increment area (BAI) from Mt. Mansfield by species.

Summary findings from Tree Increment Core Analysis:

- ✧ Trees are growing faster over the historical record, with particular increase in recent year.
- ✧ Sugar maple and balsam fir are the slowest growers; sugar maple had its peak growth in the 70's and 80's
- ✧ Red maple and red spruce in particular are growing more rapidly, especially at mid- to upper-elevations
- ✧ Red spruce, balsam fir, red maple and yellow birch show increased growth rate linked to increasing temperature, primarily due to a longer growing season. Sugar maple growth has decreased with increasing temperature

This plot-based Mt. Mansfield data can be combined with a regional dendrochronology database to examine site-specific factors that may inhibit tree growth (i.e. poor soils), to reveal landscape- or regional-scale phenomena such as the increasing growth rate of red spruce in many locations. Building a regional dendrochronology database gives the site based data context. From this context, abiotic drivers of tree growth (climate, acid deposition, CO_2, soil nutrition) are revealed. For example, the reduction in acid deposition at some sites around the region has improved the growth of red spruce but plots from areas that still exceed EPA recommended levels show poorer growth. By opening up this data rich archive of regional-scale investigation, the dendrochronology database will be a powerful tool for ongoing forest health management and monitoring.

Lessons Learned

"Over time, especially in the last twenty plus years... [Trees] are growing quite differently on the mountain. The slowest growing species are balsam fir and sugar maple... red spruce and red maple are growing faster."

-Paul Schaberg

Phenology

Josh Halman, Forest Health Specialist, Vermont Department of Forests, Parks and Recreation

Forest phenology observations began in the early 1990s when sugar maple was threatened by pear thrips, a non-native insect, and data were needed to document the timing of sugar maple budburst and its concurrence with the insect's emergence in spring. These insects proved to be less harmful to sugar maple than feared but this wealth of phenological information has now become a key metric in understanding the potential impacts of climate change on forest ecosystems.

At the VMC Mt. Mansfield intensive monitoring site, spring phenology is assessed twice weekly on sugar maple at the Proctor Maple Research Center (415 m, 1400 ft) and in Underhill State Park (670 m, 2200 ft) by calculating a mean daily phenological stage. Metrics of fall phenology, including visual ratings of percent color and percent leaf drop are also recorded.

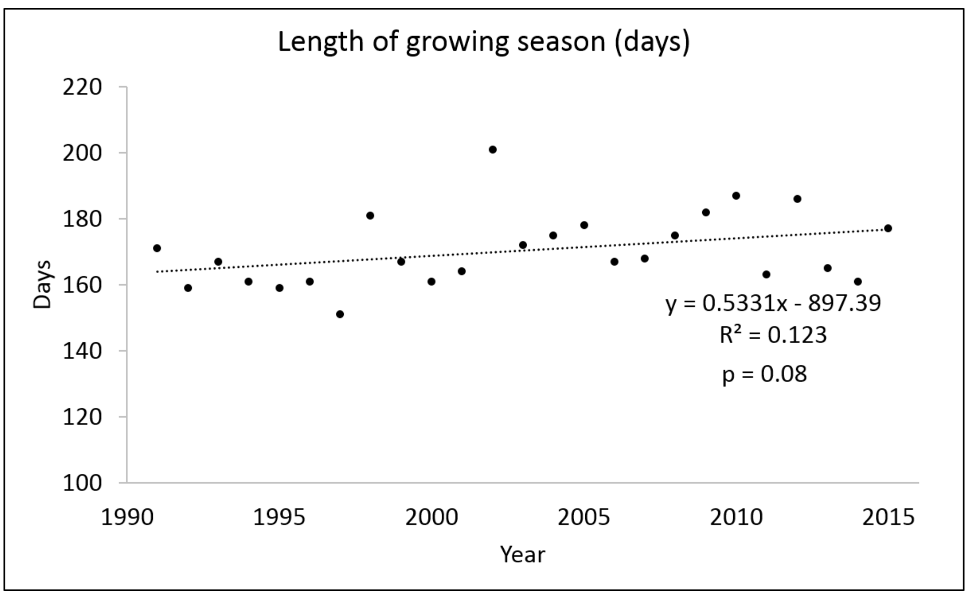

Figure 3. Annual length of growing season, in days.

These data have been used to examine changes in phenology over time and compare how species are responding to climate variability. The full leaf drop data for sugar maple is particularly robust and shows progressively later dates of key phenological events, a possible indicator of how changes in climate are directly altering forest ecosystem processes.

Summary findings from Tree Phenology Monitoring:

- Significantly earlier bud burst and full leaf out (in spite of high year to year variability)
- Significantly later peak color and leaf drop (particularly at lower elevations)
- The cumulative effect of these trends is a progressively longer growing season

While this dataset represents one of the longest and most comprehensive forest phenology records, efforts are underway to expand measurements to other species, as well as increasing the number of trees and locations sampled. This will allow for more detailed assessment of spatial patterns in phenological changes and a clearer understanding of temporal trends in spite of the high level of year to year variability.

Lessons Learned

"Peak color, especially in the lower elevation sites, is occurring much later in the season and that same holds true for leaf drop... We see a... moderately significant result in terms of how the growing season is actually lengthening with our potentially earlier springs and later falls."

-Josh Halman

Forest Fragmentation

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

Policy and management are best when informed by science. Considered one of the greatest threats to the forest resource across the state, forest fragmentation is an emerging policy issue that is in need of good science. Act 118 from the Vermont legislature called upon Forests, Parks and Recreation Commissioner Michael Snyder and Agency of Natural Resources colleagues to issue a report to assess and address this emerging threat to Vermont's forests. Commissioner Snyder outlined key findings of the report and issued a call to action to the audience.

The 2015 Forest Fragmentation Report[1] finds that Vermont has less forest cover now than it has had in over 100 years. Eleven-thousand acres of habitat are lost each year to development. Forests are critically and foundationally important to Vermont in many different ways, making them more than a collection of trees. The benefits derived from the forest resource include economic returns, ecosystem services, habitat for wildlife ("the other native Vermonters"), climate change mitigation, and the foundation for Vermont's excellent quality of life.

The division of forests into ever smaller pieces makes them less functional and less valuable. This damage can be quantified with aerial photos and satellite imagery, but to capture the type of development that is fragmenting Vermont's forests (primarily single family dwellings), higher resolution imagery is needed. This type of development results in edge effects (eroding the quality of interior forests) and isolation effects (existing fragments separated from

Figure 4. One example of how intact forests are fragmented.

[1] http://fpr.vermont.gov/sites/fpr/files/About_the_Department/News/Library/FOREST%20FRAGMENTATION_FINAL_rev06-03-15.pdf

each other). VMC long-term monitoring has been very helpful in understanding the trends in these impacts, especially on wildlife. In addition, better metrics to improve our understanding of patterns in land use are needed to address this emerging threat.

Summary findings from the 2015 Forest Fragmentation Report:

Drivers of fragmentation:

- Escalating property values resulting in increased property taxes
- Aging demographic of private land owners where turnover and subdivision are likely
- Ex-urbanization (use and conversion of forests outpacing human population growth)

Possible Solutions:

- Data collection and examination of trends to guide policy development
- Increasing education and outreach emphasizing the importance of forest
- Land acquisition and conservation
- Landowner incentives
- Land use planning

Documenting long term change is essential in crafting policy that preserves intact forests. Connectivity must be considered in the context of a healthy forest and must be included in local and regional land use planning, policy and legal frameworks. Specific recommendations to support forest integrity are forthcoming from ANR.

Lessons Learned

"There is no lens in any land use regulatory mechanism in the state - whether it's local zoning, or Act 250, Section 248 proceedings - that values forests. There are many other criteria – not forests... We're suggesting it's time to include forests, given the values they provide, as a lens in land use decision making."

-Michael Snyder

The Influence of Climate on Vermont's Forests

Lesley-Ann Dupigny-Giroux, Vermont State Climatologist and Chair, UVM Geography Department

To understand how climate can influence forest health and productivity, scientists are increasingly using a systems approach in which they consider not only direct climate impacts on forests, but also climate characteristics that indirectly impact other forest stress agents. For example, ground-level ozone, which requires certain temperature and humidity levels to develop, is harmful to plant growth. Taking these additional climate metrics into account, and examining them relative to a long, historic record provides a clearer understanding of the role of climate on forest health.

Vermont Climatologist Lesley-Ann Dupigny-Giroux applied this systems approach to examine trends in climate metrics from 1895 to 2015. Annual precipitation totals show an overall increase, but the 1960s was a decade of extreme cold and drought. The long view is important in terms of monitoring so that climate anomalies can be identified. Looking at the trends seasonally is also important and shows that we actually have a decrease in precipitation in fall, which also has implications for agriculture across the state.

Seasonal/Monthly Precipitation vs Annual

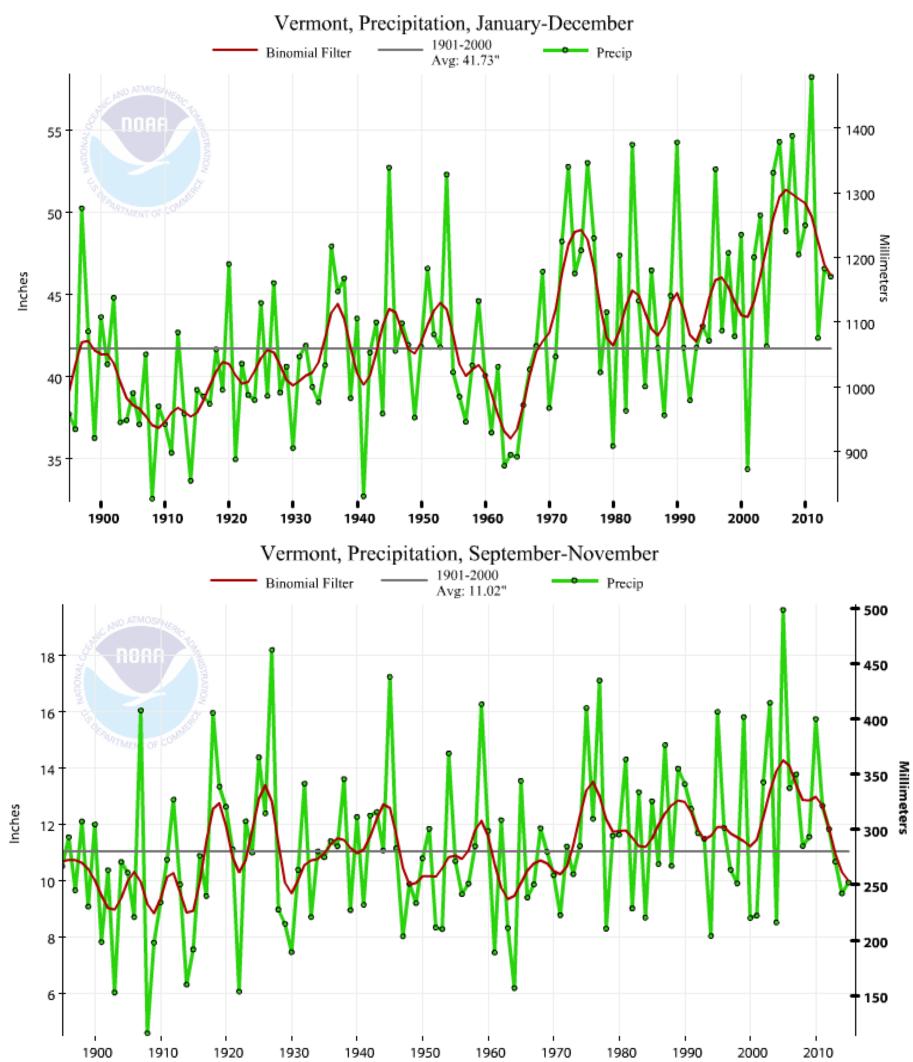

Figure 5. One-hundred years of annual (top) and fall (bottom) precipitation in Vermont.

Drought is cyclical and Vermont tends to flip between moisture extremes. The timing of drought can result in consecutive stresses or coincident stresses. For temperature, "shoulder" seasons may be most important; an early snow in autumn when trees still have full foliage or a late frost in spring when new leaves have emerged can cause damage to forests across the region.

Extreme weather events must also be considered as a key disturbance factor across the region. Tropical Storm Irene is one example, when already-saturated ground received an additional eight inches of rain leaving trees particularly susceptible to blow-down. Other examples of extreme disturbance events include ice storms, which can be exacerbated by snowfall that follows. Not all ice events are equal, depending on the season and the thickness of the ice, they can vary greatly in severity. Microdisturbances such as downbursts and isolated winds are other examples of disturbance factors, as well as high wind speeds at high elevations which can match hurricane forces.

Summary findings from a 25 Year Retrospective on the Influence of Climate on Vermont's Forests:

- ✧ We must think beyond gross characterizations of climate change to understand the role of climate on forest health
- ✧ Spatial and temporal variability must be considered, as impacts will vary across the landscape
- ✧ Vegetation can be affected in every season by a host of extreme events
- ✧ Impacts may be species-specific

The length of the growing season is also important. Observed increases from the 1980's already show an increase in frost-free days, and it is predicted that this trend will continue. A warmer and longer growing season would lead to changes species competition regimes and terrestrial carbon cycles but could be tempered by forest fires, pest infestations and summer droughts. Climate is complex and many variables need to be considered to fully understand the system.

Lessons Learned

"There are a lot of things that we still don't understand, a lot of work left to be done...so please come on board and join us... but I think it's a great time for continuing our monitoring activities so we can get to that great place."

-Lesley-Ann Dupigny-Giroux

25+ Years of Acid Deposition Monitoring in Vermont

Rich Poirot, Air Quality Planning Chief, Air Quality and Climate Division, Vermont Department of Environmental Conservation

The environmental issue of the 1980s was acid rain. It brought together scientists from different disciplines, legislators, policy makers, industry, the popular press and the public. The issue led to the Clean Air Act Amendments of 1990 which provided regulatory mechanisms for reducing the sulfur and nitrogen emissions that were causing acid rain. Working on this problem in such an all-inclusive manner was the model from which the VMC was created. Only by bringing together a range of stakeholders to examine data from across scientific fields could the connection between air pollution and forest (and broader ecosystem) health be revealed.

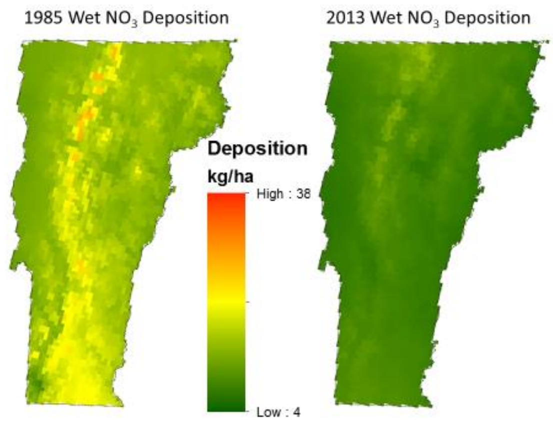

Figure 6. Statewide concentrations of acidifying nitrogen oxide in 1985 compared to 2013.

