Northeastern States Research Cooperative

Business Report

April 2018

nsrcforest.org

The NSRC website serves as a source of information about the program and a repository for results from funded projects. The twenty-four webinar recordings by NSRC researchers can be accessed from the site.

Cover Photo – Nash Stream Forest, New Hampshire.
Photo courtesy Todd Ontl, USDA Forest Service.
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Message from NSRC Directors

Since its inception in 2001, the Northeastern States Research Cooperative (NSRC) has been a critically important source of funding for applied forest research and outreach efforts throughout the Northern Forest. After years of declining congressional funding for the program and now, in the absence of federal support for the NSRC, we feel the need to comprehensively document its key accomplishments and contributions to the region's unique working landscape, address the impact that the withdrawal of support will have on the region, and chart a potential course for its future mission and direction.

We are pleased to present the NSRC's scientific contributions to the economy and culture of the Northern Forest. Over the past 16 years, the program has supported more than 335 projects, across 50 organizations. Topics of study have included forest products (e.g., maple syrup production, wood products), land and resource management, models predicting changes in Northern Forest ecosystems, recreational values and opportunities (e.g., public access to private lands, forest-based tourism), and threats to forest health. The research has provided opportunities for the Northern Forest research community to work with land owners and managers, conservation groups, agency staff, and private citizens on issues of mutual interest and concern. These collaborations have resulted in original data, predictive tools, and clear recommendations to manage, protect, and monitor essential natural resources in a regional culture and economy that depends on healthy, working forests.

The dynamics of the Northern Forest economy and ecology are complex due to shifting landowner patterns, changing markets, and evolving environmental threats and, as a consequence, the NSRC's role has never been more crucial. In light of its 16-year record of achievement, vision, and strategic plan, the NSRC is well-positioned to address these issues through high-impact science with real-world relevance. We believe that the contents of this document reflect the need for a renewed funding commitment from Congress.

We are delighted to showcase the NSRC's successes and opportunities and welcome any and all feedback as we move forward.

Sincerely,

William "Breck" Bowden, University of Vermont (**breck.bowden@uvm.edu**)
William H. McDowell, University of New Hampshire (**bill.mcdowell@unh.edu**)
David Newman, SUNY ESF (**dnewman@esf.edu**)
Aaron Weiskittel, University of Maine (**aaron.weiskittel@maine.edu**)

Contents

The Northeastern States Research Cooperative (NSRC) supports cross-disciplinary, collaborative research in the Northern Forest — a 26-million-acre working landscape that is home to more than one million residents and stretches from eastern Maine through New Hampshire and Vermont and into northern New York. Congressional authorization for the NSRC was passed as part of Public Law 105-185.

This report reviews the origin, evolution, and impact of the NSRC over the course of its 16-year history. It includes information on funding; project accomplishments and success stories; direct benefits to stakeholders, students, researchers, landowners, as well as state and federal officials; and the critical need for sustained support.

Additional information on the Northeastern States Research Cooperative projects is available at **nsrcforest.org.**

I believe losing NSRC would detrimentally affect the creation of the next generation of foresters through reducing research capacity in New England. In addition to that loss, our capacity to be resilient to future stressors of forest and human ecosystems would be reduced. How will forest economies remain competitive to competing uses and global change if we don't invest in them?

Response to NSRC 2017 survey question regarding how the loss of the NSRC would affect you in the future

Background photo by Todd Ontl, USDA Forest Service. Used with permission.

Executive Summary

The Northeastern States Research Cooperative (NSRC) is a competitive grant program funded by the USDA Forest Service, supporting cross-disciplinary, collaborative research in the Northern Forest. Launched in 2001, the NSRC is cooperatively managed by the USDA Forest Service and leaders from universities situated in the four Northern Forest states: the **Rubenstein School of Environment and Natural Resources** at the University of Vermont, the **Department of Natural Resources and the Environment** at University of New Hampshire in cooperation with the **Hubbard Brook Research Foundation**, the **Center for Research on Sustainable Forests** at the University of Maine, and the State University of New York (SUNY) **College of Environmental Science and Forestry**. Over the course of its 16-year history, the U.S. Forest Service Northern Research Station (USFS-NRS) has awarded the NSRC nearly $24 million in support of more than 335 individual projects from 50 organizations across diverse topics and issues relevant to the Northern Forest.

The NSRC is authorized by Federal legislation (**Public Law 105-185**), and allocations to the program have been directed by the USDA Forest Service since its inception. The NSRC began in 2001 with an allocation of $1.1 million to New Hampshire. The following year, Vermont joined the NSRC with an increased total allocation of $1.8 million. Federal funding peaked at $2 million in 2006, when Maine joined the collaborative. New York joined the effort in 2008. After 2006 the overall program allocation declined steadily to a low of $760,000 in 2016, despite increasing requests for project funding among researchers working to understand the environmental, social, and economic factors affecting the Northern Forest. Federal budget cuts ultimately led to the suspension of the NSRC in 2017. NSRC leaders are taking this opportunity to assess the past accomplishments of the program and to imagine a future for an NSRC 2.0. This report summarizes these findings and recommendations.