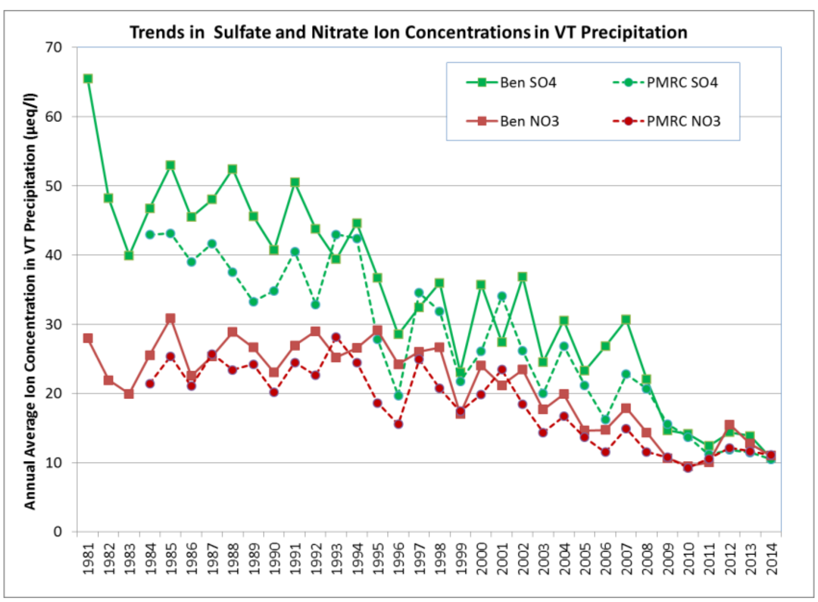

Figure 7. Annual mean sulfate (green) and nitrate (red) concentrations in precipitation at Bennington and Underhill Vermont.

Because of the intense focus on acid deposition in the 1990s, there were many monitoring networks operating in Vermont. Today, only a subset continue to collect data due to funding cuts. Rich Poirot focused on data from the National Atmospheric Deposition Program/National Trends Network for two Vermont sites where data has been collected since the early 1980's. Precipitation is collected in automated samplers as a weekly composite of precipitation events. This data record tells a story of tremendous success. The pH of precipitation in Vermont has increased from 4.3-4.4 in the 1980s to 5.0-5.1 in 2014 - an 80%

reduction of acidity in the past 30 years! However, because of their locations, these two sites are potentially underestimating precipitation at higher elevations.

Summary findings from 25+ Years of Acid Deposition Monitoring in Vermont

- We have witnessed an 80% reduction of precipitation acidity in the past 30 years
- Precipitation volume has increased dramatically which negates some of the improvements in concentration (more rain = more deposition)
- Ammonium (NH_4) deposition has slightly increased due to agricultural practices. NH_4 has acidifying and nutrient enrichment impacts on forests
- Now more total N deposition is in the form of NH_4 than NO_x

VMC was at the forefront in recording wet and dry deposition, both of which contribute to acidification. This information armed state legislatures and lawyers with information, enabling them to hold polluters accountable and get the policy changes enacted that led to this huge improvement. As can be seen in Figure 7, pH has increased significantly as a result of decreases in acidifying nitrogen oxides (NO_3) and sulfate (SO_4). Sulfate levels have improved more rapidly than nitrate. In regard to location, Bennington improved more rapidly than Mt. Mansfield. Concentration has decreased more rapidly than deposition because of increased precipitation amounts.

Lessons Learned

"This is a tremendous success story... Over the past 25 years that we've been looking, the pH of our precipitation has increased from the low fours to the low fives. That's incredible!"

-Rich Poirot

Monitoring Water Quality

Jim Kellogg, Aquatic Biologist, Watershed Management Division, Vermont Department of Environmental Conservation

Monitoring waterbodies over time is a useful tool for understanding ecosystem response to global influences, in this case, acid deposition and climate change. Jim Kellogg has been observing and documenting these responses since the early 1980s in acid-sensitive lakes through the national Acid Lakes Long-Term Monitoring program (LTM) and in streams through the Vermont Sentinel Streams network since the mid-2000s. Both use "reference waterbodies" located away from major human activities that might influence water quality in order to isolate the effects of acid deposition and climate.

The Acid Lakes LTM uses measurements of water chemistry, color and water clarity to assess water quality. Sulfur and nitrogen emissions are the precursors of acid deposition which directly acidifies lakes but also leaches calcium and other base cations from soils, causing lakes to recover more slowly than might be expected. Nonetheless, the record shows marked improvement because of clean air legislation. Alkalinity (an important parameter when assessing impairment and biological health of waterbodies) and pH are both rising over time while sulfate and nitrate levels are falling. As a result, the acid neutralizing capacity (ANC) of these lakes is increasing. These are regional and nationwide trends resulting from regulations to reduce emissions, and represent an amazing success. Despite this, many remote and undeveloped waters are still too acidic to support the expected community of aquatic biota.

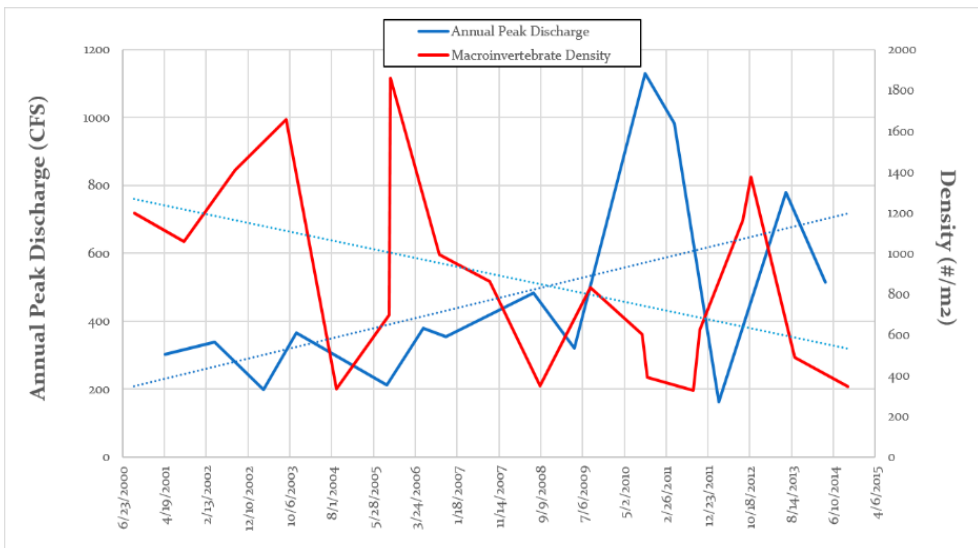

Figure 8. Annual peak water discharge in cubic feet per second (in blue) compared to macroinvertebrate density (in red) at Ranch Brook near Stowe, Vermont.

Sentinel Streams were selected to monitor the impacts of climate change on hydrology, aquatic biota, water chemistry and temperature. These "reference" streams are isolated from local impacts, particularly landscape manipulation. A primary goal of this study is to observe how the macroinvertebrate community responds to high flow events and rising temperatures that are predicted as a consequence of climate change. Ten streams are monitored annually and past studies indicate that the macroinvertebrate community is highly resilient and can recover after a high flow disturbance. High flows can scour the substrate, which can also have a negative effect on the fish community. Some sentinel streams like Ranch Brook (Figure 8) are having a difficult time recovering species density, while diversity seems relatively unaffected.

Summary findings from Vermont's Water Quality Monitoring Programs:

- ✧ Vermont has seen reductions in atmospheric S and N deposition, and an improvement in water quality
- ✧ Despite this, many remote and undeveloped waters are still too acidic to support the expected community of aquatic biota
- ✧ DOC increases could potentially limit ongoing pH increases and increase methylation and biomagnification of Hg
- ✧ Macroinvertebrate monitoring in Sentinel Streams shows that some streams have reduced species density, while diversity seems relatively unaffected
- ✧ Spikes in nitrogen during winter thaws and snow melt result in episodic acidification of lakes and streams may be more devastating to the biological community than long-term chronic chemistry issues

Nitrogen is becoming a critical factor in water quality. Spikes in nitrogen occur during winter thaws and snow melt that persists in the spring. This episodic acidification of lakes and streams may be more devastating to the biological community than long-term chronic chemistry issues. The pattern of Ca and other base cations leaching due to sulfur and nitrogen deposition may be beginning to level off, allowing soils and lakes to further neutralize. Ongoing emission reductions are necessary to decrease soil and water acidification. While this is not expected to replenish lost cations, it will partially recover reserves.

Lessons Learned

"I wish I had 10 minutes just to talk about nitrogen. We are... seeing nitrogen spiking – I think it's very climate related – it also strongly suggests we need to continue reducing emissions which include agricultural sources."

-Jim Kellogg

Mercury in Vermont: Problems, Processes, and Prospects

Jamie Shanley, Research Hydrologist, U.S. Geological Survey

Atmospheric mercury levels have varied widely over centuries as shown by ice core analysis. There are many natural sources of mercury, so the baseline is not zero. But current deposition rates are about three times the natural background due to human activities such as fossil fuel burning and artisanal gold mining. With the exception of inhaling fumes from artisanal gold mining, elemental mercury is not harmful to biota. When mercury becomes methylated however, it gets incorporated into the food web and is extremely toxic. The main pathway to humans is through the aquatic food web, which has led to fish consumption warnings for some species (i.e. walleye, lake trout) and certain consumer groups (i.e. pregnant or nursing women and children).

Global Mercury Emissions

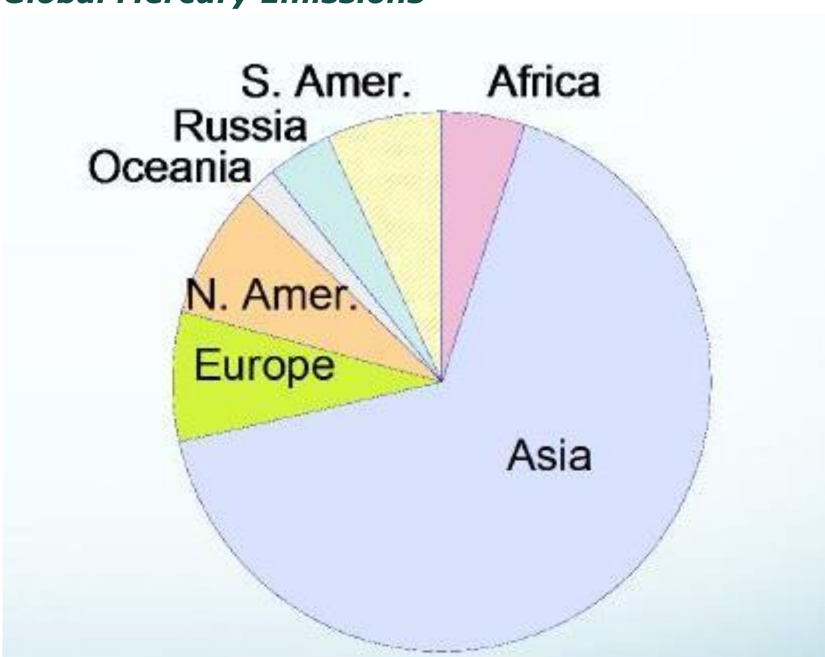

Figure 9. Geographic sources of mercury emissions.

Using both VMC atmospheric mercury deposition data and his own stream sampling data, Jamie Shanley presented a complete picture of mercury cycling in the region. VMC data show that the source of most of the atmospheric mercury reaching Vermont comes from industrial areas in the Midwest. This relationship can be seen when back trajectories of specific air flows are determined and compared with locations where mercury levels are elevated. Aside from these short-lived deposition events, the average levels detected at the VMC air quality site were fairly constant, showing no historical decreases or increases. This is likely because the VT site is spatially removed from point sources of mercury emissions so that when polluting facilities are cleaned up or shut down, we do not see a corresponding improvement. As such, the VMC site likely represents more of a global background. Mercury can persist in the atmosphere for a long time, making it a global problem regardless of its source. This may be why we have not seen decreases in mercury that are common in other pollutants.

Looking at the data from VMC soil sampling, mercury levels increase with elevation. There are also spikes in mercury in stream samples during snow melt events, which highlight the importance of snowpack in contributing to higher in-stream concentrations. High stream flow events are also important contributors of mercury which makes "storm sampling" critical to gaining full understanding of mercury cycling.

Research suggests that much of the methylation is occurring on the terrestrial landscape, not just in wetlands as was once thought. This highly toxic methylmercury enters the lake fully formed. The Vermont Center for Ecostudies' work on mercury burdens in Bicknell's thrush further documents the link between terrestrial sources and the food web. The thrushes' blood mercury levels are highest in the early spring when the only food sources are mercury-laden predatory beetles and spiders, and then declines as the food sources change to later-emerging leaf-eating insects.

Summary findings from Mercury in Vermont: Problems, Processes, and Prospects:

- ✧ Mercury comes from different sources – some regional/Midwest, but much is transported globally
- ✧ Mercury is stored in soil and released slowly (over decades)
- ✧ A small fraction of mercury is methylated (organic form) and highly toxic
- ✧ Methylmercury enters both terrestrial and aquatic food webs
- ✧ Like phosphorus, legacy mercury will persist for many years

The mass balance budget for Lake Champlain shows much more mercury coming in to the system than going out. Most of the mercury coming into the basin is retained in the terrestrial landscape. Its long residence time ensures that mercury will be a problem for a long time, even if inputs are reduced.

Lessons Learned

"Mercury and phosphorus have some similarities… they stay on the landscape for a long time"

-Jamie Shanley

Soils... and the Audacity of the Vermont Monitoring Cooperative

Scott W. Bailey, Geologist/ Geoecologist, U.S. Forest Service Northern Research Station

Soils are a critical resource that are essential to the support of life. But while air, water quality and forest health have extensive monitoring networks and long-term data sets, there is no extensive soil monitoring network. Long term monitoring of changes in soil content (calcium, mercury, lead) is needed to evaluate the effects of deposition on forest health, and to increase our understanding of carbon storage in soils.

In 1998, Sandy Wilmot and the VMC audaciously envisioned that Vermont should have a soils monitoring program. Thus began the VMC long-term soil monitoring program, designed to span 200 years.

Subsequently, five permanent soil monitoring plots were established in areas under the purview of the Vermont Monitoring Cooperative, three on Mt. Mansfield in north-central Vermont and two in the Lye Brook Wilderness Area in southwestern Vermont. Small pits are dug in different locations within

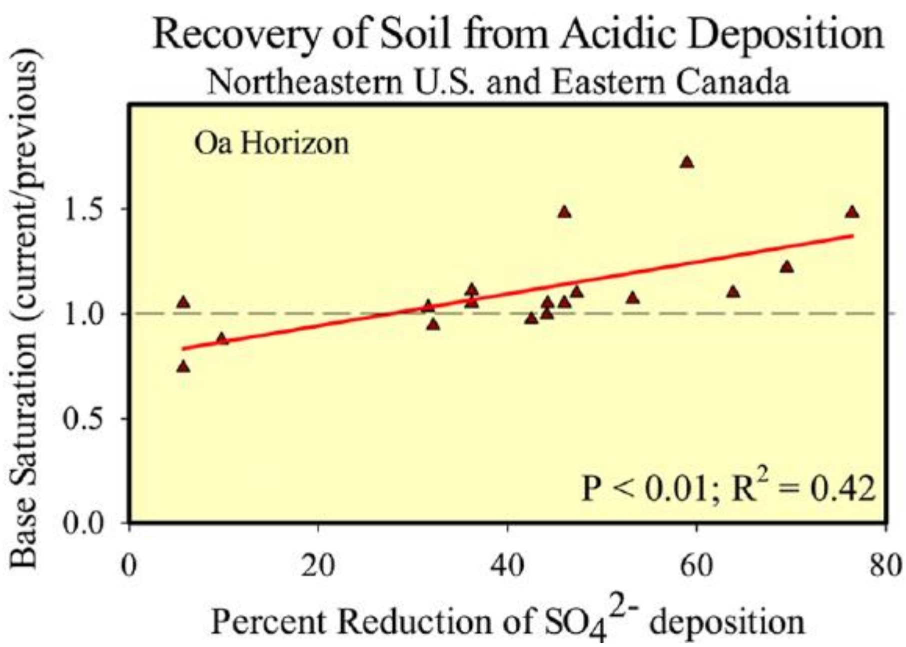

Figure 10. Increases in base saturation found in Oa horizon soil samples from the Northeastern U.S. and Canada resulting from reductions in sulfate deposition.

the plots every year, and the soils are sampled by horizon. Physical, chemical, biological and meteorological data (including evapotranspiration) and soil moisture and temperature at different depths are collected using the Soil Climate Analysis Network (SCAN). Long-term soil responses to and recovery from acid deposition are not well known, but recent studies suggest some recovery of pH in upper soil horizons has begun.

Summary findings from the Vermont Long-Term Soil Monitoring Project:

- Soil temperature at the Vermont SCAN sites does not vary much from December to April, and moisture peaks in April
- Four of the world's 12 soil orders occur on Mt. Mansfield: entisols, spodosols, histosols and inceptisols
- Natural variation, even within small plots, is extensive
- Soil acidification may be decreasing

Products from the long term soil monitoring initiative include new laboratory testing procedures and a new understanding of spatial variability, the establishment of the Northeastern Soil Monitoring Cooperative, and the first published evidence of soil acidification recovery. Despite these productive results, the big question is: can the institutions involved continue to employ the people with the mandate and skills to keep this project going?

Lessons Learned

"The American public has an increasingly distant relationship to science, especially political leaders. We need to share data, educate the public, and show them what science is and how it works"

-Scott Bailey

Vermont's Big Game Mammals

Mark Scott, Director of Wildlife, Vermont Department of Fish and Wildlife

Big game species, (moose, bear, deer), are critically important species culturally, economically and ecologically. People expect a certain population level of each of these species. The health of the forests, especially young forests, is critical to these species and these wildlife and forest populations are interdependent. Deer and moose can be destructive to forests, however. The public drives the management decisions that determine target game population numbers, which have to be in balance with their habitat.

Mammal populations have been tracked for many years in Vermont, and Vermont Fish and Wildlife is always trying to refine the models used to determine populations. Moose reappeared in the Northeast Kingdom in the 1980's, and as the herd grew, new methods needed to be developed to create accurate estimates of the population. Data from hunters is now used for moose and deer population estimates and will soon be used for bear. Data collected at game weigh-in stations includes weight, sex, age and other information on population health and reproductive capability. Vehicular deaths track big game population mortality well, too.

Hunter harvest accurately reflects deer population numbers. Currently buck weight appears to be increasing while antler beam seems to be decreasing. Overall the

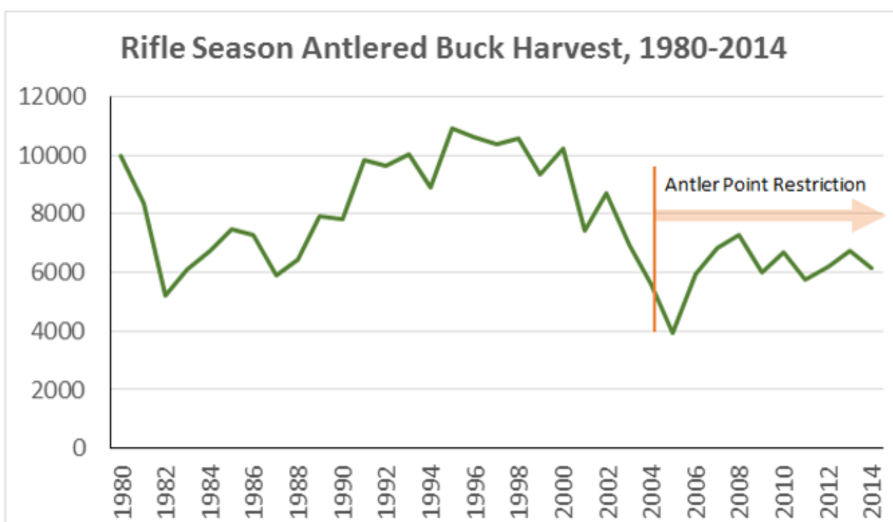

Figure 11. Annual buck harvest during rifle season in Vermont, since 1980.

deer population is relatively stable, and reproductive health is good, unlike moose, where both young and old female weights are down and reproductive health is declining as well.

Summary findings from Vermont's Big Game Mammals:

- Moose populations peaked in the early 2000's and have decreased steadily since then
- Moose health is declining, too, possibly from 1) aggressive hunting, and 2) vulnerability from warm weather, ticks and other stressors
- The deer herd is relatively stable; the population peaked from 1990-1994.
- Deer health is improving – possibly due to hunting which maintains a healthy population
- Winter severity is most deleterious to deer health; temperatures below 0° C and snow greater than 45.7 cm (18 in) are a good predictor of winter mortality
- The bear population has increased consistently over the last 35 years

Forest health and structure is key to the future of these animals. Young forest is required at one time or another during all three of these large mammal's life cycles. But young forests are declining in Vermont, with much lost annually to development. Our challenge is to continue to educate and encourage people to maintain large tracts of forested land. This will determine the long-term survival of these three species.

Lessons Learned

"Loss of the large blocks of intact forests has a big impact on hunters, and we need to maintain hunters as one of our key management tools!"

-Mark Scott

Cave Bat Population Trends and White Nosed Syndrome in Vermont

Alyssa Bennett, Wildlife Biologist, Vermont Department of Fish and Wildlife

Bats are the primary predators of nocturnal insects and while active can eat up to half their weight in insects every night. The prey of bats includes various agricultural, human and forest pests, mainly beetles and moths, but gnats, midges, mosquitoes and other species, too. Different bat species consume different types of insects. It has been estimated that a population of 50,000 bats would consume approximately 13 tons of insects per summer, so bats provide an important ecological service.

White-nose syndrome (WNS) has caused up to 90-95% mortality in some of Vermont's nine resident bat species. White-nose syndrome is an invasive fungus that thrives in the same cold conditions that cave bats like. All 6 of the Vermont cave bats have been affected by this fungus. There is differential bat mortality depending on the species of bat that is afflicted, thus in Vermont the little brown bat and the northern long-eared bat have experienced the highest mortality. Some bats can heal from this disease, so it is important to study the survivors. But the fungus can persist in the absence of bats. So far this fungus has been found in 27 U.S. states and in 5 Canadian provinces.

To assess populations, post-WNS, six types of surveys were used: summer mist netting, fall swarm and spring emergence surveys, summer maternity roost surveys and winter

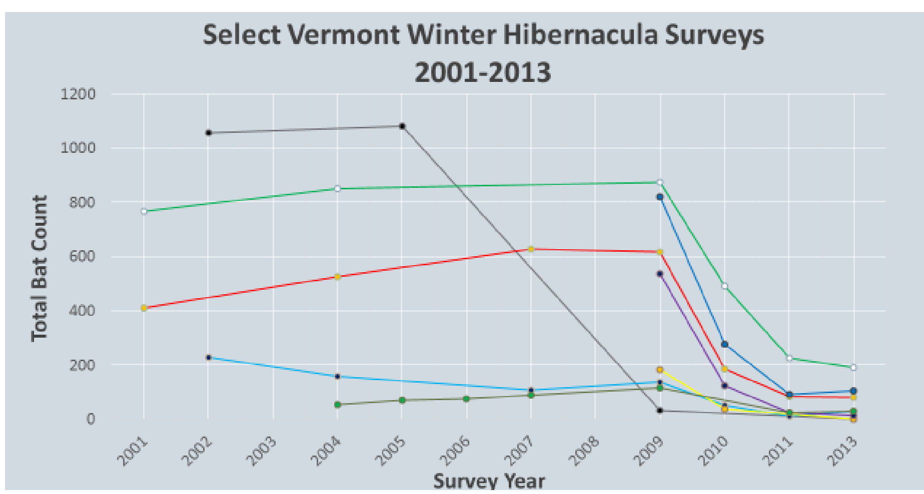

Figure 12. Bat populations in surveyed Vermont winter hibernacula from 2001-2013.

hibernacula surveys. Both stationary and driving acoustic surveys were utilized, and reports from the Vermont Department of Health rabies submissions, citizen and caving community sightings were taken into account.

The decline in bat populations due to WNS was severe. But in the 2010 post-WNS assessment that used multiple survey techniques, four of the six cave bat species surveyed showed increases in winter hibernacula populations. Little brown bat and northern long-eared bat numbers were still down in all survey types in the assessed locations.

Summary findings from Cave Bat Population Trends and WNS in Vermont:

- The impact on the bat population has been dramatic. Between 2009 and 2010 bat populations declined 90-95%
- Five of the nine bat species that occur in VT are now on the state and federal endangered species list
- It is important to standardize results across state boundaries to enable data comparisons
- Bats are the largest predators of insects, and are dependent on forests, but we need more information on how bats and forests are interconnected

In addition to white-nose syndrome, other major threats to bats in Vermont include wind tower development, loss of habitat and connectivity, human disturbance, loss of biodiversity in insects, and possibly climate change. Installation of bat friendly gates at the entrances to caves that serve as bat hibernacula leads to significant increases in those populations, and citizens can help bat populations recover by installing bat houses, which create roosting habitat.

Lessons Learned

"[Bats] don't recognize state borders so a lot of the work... to collect information from one state to another hasn't been very comparable. We are trying to standardize...those methods... so we can look at... trends on a regional scale."

-Alyssa Bennett

Long Term Trends in Amphibian Populations on Mount Mansfield

Jim Andrews, Coordinator, Vermont Reptile and Amphibian Atlas, UVM Adjunct Professor

Amphibians are sensitive environmental indicator species that can serve as a "bellwether" of ecosystem stress. Long-term monitoring shows that some species have been declining both in Vermont and globally. The primary threats that we have seen in Vermont are linked to forest fragmentation and habitat loss. On the positive side, some amphibian populations have been helped by decreases in acid deposition.

Drift fences are the primary collection method for the Mount Mansfield and Lye Brook Wilderness Area intensive population assessment efforts. Metal flashing is installed that channels traveling amphibians into buckets. Five species of salamander and five species of frog have been consistently monitored using these drift fences. At Lye Brook, egg mass counts and stream surveys were also used. In addition, the Vermont Reptile and Amphibian Atlas uses citizen reports, photo-documentation and historical records to establish population locations and species richness.

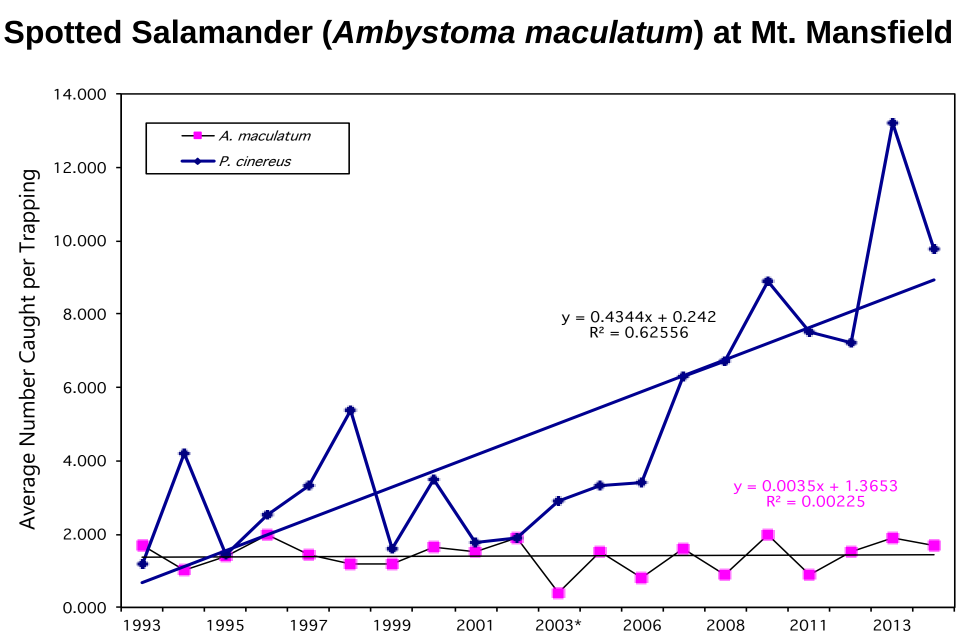

Figure 13. Spotted (Ambystoma maculatum) and Eastern Red-backed (Plethodon cinereus) salamander population indices from Mt. Mansfield, Underhill, Vermont, 1993-2014.

There is a great deal of variability with herpetological population surveys. Trends can be discerned over time but may vary by location. For example, red-backed salamanders increased over time at Mt. Mansfield, but not at Lye Brook. This species is not reliant on wetlands, unlike most other salamanders. But they are affected by deciduous leaf litter depth, which is being altered by introduced worm species. Can the differences in population trends at Mt. Mansfield and Lye Brook be explained by soil pH, leaf litter or the maturity of the forests?

Summary findings from the Long-Term Trends of Vermont Amphibians:

- Amphibians and reptiles require connectivity between forest habitat types so human disturbance and habitat consumption drive population declines.
- One species, the boreal chorus frog, has entirely disappeared
- Spring peepers and wood frogs are declining at Mt. Mansfield though there is much variability over time. At Lye Brook, spring peepers are increasing
- Red-backed salamanders are pH-sensitive, and their population changes may be due to decreasing soil litter depth due to invasive worms, chances in soil pH due to acid deposition or aging forest structure

Forests are not the only land cover type currently lost to development across the state. Many habitat types like old fields, edges and wetlands are also disapearing. If we continue to see a net loss of habitat, we are going to continue to see declines in our amphibian indicator species. We need to bring habitat net loss to zero.

It is necessary to have information on life cycles and habitat needs to determine the causes of population declines. This is where long-term monitoring studies can be very valuable. This work shows the importance of looking at several species at different locations, and shows the benefit of working in a cooperative where different data sets like soil pH and acid deposition chemistry are available.

Lessons Learned

"We've got to be looking at...the amount of resources used per capita and world population...We have to embrace it – now we're seeing populations stabilize in Vermont... I think it's up to us, who know, that this has to happen..."