The structure and organization of the NSRC has evolved over the years with a shift in 2008 toward greater integration of the four research themes managed by each state. Projects are organized into 14 core research interest areas across four broad themes: (1) sustaining productive forest communities, (2) sustaining ecosystem health in northern forests, (3) forest productivity and forest products, and (4) biodiversity and protected area management. Funding from the NSRC has provided experiential learning opportunities for more than 200 undergraduate and graduate students, research technicians, and postdoctoral researchers. More than 300 peer-reviewed scientific publications and approximately 900 professional presentations have been generated by NSRC researchers.

A 2017 survey across the spectrum of NSRC stakeholders highlighted strong support and a general need for this regional research program. The respondents included community leaders, business owners, industry professionals, academic researchers, and local and state officials. Nearly all of the respondents (96.7%) indicated that they considered the NSRC a valuable program that should continue. The beneficiaries of NSRC research results indicated that the program was responsive to their needs and addressed practical issues of importance (see inset). The recipients of NSRC awards indicated that the program advanced their professional goals and research objectives. Follow-up interviews with NSRC-funded graduate students confirmed that the program contributed significantly to the training of the next generation of Northern Forest land managers, policymakers, advocates, and scientists.

"It's been very interesting and instructive to work with academic researchers and learn from their methodology - it helps refine our work as an NGO. NSRC is a rare funding opportunity whose academic/applied connection is sorely lacking in the funding world, and its explicit emphasis on social-ecological-economic integration is rare and very important."

– **Non-profit professional from New Hampshire**

"NSRC provides an opportunity to target my research to a specific region and enables me to make more direct connections with the stakeholders in that region. It is fantastic to funnel a research focus to an area that has strong ecological, social, and economic ties to the forest."

– **NSRC Researcher, U.S. Forest Service, Northern Research Station**

In January 2018, the NSRC directors and Hubbard Brook Research Foundation convened a full-day workshop to generate a strategic vision for its future. Participants represented a wide spectrum of perspectives, ranging from university researchers, private landowners, conservation groups, and private, state, and federal foresters to legislative representatives and the NSRC administrators. Workshop attendees focused on Northern Forest research priorities, funding obstacles, and new and ongoing concerns and the role a revamped NSRC might play.

The NSRC is at a pivotal point in its history, facing new challenges and opportunities. It has proven effective in adjusting to the changing needs of researchers and stakeholders. However, continued funding for the NSRC has become challenging even as new issues emerge that demand innovative, collaborative, regional research. It is appropriate, therefore, that we take this opportunity to reflect on the 16-year history of this program and to consider how the NSRC might evolve to address the emerging needs of Northern Forest communities.

Program Overview

Mission

The NSRC supports regional, collaborative research in the Northern Forest — a 26-million-acre working landscape that is home to more than two million residents and stretches from eastern Maine through New Hampshire and Vermont and into northern New York. Research goals are stipulated in the NSRC Congressional Authorization (Public Law 105-185). A central component of the program is the importance of the Northern Forest to society and the need for relevant research that benefits "the people who live within its boundaries, work with its resources, use its products, visit it, and care about it."

History

The NSRC is a competitive grant program for Northern Forest research, directed and funded by the USDA Forest Service Northern Research Station (USDA-NRS) and a designated institution in each of the four Northern Forest states: The Rubenstein School of Environment and Natural Resources at the University of Vermont, the University of New Hampshire in cooperation with the Hubbard Brook Research Foundation in New Hampshire, the Center for Research on Sustainable Forests at the University of Maine, and the State University of New York College of Environmental Science and Forestry.

The origin of the NSRC dates back more than two decades. In the 1980s, the distinctive Northern Forest region — a working landscape with unique recreational opportunities, vast forested watersheds, and diverse northern wildlife — was designated a priority for national protection in response to growing concern that remaining forest land and its timber were at risk of unplanned fragmentation, piecemeal development, and real estate speculation.

At that time, the governors of Vermont, New Hampshire, Maine, and New York turned to the region's congressional delegations to formally create the Northern Forest Lands Council (NFLC) to address these pressing issues related to land-use and forest management. In 1994, the NFLC published *Finding Common Ground: Conserving the Northern Forest* which, among other priorities, called for the formation of a four-state research cooperative to better understand the region's social, economic, and environmental challenges. The Congressional Authorization for the Northeastern States Research Cooperative was passed as part of Public Law 105-185 (Appendix A).

During the NSRC's inaugural year, the USFS-NRS provided nearly $1.1 million in funding to support research at New Hampshire's Hubbard Brook Experimental Forest. Funds were distributed in collaboration with the Northeastern Ecosystem Research Cooperative, an independent research group with strong partnership and interest in the NSRC program. Over the next several years, funding — to both the Hubbard Brook Project and to the Rubenstein

School of Environment and Natural Resources at the University of Vermont — continued to support ecosystem research and expanded to include studies of related social and economic issues in the Northern Forest.