-Jim Andrews

The Status of Vermont Forest Birds, 1989-2013

Steve Faccio, Conservation Biologist, Vermont Center for Ecostudies

Forest birds are the most diverse vertebrate group in Vermont. Forest birds need forests but there is growing evidence that forests also need birds for pollination, pest control, seed dispersal and nutrient cycling. Since 1989, The Vermont Center for Ecostudies wildlife biologist Steve Faccio has monitored populations of forest birds, which serve as one indicator of forest ecosystem health. A recent analysis of 25 years of population monitoring had some good news and some bad news about avian populations.

The Forest Bird Monitoring Program was initiated in 1989 with 11 study sites, and by 2012 that had increased to 31 sites. Study sites are all located in unmanaged, interior forest stands to limit habitat variability and edge effects. Each site consists of five survey points spaced about 200 m apart at which 10-min point counts are conducted annually by skilled birders. Population trends are estimated using mixed-effect models with analysis limited to the species with the most robust data. Trends were modeled for 34 species and 13 ecological guilds. Among species, eight increased significantly while 13 species declined and 13 showed no significant trend. Among the guilds, two increased, seven declined, and four showed no trend.

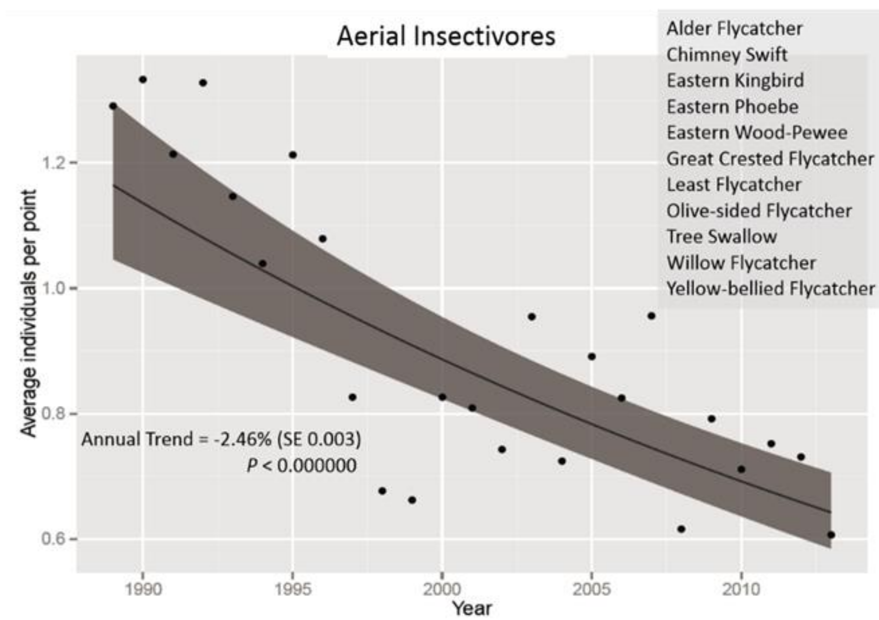

Figure 14. Decline in aerial insectivore species numbers based on Forest Bird Monitoring Program point counts.

Among the species with increasing population trends are red-eyed vireo, yellow-bellied sapsucker, black- throated green warbler and ovenbird. All four occupy different habitats and niches indicating that their diverse needs are being met by Vermont's forests and all are afforded some protection from the Partners in Flight Regional

Concern listing. Among the aerial insectivore guild, populations are declining, experiencing widespread declines possibly related to loss of prey, or, perhaps, insect phenology is changing during the birds' breeding season. West Nile virus was detected in 2000 and afflicts jays and other corvids as well as some of the aerial insectivores.

Summary findings from the Status of Vermont Forest Birds, 1989-2013:

- 24% of recorded avian populations increased
  - 63% are Partners in Flight Priority
  - 50% are neotropical migrants
- 38% of recorded avian populations declined
  - 46% are Partners in Flight Priority
  - 62% are neotropical migrants
- West Nile Virus (WNV) may be affecting some species
- There is a high proportion of forested-wetland and ground or shrub-nesters/feeder population declines

VCE's surveys show that species most abundant on forested wetlands, such as Canada Warblers, also have the West Nile Virus signature, wetlands likely being a high-risk habitat for this disease. Neotropical Migrant Birds, Bicknell's Thrush among them, face multiple threats throughout the year, and the full life-cycle of migratory birds must be considered in evaluating limiting factors.

Lessons Learned

"This is pretty complex to determine what are driving these trends...there's more that can be limiting populations than just things that are going on in the breeding grounds."

-Steve Faccio

Reflections on 25 Years of VMC: 25 years of Forest Ecosystem Monitoring Excellence

The 2015 Annual Cooperators Conference marked the 25th anniversary of the Vermont Monitoring Cooperative (VMC), and while the whole day celebrated that milestone, a brief remembrance of the formative years concluded the morning plenary. The 1980's were a time when acid rain was just beginning to be recognized as a major contributing factor to the decline of alpine species such as red spruce and balsam fir and increased acidification of many lakes and ponds. At this time, Canada and the United States were trying to align their assessments of forest inventory and analysis, which ultimately expanded to the national Forest Health Program within the US Forest Service. VMC grew out of collaborative efforts among the US Forest Service, Vermont Agency of Natural Resources and the University of Vermont, and leaders from all of these organizations, along with Senator Patrick Leahy and then Governor Madeline Kunin, were instrumental in not only providing funding, but also in creating the vision and structure that became the VMC.

> ***"It was exciting, like an awakening at a state level and a national level – that we really had to have good sound data". "I'm amazed…about how hungry the public is for information based on good science.***
> ***– Connie Motyka***

VMC was fortunate to be able to enlist the services of several foundational figures to speak at the conference. That effort was spearheaded by Bob Paquin who was a junior member of Senator Patrick Leahy's staff in 1990 when VMC was founded. Bob in turn recruited Larry Forcier[2], Conrad (Connie) Motyka[3] and Tom Berry[4] to also present some thoughts.

Bob began by recounting Senator Leahy's invitation to Lee Thomas, then Director of the EPA, to visit VT where they and several others were led on a climb up Camel's Hump by Hub Vogelmann to view acid rain induced-damage first hand. A discussion of forest health ensued that day and Governor Kunin later appointed a task force chaired by Dr. Luginbuhl, Dean of UVM College of Medicine and an arborist in his own right to study the situation and report back. The creation of VMC was a major action stemming from that report.

> ***"It was clear that there was a need for some continuous monitoring of forest ecosystems and communication of that information to policy makers, land managers and the general public, who support policy makers in doing the right thing". – Bob Paquin***

Our speakers remarked about the passion and dedication bought by early leaders of the organization such as Tim Scherbatskoy, Sandy Wilmot and Rich Poirot). They were struck and impressed by the unselfish spirit of cooperation, collaboration and dedication to sound science to be shared widely, across organizations, agencies and disciplines; this has been a hallmark of VMC from day one and has continued throughout the years. Many of the ideas coming out of VMC were later incorporated into state and/or federal monitoring and research programs.

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[2] Larry Forcier, former Dean UVM's School of Natural Resources (1990).

[3] Conrad Motyka, former VT State Forester & Commissioner, VT Dept. Forests, Parks & Recreation.

[4] Tom Berry, Field Representative, Senator Patrick Leahy.

"Vermont is a little point, but a very important point...we have a culture that says we want to know what is happening to our forest". "You have got to talk to each other regardless who you work for, the resource is too important and it doesn't stop at a boundary, it doesn't stop at a state line". – Larry Forcier

Tom Berry concluded the morning with a few words on behalf of Senator Patrick Leahy, a staunch supporter of VMC and a principal in establishment of several other enduring programs which also began in 1990 (i.e. Forest Legacy Program, the National Organic Standards Act, and the Lake Champlain Special Designation Act that established the LCBP). Tom noted that all of these programs only have value because of their 25-year-long data records. He praised the US Forest Service for its steadfast support for VMC over the years and for understanding the value of long-term monitoring programs. Tom, and in fact all of the speakers, while recognizing what has been accomplished over the past 25 years, made impassioned pleas to kept VMC vital and for leaders to employ all of their creative energy, foresight, passion and dedication toward tackling tomorrow's problems and issues over the next 25 years.

"Leadership at UVM, the State of VT, US Forest Service and otherwise have brought this program successfully through the first 25 years". "Hopefully we can be as creative now and have as much foresight as to what needs to be done over the next 25 years". – Tom Berry

Summary of Working Sessions

Session summaries were made available for several sessions, and are included below. No summaries are available for "Class I Wetlands - Planning Public Outreach and Organizing for the Greatest Wetland Protection", "Monitoring Earthworm Invasions into Northern Hardwood Forests", "Overcoming the Barriers to PPSR" or "Vermont Water Monitoring Council Meeting" sessions.

Exploring a Forest Indicators Dashboard

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

Forested ecosystems are complex, with many interactions and feedbacks among abiotic components and a diverse array of living organisms. This makes it difficult to capture the overall condition of the ecosystem as a whole, monitor changes in its health over time, or quantify the impacts of various management or remediation efforts. While many focus on yearly forest inventories or surveys to monitor forest health, our goal is to develop a forest health monitoring dashboard that uses a more holistic "systems approach" to ecosystem assessment that can be regularly updated through the VMC collaborative network. This type of information can provide decision-makers and the general public with relevant information on the current state and trends in forest condition.

Many organizations now use ecological indicators to describe and monitor the status of complex ecosystems in simple terms that can provide a more holistic view of the structure, function, and services provided by ecosystems (Figure 15). In this workshop we explored the potential utility of using a coarse assessment of multiple forest ecosystem health indices to summarize the relative condition of Vermont's forests. This included details of what a current dashboard might look like, identification of a target audience, discussion of potential key indicators to include, next steps to refine the approach, and outlets for dissemination. Here we summarize the general feedback around each of these discussion points and present a draft version of a Vermont Forest Indicators Dashboard based on participants' feedback.

> "Our goal is to develop a forest health monitoring dashboard that uses a more holistic "systems approach" to ecosystem assessment and can be regularly updated through the VMC collaborative network."
>
> - *J. Pontius,*
>   *VMC Principal Investigator*

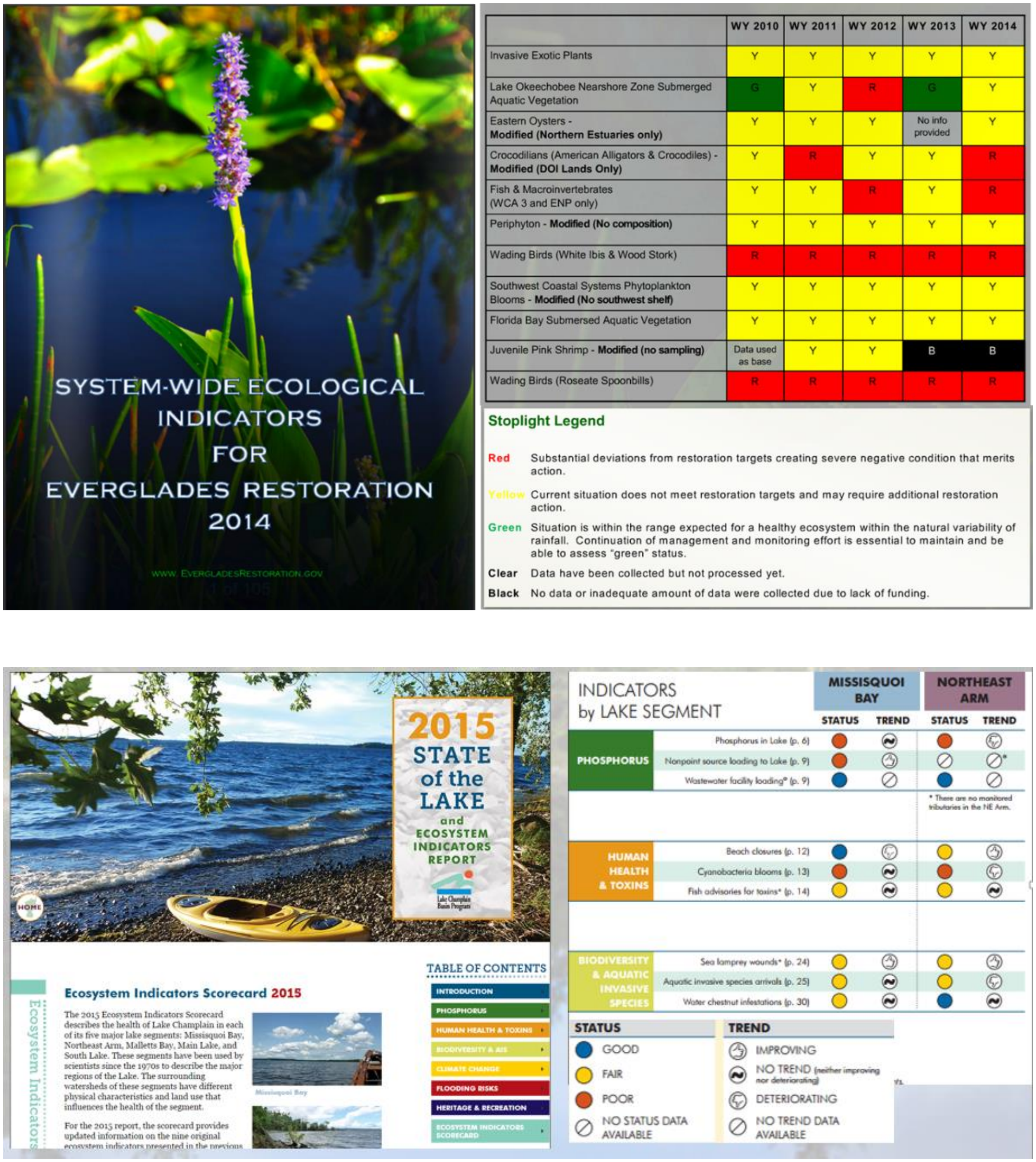


Figure 15. The adoption of ecological indicators for monitoring complex ecosystems is growing, including use by the intergovernmental effort to restore the Everglades watershed in southern Florida (top, source: www.evergladesrestoration.gov) and the Lake Champlain Ecosystem Indicators Program (bottom, source: http://sol.lcbp.org/ecosystem-indicators-scorecard.html).

Target Audience

Workshop participants agreed that a forest health indicators dashboard would be useful to a broad audience and would currently fill a gap in information available. While an online dashboard would be readily available to the public, the working group believed that this information would be most useful for forest managers and decision makers. Many governmental organizations are already moving towards a "dashboard" approach to help inform the public and guide the development of new, and revision of existing policies. As an example, Vermont's Governor Shumlin has developed a "Governor's Dashboard" intended to provide access to relevant information about the state with specific statistics that show how the state is doing in relation to the nation, other states and over time (http://governor.vermont.gov/govdash) (Figure 16). This includes a section on the Environment that summarizes indices such as percent forest cover, greenhouse gas emissions, acres enrolled in current use and municipal solid waste production. Participants in the group suggested that the creation of a forest health indicators dashboard might be considered for inclusion in the Governor's dashboard, and at the least would be useful to guide policy direction within legislative bodies.

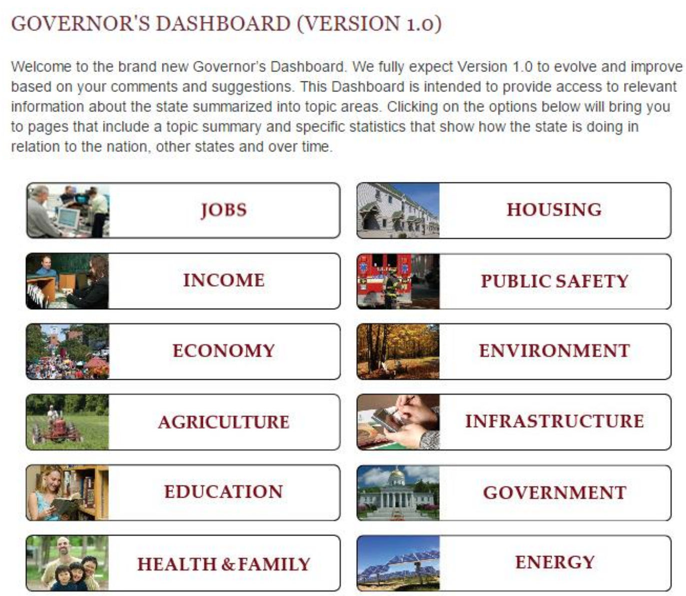


Figure 16. The Governor's Dashboard provides a simple summary of key statistics by which to compare the state of Vermont to other states and long-term trends.

Forest Health Monitoring Dashboard Template

Participants suggested a one-page visual summary of both the relative current status and long-term trends for a suite of key forest health ecological indicators that would be easily accessible through the Vermont Monitoring Cooperative landing page. The goal is to develop a monitoring system based on existing data that can be rapidly deployed, with automated updates as new data comes in.

Specifically, this dashboard would be designed to include:

- Careful identification of a small set of key indicators that capture both the general condition of the forest ecosystem but also include high sensitivity metrics that may serve as "canaries in a coal mine" for longer-term stress agents;
- The addition of metrics to capture:
  - primary abiotic factors that impact forest health
  - ecosystem services that forests provide;
- Normalization of indicators to units of deviation from historic norms to provide perspective on the severity of each metric;
- While this dashboard would report coarse assessments of the current relative condition, and historic trends, for a small set of ecological indicators, links would be available for each metric to the original data source for more in-depth exploration and analysis.

Key Indicators

Workshop participants agreed that any forest ecosystem health indicators dashboard must include information beyond just the trees. However, the list of potential metrics was extensive and clearly biased by the professional focus of the participants themselves. As such, we began with a discussion of the minimum requirements for datasets for consideration as well as a brainstormed list of potential indicators to include in the initial dashboard draft.

Criteria for indicator selection:

Datasets considered for inclusion in the forest health indicators dashboard must meet the following minimum criteria:

- represent key information about structure, function, and composition of the ecological system;
- are meaningful to decision makers and resonate with the public
- are sensitive to stresses on the system and respond to stress in a predictable manner;
- are widely accepted as high quality data
- must have a baseline for comparison of yearly metrics (or minimum 10-year historical record for establishing a baseline)
- come from existing data sets that are easily measured;
- have stable funding to ensure ongoing data collection
- are updated with new monitoring data regularly to best reflect "current" conditions

Potential Indicators for Inclusion

Workshop participants brainstormed a long list of potential metrics to be considered in a forest health indicators dashboard (Table 1). The challenge is to derive a manageable set of indicators that together meet the criteria listed above. While the ultimate development of a final set of ecological indicators must involve scientific and stakeholder vetting, it was suggested that the brainstormed list be whittled down to a draft set of key metrics so that the development of the dashboard could begin. The general consensus was that this initial version should include a general measure of forest extent, forest condition, biodiversity, and abiotic stress agents.

Table 1. Brainstormed list of potential indicators to be included in a forest ecosystem health indicators dashboard.

Forest Structure		Forest Condition	
State Forest Health Reports	Forest Cover	**Inventory based**	Crown Condition Metrics
	Acres in conservation	(FIA/VMC/NAMP)	Regeneration
	Species composition		Invasive Species
Inventory based	Forest Cover		Recorded Damage Agents
(FIA/VMC/NAMP)	Yearly growth	**State Aerial Detection Surveys**	Total Mapped Damage
Unknown Sources	Fragmentation		Mapped Mortality
	Mean parcel size	**Satellite Products**	MODIS growing season mean, cum, max NDVI
	Stand complexity (resilience metric)		length of growing season

Ecosystem Services		Drivers of Change	
VMC Database	Surface Water Quality	**VMC Database**	Acid Deposition
	Wildlife Biodiversity		Ozone concentration
State F&W	Hunting records		Mercury deposition
	Population estimates	**State Forest Health Reports**	Adverse Climate Conditions
Inventory or Satellite based	Carbon Storage		Pest/ Pathogen Outbreaks
	Carbon Sequestration	**Unknown Sources**	Development rates
State Records	Timber Extraction		Fragmentation
	Recreation Rates		
	Tourism Dollars generated		
	Economic Output		

Priority list of indicators for inclusion in Version 1.0

Because of the collaborative efforts within the VMC network, many pertinent data sets exist but have yet to be aggregated into a summary view of overall forest ecosystem health. The challenge is to capture the complexity of Vermont's forested ecosystems using only existing data sets that are readily available, have been scientifically validated, and have long-term data records for relative assessment of condition. In order to avoid overlap, or overrepresentation of indicators, this initial list (Table 2) is limited to 2-3 indicator metrics for each of the basic themes listed in Table 1: forest structure, forest health, ecosystem services and abiotic drivers of change.

Table 2. Prioritized list of metrics for inclusion in the Forest Health Indicators Dashboard Version 1.0

Source	Metric	*Units*
Forest Structure		
FIA Reports	Statewide Forest Cover	*Percent*
State Forest Health Reports	Statewide acres in conservation	*Acres*
Forest Condition		
VMC database	***Canopy Condition***	*Mean dieback (all species)*
State Aerial Detection Surveys	***Mapped Damage***	*Acres (all damage agents)*
Satellite Products	MODIS NDVI "greenness"	*Cumulative growing season NDVI*
Ecosystem Services		
VMC Database	***Surface Water Quality***	*Forest interior lake pH*
VMC Database	***Wildlife Biodiversity***	*Amphibian Density and Species Richness*
		Avian Diversity (Shannon-Weiner Index)
Abiotic Drivers of Change		
VMC Database	***Acid Deposition***	*precipitation pH*
State Forest Health Reports	Adverse Climate Conditions	*frequency and severity of extreme events (drought, flood, wind, frost, etc.) reported as classes of* ***typical, low, moderate or high*** *climate stress years*

Metrics in bold indicate current VMC holdings captured in the Dashboard Mock up (Figure 17)

Dashboard Development: Next Steps

Mocking up Version 1.0 of the Forest Health Indicators Dashboard will serve as a template from which to organize feedback from a broad scientific panel. The goal is to have a live web page with Version 1.0 available for comment and review by May of 2016. A scientific advisory panel should be convened over the summer of 2016 to consider the following questions:

- Which indicators to include: Addition of new indicators or removal of some from this base list in Table 2.
- Vet new indicators: Do potential data sets meet minimum criteria described above?
- How to best assess relative status of Indicators: Deviation from historical norms, comparison to baseline of "good health"?
- How to represent indicator values: General classes of good, average, poor or specific metrics of deviation?
- Possibility of aggregating indicators into one summary statistic of overall ecosystem condition
- Dashboard Utility: How to communicate the dashboard utility to stakeholders and document its impact?

- Potential to expand Forest Health Indicators Dashboard to neighboring states for a regional assessment of forest condition.

We anticipate that this will be an iterative approach to refining and improving the dashboard to ensure its accuracy at capturing the condition of the broader Vermont forested ecosystem and its utility for key stakeholders. Each summer the scientific panel will be convened to review updated data, as well as vet potential new indicators for addition to the dashboard.

We believe that this indicators dashboard will be of great utility for monitoring the condition of Vermont's forested ecosystems, detecting changes in ecosystem structure and function and help identify the role of common stress agents in those changes. Many of these datasets are currently replicated and/or archived within the VMC holdings for easier integration in other ongoing efforts, meaning data upkeep is a minimal hurdle. Furthermore, automated updating of these indicators is something that can be easily achieved through VMC's current data infrastructure, and will be a priority activity once the initial broad-brush design of the Dashboard is agreed upon.

While we could take a slow approach, waiting for complete vetting and refinement before releasing this product, the working group suggested that if the input data has already been scientifically vetted, putting up a summary of the indicators we are currently confident in now is better than waiting for perfection to make anything available. Because of this iterative approach to design and release, these preliminary versions of the forest indicators dashboard will include the following usage advice:

> **This dashboard represents a small subset of potentially important ecological indicators to more comprehensively assess the condition of Vermont's forested ecosystems. While each data set is fully vetted independently, its aggregation to represent a holistic assessment of forest health and function should be interpreted cautiously. Ongoing scientific review panels will continue to modify and improve the data sets included in this dashboard, as well as their interpretation relative to historical or baseline "norms". If you are interested in contributing to this discussion, please contact Jennifer Pontius at Jennifer.pontius@uvm.edu.**

Forest Indicators Dashboard Example Output for 2014 Indicator data

Metric	2014 Status	Long Term Trend
Forest Structure		
Percent Forest Cover	ND	ND
Acres in Conservation	ND	ND
Forest Health		
Mean Canopy Dieback (all species)	0.36	0.06
ADS Total Mapped Damage	0.77	0.04
MODIS cumulative growing season "Greeness"	ND	ND
Ecosystem Services		
Surface Water pH	0.66	0.11
Biodiversity: Avian Diversity Index	-0.52	0.03
Amphibian Density	-1.20	-0.13
Amphibian Species Richness	0.81	0.00
Drivers of Change		
Acid Deposition (mean precipitation pH)	1.65	0.14
Adverse Climate Conditions	ND	ND

Figure 17. Draft of a Forest Indicators Dashboard for the initial set of key ecological indicators identified by the working group. '2014 Status' is a z-score where positive values represent heathier than average conditions for the time period of 1992 – 2014. Increasing Long Term Trends indicate improving conditions for a given metric over this same time period. ND indicates that these datasets are not currently included in the analysis but are available for inclusion for the official launch of Version 1.0.

Forest-Lake Connections

Organizer: Peter Isles, UVM Rubenstein School of Environment and Natural Resources

The forest-lake working group was focused on finding ways to use monitoring data to connect changes in forested ecosystem with changes in downstream lakes, and in finding ways to use lake monitoring data to inform our understanding of watershed processes. This working group was focused primarily on inland lakes with forested catchments, with the understanding that these lakes may be responding differently to ongoing changes in climate than lakes in more developed areas.

We started the working group with introductions. There was a pretty diverse group of interests represented in the group, primarily from the aquatic sciences side of things, but with several forestry and watershed folks present as well. The session organizer (Peter Isles, UVM RSENR) briefly outlined a couple of thoughts about how climate may impact lakes both in terms of direct energy inputs (temperature, wind, solar radiation), and in terms of mass inputs (water, nutrients, DOC, contaminants). The introduction also highlighted a couple of research questions from recent literature that might be interesting to pursue in small lakes with forested catchments (long-term trends in DOC and brownification; and long-term declines in nitrogen). The organizer then presented a slide from Andrea Lini (UVM, Geology) describing the lakes where he has sediment core data, to bring a paleolimnological perspective to the discussion.

Next, Kellie Merrell (VT DEC Lakes and Ponds program) described some of the inland lakes datasets that have been collected, focusing particularly on 13 sentinel lakes that she and others identified as good candidates for climate sentinel lakes and began monitoring consistently starting in 2011. These lakes were chosen as minimally-impacted lakes, well buffered from acid effects (so that climate effects would not be confounded by long-term trends in acid deposition), and lakes which had largely protected shorelines. These sites (which are concentrated in the northeast kingdom, though not exclusively) seemed to be central to the types of questions that we were focused on in the working group, and there was some discussion about whether there are key variables which should be monitored in these sentinel lakes that aren't currently (this was left somewhat open ended, but there was discussion of the potential for putting HOBO temperature and dissolved oxygen dataloggers in the 13 sentinel lakes if funding is available, possibly including potential collaboration with a future UVM graduate student).

After that, Jen Stamp (TetraTech) described the regional monitoring networks that she has been involved with through work with the EPA. These networks are located primarily in the Midwest and in the eastern states from the Mid-Atlantic region northward through New England. These efforts have focused first on the development of voluntary networks of sentinel streams, and are now moving towards the development of a network of sentinel lakes. At this stage, efforts are underway to identify collaborators and develop standards for data collection.

Following the invited presentations, the conversation opened up, and we talked about how to progress with establishing research programs focusing on the inland lakes, and how to tie these lake data into data about forest processes. A couple of the research areas that people seemed particularly interested in working on were: 1) the effects of changes in forest phenology on nutrient export from forested catchments, and resulting responses of downstream lakes, 2) the effects of elevational gradients on long-term responses of lakes to forest processes, and 3) the comparison of lakes in forested catchments with those in more developed catchments.

One hole in our available datasets that emerged was a lack of comprehensive forest datasets in lake catchments. Several possible remedies to this were suggested, including use of remote-sensing data to assess forest types, and the potential availability of some forest composition data in Land Trust plots or other managed forests. It was suggested that it might be particularly useful to have baseline data regarding forest composition in the catchments of the sentinel lakes now, near the beginning of this sentinel effort. On a related note, there appears to be very little data available from streams feeding these smaller lakes, and such data might be useful for drawing connections between forests and lakes, particularly for questions involving mass balances.

At the end of the working group, there appeared to be momentum among a number of participants to continue working on these questions, and contact info was collected and distributed to facilitate future communications.

Incorporating Forest Management and Stakeholder Expertise into a Vermont-Specific Forest Management Decision Support Tool

Organizers: Clare Ginger, Tony D'Amato, Mary Sisock, UVM Rubenstein School of Environment and Natural Resources

The McIntire-Stennis Forest Health and Climate Research Group in the Rubenstein School at the University of Vermont is gathering data and developing models to assess the potential impacts of global change on forest ecosystem health in the state of Vermont. We will integrate these data into a spatially-structured decision support tool for use by forest landowners, managers and stakeholders. This tool will be Vermont-specific and differ from other decision support tools such as Tree Atlas, which provides information at a coarser/regional scale and in the absence of forest management activities. An overview of the tool is attached.

The Research Group assumes that global change will result in substantial changes in environmental conditions. Although details remain uncertain, we anticipate that the structure and composition of forests will change over the coming century. In addition, we expect patterns in other phenomena such as rainfall, snowfall, invasive species, and land use will change.

To ensure the forest management decision support tool is relevant, we need to build into it the expertise of those with experience and knowledge about recent, historic, and potential future forest management in the state of Vermont. To further this goal, the purposes of this working session were to:

- To gain knowledge from foresters working in various settings in the state of Vermont (public land; industrial, and non-industrial privately owned forests; conservation land) about the types of forest management activities (e.g., harvesting practices and their frequency and intensity) that have occurred historically and recently on land with which they are familiar;
- To discuss whether and how forest land owners and managers are altering their planning and management activities in response to global change, including what factors are likely to affect alterations in planning and management activities.

Participants in the working session came from a range of positions including county foresters, personnel in government agencies with forest management responsibilities, personnel in non-profit organizations with forest management in their portfolio, and consulting foresters.

During the first part of the session, participants provided information about forest management activities through a worksheet and gave feedback about the worksheet as a way to gather information from others about forest management activities in Vermont. Some found it offered a good way to provide information, while others suggested different ways to gather this information they thought would be more effective.

During the second part of the session, participants made the following points about whether and how forest land owners and managers are altering their planning and management activities in response to global change included:

- Changed tree plantings in areas where species have been managed out of the system to reintroduce them, although this activity is not necessarily directly connected to planning related to climate change.

- Managing with invasive species in mind, for example, reducing presence of invasive species as much as possible and harvesting only when it seems reasonable to that species other than invasives can be established in the system.
- Change in pruning and other practices for managing sugar bushes so trees and stands can better withstand ice and wind storms.
- Using new equipment for timber production to reduce impacts and allow for harvesting at what would otherwise be marginal times; this takes into consideration changing seasons, and the reduced time available for using standard equipment for timber production.
- Improving infrastructure for stream crossings, often related to management objectives for aquatic organism passage and not necessarily connected to climate change per se, but perhaps relevant given the changes expected with respect to frequency and intensity of rain and snowfall.
- Managing roads and trails to ensure they are sustainable and can withstand increasing frequency and intensity of storms.
- Use Value Appraisal system for features on the landscape, recognizing features that have importance and may be vulnerable to change or be in a tenuous state, and taking this into account in planning. This is not always linked to climate change but can be at times.
- Pursuing landowner education (broad based programs, one-to-one consulting, and peer-to-peer exchanges) about changing forest structure and composition with connections to specific management objectives (e.g. bird life, sugar bush management).
- Recognize that some landowners (e.g. sugar makers) and loggers are aware of changes underway and the implications for forests because their activities take them into the woods repeatedly and regularly. Similarly, some landowners have a deep knowledge of the forests they work in because of their personal history and practices, are knowledgeable about changes and changing their practices to accommodate them.
- Recognize that some landowners do not think that much about their forests, rarely look at their plan or may not even know there is a forest plan for their land. This presents a challenge, and requires outreach to provide information. Peer-to-peer mentoring can be very effective.
- For those who think that nothing can be done in response to climate change, it is important to communicate that some operationally, on-the-ground steps/actions can be taken to have a positive impact on forest conditions.
- Using climate change as an intentional lens in considering best practices and issuing guidelines for management.
- The group discussed the map that illustrated the role of climate in sugar maple health in the state (presented by Dr. Jennifer Pontius in an earlier session of the conference). Participants agreed this map is relevant to the questions posed in this working session. The group talked about ways to package this information, and what we can be doing to make data like this available and useful to people. Also discussed were ideas about how to disseminate this information, including how it is packaged and interpreted, and where it might be presented.
- Consider whether the infrastructure for forest harvesting may fall away and where markets fit into this conversation. Costs of rehabilitation of forested land can be prohibitive if there is no market for the timber. Although not everyone has commercial objectives, for those who do, this is an important consideration.

- Consider that we don't have high levels of harvesting in the state at this time, even with current conditions. Will the future bring even fewer opportunities for commercial forest production? So, when we consider the current low level of harvesting activity we have in the state, with global change and associated changes in forest conditions, it might go down even further. So, in looking at composition and structure, how will forest look going forward, and do we have tools to bring composition and structure to a desirable state?

The working session ended with a general consensus that many would participate in next steps associated with developing the forest management decision support tool, and each had an opportunity to indicate their availability for doing so, and contact information in the worksheet we used in the first half of the session. Next steps include:

- Assess information and ideas gathered in this session about the types of forest management activities occurring in the state, and about whether and how forest land owners and managers are changing forest planning and management activities in response to global change.
- Gather additional information from other foresters working in various settings in the state of Vermont about the types of forest management activities that have occurred historically and recently on land with which they are familiar; and also information about how land owners and managers not present in the working session are changing their activities in response to global change.
- Develop and implement ways to gain input on the development of the decision support tool, in consultation with working session participants who expressed interested in this aspect of the project.

Acknowledgement

The conveners of this session thank the participants for their time and thoughtful participation.

Finding Opportunities for a Regional Forest Health Monitoring Cooperative

Organizers: Jim Duncan and Carl Waite, Vermont Monitoring Cooperative and UVM Rubenstein School of Environment and Natural Resources

Over the past year, the Vermont Monitoring Cooperative (VMC) began exploring the exciting prospect of transitioning to a regional framework by working with neighboring states to expand the well-established cooperative monitoring model. The first steps were taken at the 2015 VMC annual meeting, where we brought together Forest Health Protection program managers from Vermont and the surrounding states – Maine, Massachusetts, New Hampshire, and New York, and our US Forest Service partners from State and Private Forestry, the Northern Research Station, and the Green Mountain and Finger Lakes National Forests. This productive initial conversation identified a number of steps that VMC could take over the next few months to expand its mission to support collaboration and information-sharing for ecosystem monitoring in the Northeast.

Main Points

- Based on the discussion in the group, there are some key opportunities for VMC to provide services at a regional scale, especially around data discovery and access, and coordination and outreach.
- There appeared to be agreement that providing a space or mechanisms to discover who holds what information will be useful. This could include access to actual data, or just links out to others that hold the data or information.
- There appeared to be a role for VMC to play in trying to convene people around key focal issues across disciplines and organizations. Possible areas of focus included data sharing, data standards, and regional aggregation of data/information/findings that may only exist at a state level.
- VMC should find a clear, succinct and easily deliverable method of articulating the value added by the cooperative approach.
- Other potential opportunities identified that were not discussed in more detail:
    - Integrating VMC's data holdings and/or monitoring into national forest planning processes as part of the monitoring regime (i.e. Forest Planning rule, Climate change preparedness planning)
    - Implementation of new monitoring programs, such as regional phenology monitoring
    - Advising on the establishment of new monitoring programs based on experience within the Cooperative, and/or facilitating a discussion of what the core foundational monitoring priorities should be.

Follow-up Questions for Each State:

- What key forest health datasets or information are currently being collected in your state?
    - If these data are not being collected by you, who is collecting it?
    - Are these data publically available or is access restricted?

- Is there data that's not being collected at all (data gaps)? Do you believe these missing data are of local importance only or regional important?
- Are there data available through the VMC that you would like to see made accessible in your state?
- What are the issue areas or topics (i.e. acid deposition, mercury, attitudes & values, urban vs. rural forests) that most matter to you for assessing and managing forest health in your state and regionally?

Action Items and Proposed Timeline

- Follow up with each state to receive answers to the questions above, either via e-mail or on the phone (complete by January 29, 2016)
- Begin contacting partners identified at the meeting and through subsequent conversations to understand their data holdings and current monitoring programs (ongoing as they become available).
- Develop an implementation plan for presentation to the VMC Advisory and Steering Committees (deliver on February 5, 2016)
- Begin expanding VMC catalog to include more linkages to efforts around the region that address key issue areas and datasets identified through follow-up discussions (Present status update to group by May 1, 2016)

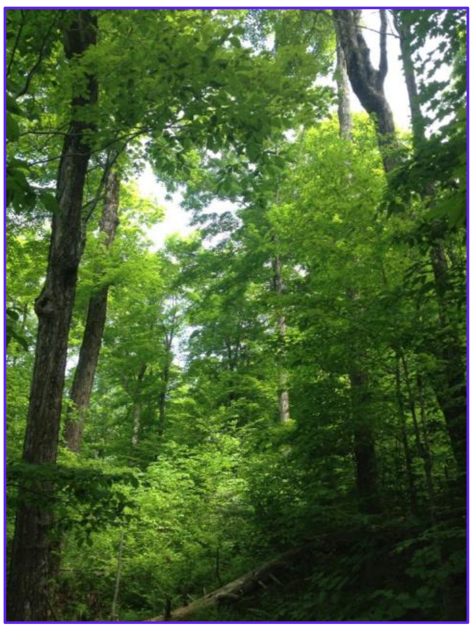
Contributed Abstracts

There were 15 talks contributed to the conference, presented in three concurrent sessions. The concurrent sessions were Changing Forests and Management moderated by Nicole Rogers, Water Quality and Watersheds moderated by Tami Wuestenberg, and Fauna and Landscapes moderated by Cathleen Balantic. Below are the abstracts submitted for these talks, including author affiliation. The presenting author's name is in bold type.

Management for old-growth characteristics and late-successional biodiversity in temperate montane forests

William Keeton[1]

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



Structural Complexity Enhancement unit, Mt. Mansfield State Forest, VT. June 2014 - from presentation

Many have wondered if active management could be used to restore some characteristics of High Conservation Values forests, such as increasingly rare temperate old-growth systems, to managed landscapes. Silvicultural systems for this purpose are being tested in several regions globally and have been the focus of the Vermont Forest Ecosystem Management Demonstration Project (FEMDP), now in its 15th year. The FEMD is testing the hypothesis that an approach called "Structural Complexity Enhancement" (SCE) can accelerate rates of late-successional/old-growth development faster than conventional selection systems. The study employs a Before-After-Control-Impact experimental design to compare SCE against modified single-tree and group selection treatments. Manipulations and controls were applied to 2 ha experimental units and replicated four times at two research areas in Vermont. Field data were collected over two years pre- and 13 years post-treatment. Operational expenses and revenue were tracked as was information on market conditions. Ten years after harvest, measured aboveground carbon in SCE units was 15.9% less than simulated no-harvest baselines, compared to 44.9% less in conventional treatments. Statistical results show that herbaceous understory composition was 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 conditions within group selection units. Fungi and salamander responses were strongly associated with microsite characteristics, particularly coarse woody debris, and increased significantly under SCE, but showed no statistically significant decrease in gaps created by group selection. SCE is economically viable under the right site and market conditions, but does not maximize timber revenue. Potential applications include old-growth restoration, riparian restoration, carbon management, and low intensity commercial management. Silviculture promoting old-growth characteristics can contribute to biodiversity conservation and terrestrial carbon storage in northern hardwood-conifer systems while providing both timber and non-timber economic opportunities.

Effectively Communicating Science: Lessons Learned

Sandy Wilmot[1]

[1] Vermont Department of Forests, Parks and Recreation

Figure 18. VT Forests, Parks and Recreation Commissioner Mike Snyder, speaking at a VMC annual conference.

You may be a brilliant scientist achieving wonders in your area of expertise, but how effectively are you reaching non-scientists? If there is to be real progress in land use and resource management, graphs and charts with plenty of statistics may not bear fruit. Reasons are plenty for ineffective communication with non-science audiences. New studies are helping explain why our science message may be falling flat. This presentation will share lessons learned in communicating ecosystem science by VMC Cooperators, by staff at the Agency of Natural Resources, and by other Vermont science organizations, in the context of new social studies. In an era where science is not held as truth on a pedestal, there is need for more scientists who become expert science communicators.

Tracking parcelization and addressing forest fragmentation – tools and strategies for reversing negative trends in Vermont.

Jamey Fidel[1]

[1] Vermont Natural Resources Council

Figure 19. *"A Snapshot of the Northeastern Forests," USDA Forest Service publication, October 2005*

Despite being so heavily forested, for the first time in over a century Vermont is losing forestland due to parcelization, subdivision, land clearing and development. In order to minimize the effects of parcelization and subdivision, it is necessary to understand where it is occurring, the rate at which it is occurring, and how it can be managed to reduce its impacts. This presentation will share data on recent trends, and examine strategies that are being developed for land managers, conservation organizations, municipalities, and the Vermont Legislature to address parcelization and forest fragmentation. The presentation will also explain a new tool that is being developed to create a user friendly webpage and interactive map interface that will allow for the visual inspection, querying and dissemination of parcelization and subdivision data on an annual basis over time. This tool will benefit researchers, state agencies, municipalities, professional planners, land managers, foresters, conservation organizations, and interested citizens in their ability to develop effective strategies to keep forestland intact in Vermont.

An Overview of the Vermont Boreal Flora

Robert Popp[1]

[1] Vermont Fish & Wildlife Department

While it is speculated that the boreal flora of the Northeast is under increasing threat due to climate shifts, the evidence from Vermont shows a mix of increases and declines. We look at several species at a number of sites in Vermont and speculate as to the possible cause of any population shift. On Mt. Mansfield anecdotal observations indicate a possible decline in *Diapensia iapponica* (Figure 20); however a new population was recently discovered at a new location in 2014. *Dryopteris fragrans*, another boreal species was relocated in 2014 at a site where it had not been observed since 1906. Lastly, a site for a number of populations of boreal calcareous species that was visited by Pease in 1929 was relocated and all but one of the rare boreal species were still extant. All of these locations have the benefit of either being remote or closed to the public whereas noticeable declines in the boreal flora have been documented at smaller, more heavily visited sites such as Mt. Abraham and Mt. Hunger. We speculate that much of the decline in boreal species may be due to trampling by hikers rather than to climate change and monitoring protocols must be adjusted accordingly.

Figure 20. Boreal Diapensia iapponica on Mount Mansfield.

The role of climate in sugar maple health: projections for the future

Jennifer Pontius[1], Evan Oswald, Sandy Wilmot[2], Shelly Rayback[3] and Lesley-Ann Dupigny-Giroux [3]

[1] University of Vermont Rubenstein School of Environment and Natural Resources & US Forest Service Northern Research Station
[2] Vermont Department of Forests, Parks and Recreation
[3] University of Vermont Geography Department

Figure 21. Sugar maple on long term monitoring plot in Vermont.

We compare sugar maple health metrics from long-term monitoring plots to downscaled climate data, including several novel ecological-climate indicators to better understand how climate patterns influence sugar maple condition and the implications for the future of sugar maple in Vermont. Results indicate that there are several specific climate metrics that have historically influenced sugar maple health at levels comparable to the variability introduced by defoliation and other disturbance events. The nature of these variables indicate that it is important for any assessment of sugar maple response to climate change include more nuanced and spatially explicit climate metrics, as opposed to gross estimates of average or extreme temperatures. Our projections of how these key climate variables may change over the next 75 years indicate that this trend towards increased climate-induced decline will only increase in severity and extent. We suggest that land managers take steps to protect sugar maple stands currently located in more favorable climate islands identified here in order to maximize the sustainability of this critical resource.

Mountain hydrology – 15 years of stream gaging on Mount Mansfield

Jamie Shanley[1], Beverley Wemple[2]

[1] US Geological Survey
[2] University of Vermont Department of Geography

Figure 22. Stream gaging station at Mount Mansfield, Vermont.

Since 2000, VMC has supported stream gaging for a paired watershed study by USGS, UVM and others at Mt. Mansfield. The paired watershed approach was designed to assess the effects of high-elevation development, but has also generated compelling findings on the nature of extreme hydrologic events in Vermont's mountains. Our results suggest that extreme events in the mountains are more frequent, more extreme, and more localized than the events that make headlines in the populated lowlands.

Edge of Field Monitoring in Vermont

Fletcher (Kip) Potter[1] Julie Moore[2], Dave Braun[2], Don Meals[2], Mike Middleman[3], and Eric Howe[4]

[1] USDA/Natural Resources Conservation Service
[2] Stone Environmental
[3] Vermont Agency of Agriculture, Food & Markets
[4] Lake Champlain Basin Program

Nonpoint runoff from agricultural lands is a major source of phosphorus loading to Lake Champlain. In some Vermont watersheds agriculture is estimated to contribute as much as 62% of the total phosphorus load. For decades NRCS and VAAFM have been recommending and providing technical and financial support for conservation practices to reduce sediment and phosphorus loss from Vermont farms. For some of these practices there is very little relevant data on their effectiveness. In 2012 NRCS in Vermont initiated an effort to evaluate selected agricultural practices using an "edge of field" monitoring system. These systems are using a paired watershed, or an above and below experimental design, with a monitoring period of 3 to 5 years. Treatment results will be available from the first projects sometime in early 2016. Monitoring data collected from these projects during the calibration period has provided important information on phosphorus concentrations and loadings in surface runoff from agricultural fields. As part of NRCS's new National Edge of Field Monitoring Program new monitoring projects will quantify phosphorus loadings in tile drainage water and determine the effectiveness.

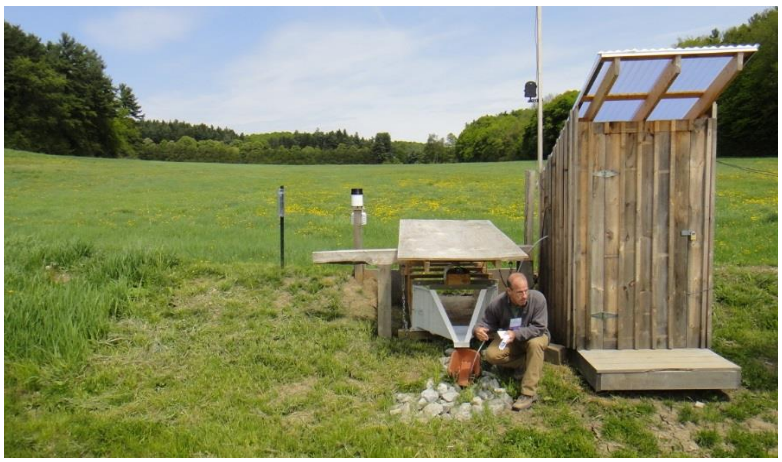


Figure 23. Monitoring nonpoint runoff from agricultural lands.

High-resolution Mapping of Potential Vernal Pools using LiDAR and Object-based Image Analysis

Sean MacFaden[1], Steven Faccio[2]

[1] University of Vermont Spatial Analysis Laboratory
[2] Vermont Center for Ecostudies

Given the ecological significance of vernal pools as essential breeding habitat for amphibians, there is much interest in finding efficient techniques for mapping potential pools across large study areas. Automated identification of potential vernal pools is now possible with a combination of LiDAR and object-based image analysis (OBIA), an expert-system approach that incorporates landscape context and other traditional elements of image interpretation. An OBIA model for Addison County, Vermont used LiDAR-derived topographic models to identify candidate landscape depressions and then used LiDAR intensity and 4-band multispectral imagery (visible bands plus near infrared) to classify them according to the likely presence of water during spring conditions. When compared to an existing database of potential vernal pools in Vermont, the model captured 91% of the pools with discernible evidence of water. As LiDAR availability increases in Vermont and elsewhere in the Northeast, this mapping approach can help facilitate vernal pool conservation by expediting initial identification of potential pools and guiding field-based examination of functional amphibian breeding habitat.

Figure 24. Vernal pool.

Climate-driven changes in energy and mass inputs alter N:P stoichiometry differently in deep and shallow sites in Lake Champlain

Peter D.F. Isles[1], Yaoyang Xu, Jason D. Stockwell, Andrew W. Schrothen

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

Figure 25. Jason Stockwell and crew sampling a cyanobacteria bloom on Shelburne Pond, VT.

The balance of nitrogen (N) and phosphorus (P) is a key factor controlling the likelihood of cyanobacteria blooms in lakes. Concentrations of N and P may be affected differently by nutrient delivery from watersheds and by changes in rates of internal nutrient cycling driven by physical conditions such as temperature and stratification, and both nutrients and energy inputs are likely to change with climate warming. Responses of lake nutrients to changing climate may be different in deep and shallow basins, due to the accessibility of sediments in shallow sites. In this study, we use 23 years of monitoring data to compare long-term trends in total N (TN), total P (TP) and TN:TP at 15 sites in Lake Champlain to external nutrient inputs as well as long-term meteorological trends. We find that TN: TP has declined sharply lake-wide, particularly in the past decade. In deep sites, these declines appear to have been driven by the ratio of dissolved N: P in tributary inputs and by decreases in hypolimnetic dissolved oxygen. In shallow sites, declines in N: P appear to be primarily driven by long-term increases in temperature and decreases in wind speeds.

Vermont Department of Environmental Conservation Watershed Management Division's LaRosa Partnership Program

Rachael DeWitt[1] Caitlin Trimmer, Samantha Clerkin, Lauren Jenness

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

The Vermont Department of Environmental Conservation (VTDEC) Watershed Management Division monitors water quality throughout Vermont. Its goal is to protect, maintain, enhance, and restore the state's surface waters. Their goals are achieved with the help of watershed management associations, monitoring groups, and citizen scientists located throughout Vermont. Each organization monitors water quality and implement projects within their watershed. The Watershed Management Division developed the LaRosa Partnership to assist watershed associations with the laboratory analysis of their water samples. The VTDEC is currently seeking feedback on how to improve and evolve the LaRosa program. Our team is conducting interviews with representatives from the watershed associations involved in the program in order to obtain an informed perspective of the current status of the program's effectiveness. This presentation will feature our recommendations for the LaRosa program moving forward.

Figure 26. Stream in forested watershed, Vermont.

Decline of bumblebee species diversity in Vermont, 1900-2013

Leif L. Richardson[1], Kent McFarland[2] and Sara Zahendra[2]

[1] University of Vermont Gund Institute for Ecological Economics
[2] Vermont Center for Ecostudies

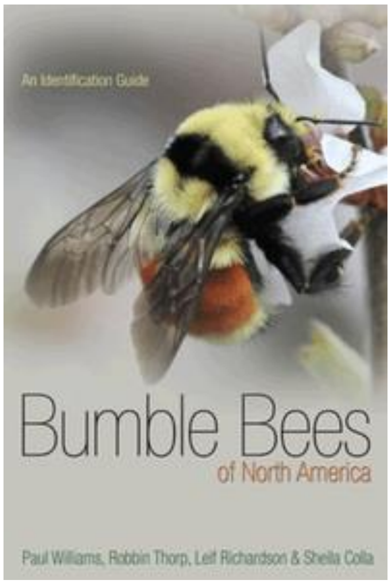


Figure 27. Bumblebee identification guide

Bumblebees (Bombus; Apidae) are important components of temperate ecosystems, playing key roles in the pollination of wild and crop plants. Bees face many threats, yet efforts to assess conservation needs are hampered by a lack of data on historical distributions of most species. To address this deficit, we conducted a survey of the bumblebee species native to Vermont. We identified and digitized 1,669 historical specimens held by museums, and made new collections, including a citizen science effort in 2012-2013 that netted >10,000 new records. Comparing these historic and modern datasets, we conclude that 29% of the 18 species historically present have been extirpated since 2000, and an additional 22% are threatened. We find strong geographic patterning to the data, with factors such as road density and land use patterns predicting distribution of some species. Based on our assessment, three bumblebee species, *Bombus affinis*, *B. ashtoni* and *B. terricola*, have been afforded protection by the state's endangered species statute. Given rapid changes in bee species distribution, this inventory forms a critical baseline to which future surveys of these important insects can be compared.

Not your parents' field guide: a site-specific macroinvertebrate IPhone app for citizen scientists

Declan McCabe[1] Janel Roberge, Lindsay Wieland, Patrick Clemins, Steven Exler, Erin Hayes-Pontius, Lillian Gamache, Elissa Benedetto, Jeremy Gould, My Mai, Lara Nargozian, Colum Smith

[1] Saint Michael's College Biology Department

Taxonomic keys are the gold standard for aquatic invertebrate identification. Keys work by elimination; we find the needle in the haystack by removing hay until just the needle remains. Frustrated students wading through keys, often 'learn' that the organism sampled in Vermont occurs only in California. Field guides reduce the list of organisms to a common, broadly-distributed subset of a taxon. Keys and guides are of limited use when citizen scientists attempt to accurately identify organisms from particular sites. To lower barriers for high-school collaborators, faculty and students working on Vermont EPSCoR projects (NSF Grant EPS-1101317) developed tailored field guides to macroinvertebrates for specific streams. The guides are hosted on a wiki site mirrored on an IPhone app. To build each wiki page, we sampled 86 streams in Vermont, New York, and Puerto Rico to develop lists of commonly collected organisms. For each organism, we developed a web template that includes a photograph, description, and ID tips. The templates are used on multiple pages on the web or hand-held device. Organisms newly found can easily be added to existing field guides. The hand-held app can be synchronized with the web page using wifi or cell connections and then used at field sites lacking web connections. The free app is available in Apple's App Store.

Figure 28. St. Michael's College students identifying macroinvertebrates.

Improving Large-scale Forest Mapping in the Northeast: Coupling Pixel-based and Object-based Classification of Multitemporal Landsat Imagery

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

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

Spatially-explicit distribution maps of tree species are increasingly valuable to forest managers and researchers, particularly in light of the anticipated effects of climate change and invasive pests on forest resources. Yet, current regional and national forest cover maps provide only coarse classifications (e.g. deciduous, evergreen, or mixed) with minimal validation. Advanced remote sensing techniques, such as spectral unmixing and object-based image analysis (OBIA), offer a novel approach to mapping species distributions by utilizing multitemporal imagery and a suite of ancillary datasets to quantify basal area on a per-species basis. Spectral unmixing outperforms traditional pixel-based classifiers by decomposing ("unmixing") mixed pixels and assigning tree species proportions for each pixel. This is particularly useful in northern forests where species composition is often mixed. Here, we present an integrated pixel-based unmixing and OBIA method for quantifying basal area distribution for 12 key tree species using multitemporal Landsat TM imagery. We highlight the accuracy of this approach, as well as how it compares to traditional forest distribution maps.

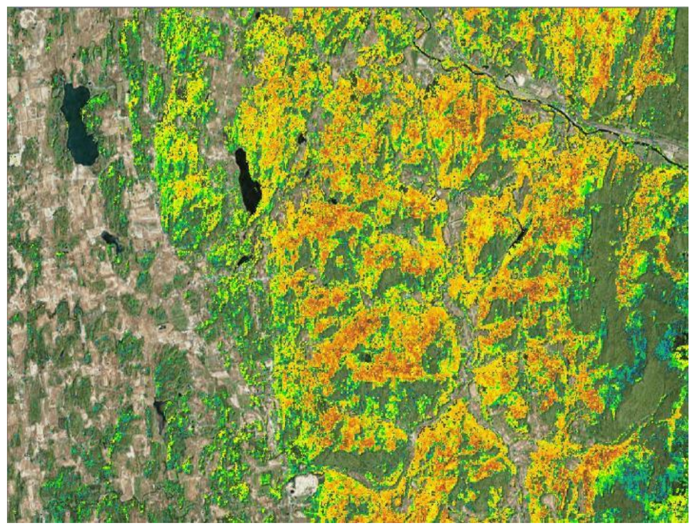


Figure 29. Landsat path 14 imagery

Drones Mapping Vermont's Changing Landscape

Jarlath O'Neil-Dunne[1] Sean MacFaden, Sarah Leidinger, Nathanial Ward, Noah Ahles and Zoe Davis

[1] University of Vermont Spatial Analysis Laboratory

Figure 30. Unmanned Aircraft Systems (UAS) provided imagery to disaster management during the 10/05/2015 Amtrak derailment in Northfield, VT – image from SAL website.

Overhead imagery is an important tool in documenting changes to our landscape. Unfortunately, for many applications imagery is either outdated, unavailable, too costly to obtain, or lacking in detail. Using case studies from throughout the state this presentation will show how mapping-grade imagery from drones can be used to monitor Vermont's changing landscape more rapidly and with greater detail than ever before.

Calculating carbon storage in the Northern Forest: a methods comparison

Alison Adams[1], Jennifer Pontius, Gillian Galford, David Gudex-Cross

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

Accurate measurement of carbon storage (CS) in forests is crucial to determine the impact of changes in forest cover on carbon cycles. CS estimates interpolated from forest inventory data are widely-used, but are resource-intensive and inaccurate in heterogeneous landscapes. Remotely-sensed data products, combined with novel software (Dinamica-EGO), provide an opportunity to improve carbon assessments in such landscapes. This study compares the impact of using remote sensing inputs with different degrees of forest type specificity when assessing carbon in Vermont forests. Specifically, we compared: 1) calculations based on species basal area maps matched with species-specific allometric equations, 2) calculations based on common forest species assemblages (e.g. spruce/fir, maple/beech/birch), and 3) calculations based on coarse land cover type classifications (e.g. deciduous, evergreen, mixed). Validation using VMC forest inventory plots allowed us to determine the most accurate landscape scale CS model, and to analyze how that differs from traditional approaches. This information is critical to understanding the role of the Northern Forest in carbon storage and sequestration.

Figure 31. View of Camel's Hump, Vermont.

Image and Photo Credits

Cover Photo

Red maple seedlings. Photo by Vermont Monitoring Cooperative.

Introduction

Morning view of West Road, Westminster West, Vermont. By Flickr user Putneypics. Online at https://www.flickr.com/photos/38983646@N06/3812355879 and reproduced under a Creative Commons BY 2.0 License (www.creativecommons.org/licenses/by-nc/2.0/)

Plenary Session

Forest Pests and Disease: Photo and graph from presentation.

Tree Growth Trends Section: Red spruce branches, online at http://www.fs.fed.us/nrs/news/release/resources/gallery/schaberg-red-spruce-revival/originals/4-healthy-red-spruce.jpg.

Phenology: Photo and graph from presentation.

2015 Forest Fragmentation Report: Bobcat image and forest fragmentation terminology graphic, both from report.

The Influence of Climate on Vermont's Forests: Graphs from presentation.

25+ Years of Acid Deposition Monitoring in Vermont: Photo of Underhill air quality site by Judy Rosovsky, graph from presentation.

Monitoring Water Quality: Photo of Bourn Pond and graph of Ranch Brook response to peak flow from presentation.

Mercury in Vermont: Problems, Processes, and Prospects: Photo of insectivorous birds, Nicholas Rodenhouse, online at http://nsrcforest.org/project/mercury-northeast-forest-food-webs-insects-spiders-salamanders-and-birds. Chart from presentation.

Soils...and the Audacity of the Vermont Monitoring Cooperative: Photo and chart from presentation.

Vermont's Big Game Mammals: Moose at weigh-in photo and chart from presentation.

Cave Bat Population Trends and White Nosed Syndrome in Vermont: Roosting bats photo and chart from presentation.

Long Term Trends in Amphibian Populations: *Ambystoma jeffersonianum* picture and chart from presentation.

The Status of Vermont Forest Birds, 1989-2013: Photo and chart from presentation.

Contributed Abstracts Session

All photos from speaker presentations with the following exceptions:

Figure 32. Jason Stockwell and crew sampling a cyanobacteria bloom on Shelburne Pond, VT. Photo courtesy of Jason Stockwell.

Figure 33. VT Forests, Parks and Recreation Commissioner Mike Snyder, speaking at a VMC annual conference. Photo by Jim Duncan.

Figure 34. Bumblebee identification guide. Photo courtesy of Princeton University Press.

Summary of Working Sessions

See individual sections for photo credits.

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Appendix: Agenda for the 2015 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/2015/agenda.

2015 Vermont Monitoring Cooperative Conference

25 Years of Forest Ecosystem Monitoring: Trends, Patterns, and Lessons Learned

Davis Center, University of Vermont

Friday, December 11, 2015

About the 2015 Conference

This year, the theme for the conference is:

25 Years of Forest Ecosystem Health Monitoring: Trends, Patterns, and Lessons Learned

As the VMC celebrates its 25th year of environmental monitoring we are taking stock of how long-term data can be used to keep us apprised of the condition of our forested ecosystem, identify emerging threats and inform planning and management decisions. This year we focus on the long-term records of many of our VMC collaborators. The morning plenary features invited presentations from experts in various disciplines synthesizing the long-term trends in their data and implications for the forested ecosystem, followed by a reflection on 25 years of cooperative monitoring and a look ahead to the future. The afternoon features three tracks of concurrent sessions where collaborators present their most recent work, followed by seven working group sessions convened by members of our professional community. We will wrap up the day with a poster session and social hour.

A special thank you to our graduate student Conference Facilitators Cathleen Balantic, David Gudex-Cross, Alexandra Kosiba, Nicole Rogers, and Tami Wuestenberg for their help in facilitating the plenary session question-and-answer process, and moderating the afternoon concurrent sessions.

Schedule at a glance

9:00 – 9:10	Welcome
9:10 – 11:40	Long-term trends in the forested ecosystem
11:40 – 12:00	Reflection on 25 years of VMC
12:00 – 1:00	Lunch
1:00 – 2:40	Contributed Presentations
2:50 – 4:10	Concurrent Working Sessions
4:10 – 5:15	Poster Session and Social Hour

News from the Cooperative in 2015

The Vermont Monitoring Cooperative Long-Term Monitoring Update – 2014

A review of long term trends in twelve key areas affecting regional forest ecosystem health, updated for 2014.

Available online at http://www.uvm.edu/vmc/about/annual_report/2014

New Members Welcomed to the Steering and Advisory Committees

We are pleased to welcome Connie Carpenter (US Forest Service, Northeastern Area State and Private Forestry), Heidi Hales (VT Department of Environmental Conservation), John Sinclair (Green Mountain and Finger Lakes National Forests) and Jim Westfall (US Forest Service Northern Research Station) to the VMC Steering Committee, and we want to thank Steve Sinclair for stepping into the Chairperson's role. We also welcome Bennet Leon (VT Department of Environmental Conservation) to the VMC Advisory Committee.

Forest Health Monitoring Network Doubled in 2015

Building on existing forest health inventories, VMC worked with partners in Vermont Forests, Parks and Recreation and the Green Mountain National Forest to vastly expand the historical and spatial extent of our forest health monitoring network.

More information and data online at http://www.uvm.edu/vmc/project/forest-health-monitoring

Cover Photo – "Maple Seedlings" The Vermont Monitoring Cooperative

Agenda

8:15 – 9:00 Registration *(Livak Fireplace Lounge)*

9:00 – 9:10 Host's Welcome and Introductory Remarks *(Sugar/Silver Maple)*

Nancy Mathews, *Dean of the Rubenstein School of Environment and Natural Resources, University of Vermont*

Jennifer Pontius, *Principal Investigator, Vermont Monitoring Cooperative*

9:10 – 11:40 Plenary Session

Long-term trends in the forested ecosystem

Fast-paced presentation of long-term trends in key ecosystem processes and components.

Moderator: Steve Sinclair, Director of Forests, VT Department of Forests, Parks and Recreation

Tree Pests & Damage *Barbara Schultz*	Tree Growth Trends *Paul Schaberg*	Phenology *Josh Halman*	Forest Fragmentation *Michael Snyder*

--- Coffee Break ---

Climate *Lesley-Ann Dupigny-Giroux*	Acid Deposition *Rich Poirot*	Monitoring Water Quality *Jim Kellogg*	Mercury *Jamie Shanley*	Soils *Scott Bailey*

--- Coffee Break ---

Vermont's Big Game Mammals *Mark Scott*	Bat Populations *Alyssa Bennett*	Amphibians and Reptiles *Jim Andrews*	Forest Birds *Steve Faccio*

NOTE: Rather than taking questions during the session, we will be collecting questions over the course of the morning, and working with presenters to post answers online by the end of lunch. Either post your questions to the Facebook event page or write them down and hand to one of the morning facilitators. Online: https://www.facebook.com/events/482076881972588

11:40-12:00 Reflections on 25 Years of VMC

Robert Paquin, Vermont State Director, USDA Farm Service Agency and long-time Legislative Assistant and Congressional Aide to Senator Leahy, Lawrence Forcier, former Dean of the UVM School of Natural Resources and College of Agriculture and Life Sciences and Conrad Motyka, former VT State Forester and Commissioner of Forests, Parks and Recreation all played critical roles in establishing the Vermont Monitoring Cooperative 25 years ago. They along with key individuals from the U.S. Forest Service brought together the VMC partners and crafted a vision and direction for the organization. They will speak about those early foundational days, VMC's evolution and impacts over the years, and also try to look forward to some of the major opportunities and challenges for the continually-evolving organization. Thomas Berry, Field Representative for U.S. Senator Patrick Leahy, will deliver some remarks on behalf of the Senator.

12:00 – 1:00 Lunch *(Sugar/Silver Maple)*

1:00 - 2:40 Contributed Presentations *(Rooms listed below)*

Learn about new and ongoing research, monitoring, conservation and outreach initiatives related to the forested ecosystem through several concurrent sessions of presentations.

Changing Forests and Management	-	*Silver Maple*
Water Quality and Watersheds	-	*Livak Ballroom*
Fauna and Landscapes	-	*Jost*

The full schedule is listed at the end of the agenda, and the abstracts are available at the registration desk.

2:40 – 2:50 Coffee Break *(Silver Maple)*

2:50 - 4:10 Concurrent Working Sessions *(Rooms listed below)*

Proposed, organized and run by meeting participants, this time allows for more structured networking and communication among current and potential collaborators.

Class I Wetlands - Planning Public Outreach and Organizing for the Greatest Wetland Protection -By Invitation-
Organizer: Danielle Owczarski, VT Department of Environmental Conservation
Room: Boulder Society

Exploring a Forest Indicators Dashboard -Open to All-
Organizer: Jennifer Pontius, Rubenstein School of Environment and Natural Resources, US Forest Service Northern Research Station
Room: Mildred Livak

Forest-Lake connections -Open to All-
Organizer: Peter Isles, Rubenstein School of Environment and Natural Resources
Room: Frank Livak

Incorporating Forest Management and Stakeholder Expertise into a Vermont-Specific Forest Management Decision Support Tool -By Invitation-
Organizer: Clare Ginger, Tony D'Amato, Mary Sisock, Rubenstein School of Environment and Natural Resources
Room: Chittenden

Monitoring Earthworm Invasions into Northern Hardwood Forests -Open to All-
Organizer: Josef Gorres and Ahmed Hamed, University of Vermont
Room: Spruce

Overcoming the Barriers to PPSR -Open to All-
Organizer: Bridget Butler, Bird Diva Consulting/Cold Hollow to Canada
Room: Jost

Vermont Water Monitoring Council Meeting -Open to All-
Organizer: Neil Kamman, VT Department of Environmental Conservation
Room: Sugar Maple

4:10 – 5:15 Posters & Social Hour *(Sugar/Silver Maple)*

Enjoy conversation, posters and a cash bar at the end of the day.

Contributed Presentations Schedule

Time	Changing Forests and Management *Moderator:* Nicole Rogers *Room*: Silver Maple	Water Quality and Watersheds *Moderator*: Tami Wuestenberg *Room*: Livak Ballroom	Fauna and Landscapes *Moderator*: Cathleen Balantic *Room*: Jost
1:00 to 1:20	Management for old-growth characteristics and late-successional biodiversity in temperate montane forests *William Keeton, University of Vermont Rubenstein School of Environment and Natural Resources*	Hydrology *Jamie Shanley, US Geological Survey*	Decline of bumblebee species diversity in Vermont, 1900-2013 *Leif L. Richardson, Gund Institute for Ecological Economics, University of Vermont*
1:20 to 1:40	Effectively Communicating Science: Lessons Learned *Sandy Wilmot, Vermont Department of Forests, Parks and Recreation*	Edge of Field Monitoring in Vermont *Fletcher (Kip) Potter, USDA/NRCS*	Not your parents' field guide: a site-specific macroinvertebrate IPhone app for citizen scientists. *Declan J. McCabe, Saint Michael's College Biology*
1:40 to 2:00	Tracking parcelization and addressing forest fragmentation – tools and strategies for reversing negative trends in Vermont. *Jamey Fidel, Vermont Natural Resources Council*	High-resolution Mapping of Potential Vernal Pools using LiDAR and Object-based Image Analysis *Sean MacFaden, University of Vermont Spatial Analysis Laboratory*	Improving Large-scale Forest Mapping in the Northeast: Coupling Pixel-based and Object-based Classification of Multitemporal Landsat Imagery *David Gudex-Cross, Rubenstein School of Environment and Natural Resources, UVM*
2:00 to 2:20	An Overview of the Vermont Boreal Flora *Robert Popp, Vermont Fish & Wildlife Dept.*	Climate-driven changes in energy and mass inputs alter N:P stoichiometry differently in deep and shallow sites in Lake Champlain *Peter D.F. Isles, Rubenstein School of Environment and Natural Resources, UVM*	Drones Mapping Vermont's Changing Landscape *Jarlath O'Neil-Dunne, University of Vermont*
2:20 to 2:40	The role of climate in sugar maple health: projections for the future *Jennifer Pontius, UVM RSENR and USFS NRS*	Assessment of Vermont Department of Environmental Conservation Watershed Management Division's LaRosa Partnership Program *Rachael DeWitt, University of Vermont Rubenstein School of Environment and Natural Resources*	Calculating carbon storage in the Northern Forest: a methods comparison *Alison Adams, Rubenstein School of Environment & Natural Resources, UVM*

Concurrent Working Session Descriptions

Class I Wetlands - Planning Public Outreach and Organizing for the Greatest Wetland Protection -By Invitation-

Class I Wetland designation provides the strongest protection for VT's wetlands. A Class I designation requires compelling public support, so how do we plan for successful designations for VT's most valuable wetlands? The session will start with a background on Class I wetland designations and an overview of the new process the State of VT has been developing to identify these wetlands, and then move on to the question of how we can get the public involved with the process in a positive way. In this working session we will discuss: where's the best place to start, what's the best way to organize this process, how do we get the word out, and how do we find our strongest partners.

Organizer: Danielle Owczarski, VT Department of Environmental Conservation

Room: Boulder Society

Exploring a Forest Indicators Dashboard -Open to All-

We explore the utility of using a coarse assessment of multiple forest health metrics to summarize the relative condition of Vermont's forests compared to historical records. This will include a discussion of additional data sets for inclusion, potential uses of such a tool, potential drawbacks of summarizing a complex system in a simple metric, and outlets for dissemination.

Organizer: Jennifer Pontius, Rubenstein School of Environment and Natural Resources and US Forest Service Northern Research Station

Room: Mildred Livak

Forest-Lake Connections -Open to All-

A great deal of limnological research in Vermont has focused on agricultural impacts on Lake Champlain, however many of Vermont's smaller lakes exist in predominantly forested catchments, which may be experiencing different stressors as a result of changes in climate, atmospheric nutrient and acid deposition, and forest ecosystem changes. For example, many lakes in forested catchments in Sweden and Canada have experienced "browning" as a result of increasing DOC concentrations, reducing lake productivity and altering the balance between carbon sequestration and carbon release. Lakes may also act as "climate sentinels," providing integrated information about climate effects on watershed processes. In this session, we will bring together researchers in forestry, hydrology, and limnology to address the availability of complimentary datasets in Vermont lakes and forests and identify sites where increased data may lead to valuable insights about forest and small lake ecosystems.

Organizer: Peter Isles, Rubenstein School of Environment and Natural Resources

Room: Frank Livak

Incorporating Forest Management And Stakeholder Expertise Into A Vermont-Specific Forest Management Decision Support Tool -By Invitation-

The Forest Health and Climate Research Group in the Rubenstein School at the University of Vermont is developing a tool to inform forest management in Vermont under conditions of global change. This tool is intended to be used by forest managers and stakeholders. It will be different from coarser, regional scale tools such as Tree Atlas because it will be Vermont-specific and incorporate forest management activities. The purpose of the working session is to gather input from potential users of the tool.

Organizer: Clare Ginger, Tony D'Amato, Mary Sisock, Rubenstein School of Environment and Natural Resources

Room: Chittenden

Monitoring Earthworm Invasions into Northern Hardwood Forests -Open to All-
Earthworm invasions represent a serious threat to forest health. However, resources are scarce to detect affected ecosystems and judge the degree of damage done. Volunteer networks of citizen scientists are probably the only practicable way to assess and monitor the state of the invasion in northeastern forests. In this workshop you will learn the telltale signs of earthworm invasions and how you can contribute to public awareness of this invasion and inform the forest and ecological science community by utilizing social media.
Organizer: Josef Gorres and Ahmed Hamed, University of Vermont
Room: Spruce

Overcoming the Barriers to PPSR -Open to All-
PPSR is the acronym for Public Participation in Scientific Research, otherwise known as citizen science. As citizen science has grown in popularity, some professional scientists are skeptical of the public's scientific potential. Additionally, the excitement behind the crowdsourcing trend has led to projects without support from professional scientists and with data being collected without a defined and relevant purpose. In this working group, we'll look at some exemplary projects, hear about their stumbling blocks and tips for success, as well as identify potential future projects where PPSR could be used effectively.
Organizer: Bridget Butler, Bird Diva Consulting/Cold Hollow to Canada
Room: Jost

Vermont Water Monitoring Council Meeting -Open to All-
The Vermont Water Monitoring Council serves to complement VMC's statewide work by convening a broad stakeholder group for whom the availability of water quantity and quality data is of significant interest. During this session, the Council will meet to discuss: 1) Recent developments regarding the State's LaRosa Partnership Program, including a presentation from a UVM Consulting Team on proposed modifications to the program; 2) updates from USGS and EPA on current initiatives (invited content will include the National Aquatic Resources Survey of EPA, and USGS' proposed High-Elevation monitoring network); 3) updates from the State regarding how the new Vermont Clean Water Act will influence water quality monitoring in VT; 4) roundtable discussion on monitoring successes from 2015.
Organizer: Neil Kamman, VT Department of Environmental Conservation
Room: Sugar Maple