The NSRC Charter was drafted and signed by the Executive Advisory Board of the NSRC in 2004. This document created the structure, governance, and guidelines for this cooperative. Under the direction of the Center for Research on Sustainable Forests at the University of Maine, a third theme focused on forest productivity and forest products was added the following year. In 2008, the NSRC expanded to include a fourth theme at the State University of New York College of Environmental Science and Forestry focused on biodiversity and protected areas management. The charter was revised in 2008 to accommodate the four-state model and was revised again in 2012 to reflect the new leadership of the NSRC.

Since its inception in 2001, the NSRC has awarded more than 335 competitive research grants ranging from $3,000 to more than $250,000 for projects throughout the region. The results of these projects have addressed the region's changing economic and climate conditions over the past decade, and have significant potential for future impacts.

Breadth of Research Topics

The primary goal of the NSRC as defined in its enabling legislation and refined in its charter is "to coordinate and improve ecological and economic research" on the forest resources of the Northern Forest Region of Maine, New York, New Hampshire, and Vermont. Over the past 16 years, the NSRC has funded research, supported outreach, and catalyzed decisions designed to balance protection, stewardship, and responsible management of Northern Forest resources. The world cloud shown in Figure 1 illustrates the breadth of topics addressed in NRSC research projects. The NSRC is committed to advancing the practical applications of the research for the health and benefit of the natural and human communities of the Northern Forest region. To achieve this goal, the NSRC has supported initiatives in four, broad thematic areas.

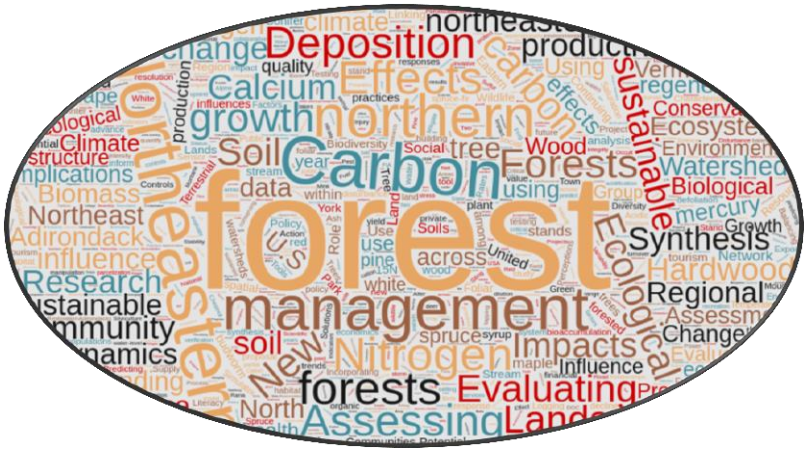


Figure 1. Representation of research topics covered by NSRC projects.

Northern Forest Thematic Focus Areas

1. **Sustaining Productive Forest Communities**: This theme has supported more than 120 research projects focused on sustainable solutions to the integrated social, economic, and ecological challenges of communities, businesses, and working landscapes in the Northern Forest. Projects have focused on sustainable forest management, community and economic development, ecological economics and ecosystem services, recreation and tourism, and watershed science and planning.

2. **Sustaining Ecosystem Health in Northern Forests**: This theme has supported nearly 130 research projects on the health and productivity of terrestrial and aquatic ecosystems in the Northern Forest as a function of hydrological and biogeochemical processes.

3. **Forest Productivity and Forest Products**: This theme has supported 50 research projects designed to quantify, improve, and sustain productivity of the products-based economy of the Northern Forest. Projects explored underlying biological processes, management practices, and methods of prediction that influence future wood supplies and forest conditions.

4. **Biodiversity and Protected Area Management**: This theme has supported more than 30 research projects designed to protect and enhance the economic and ecological health of the Northern Forest, taking into account jobs, clean water, recreational opportunities, and biological diversity. Projects explored forest biodiversity, conservation, ecological services to society, and protected area management.

Partnerships

Strong partnerships are the foundation of the NSRC's success. Partners include leaders from the USFS-NRS and the four universities overseeing the program, citizens of the Northern Forest, principal investigators and their co-researchers, and personnel from cooperating organizations. NSRC shareholders include scientists and experts from academic institutions; officials from local, state, and federal agencies; NGO and industry professionals; and private residents of the Northern Forest (Figure 2).

Figure 2. NSRC partnerships.

Greg Adams - Stakeholder

Manager, Research and Development at J.D. Irving, Limited, New Brunswick, Canada

Current Interests: Sustainable forest management

NSRC Project Participation: Testing and propagation of weevil-resistant strains of white pine

Greg has been a leader in the forest management industry for more than 25 years, supervising tree genetics, silviculture and nursery operations at J.D. Irving, Limited. He has coordinated the company's Forest Research Advisory Committee (FRAC) which was initiated in 1998 to help the company understand effects of our forest management on biodiversity and wildlife habitat values and provide recommendations in adaptive forest management. This group includes leading regional experts in forest management and ecology from academia, government, and NGO's from New Brunswick and Maine. The company provides funding assistance for FRAC research priorities, and more than 30 graduate student projects have been completed since the work began. J.D. Irving, Limited has been a long-time member of the Cooperative Forest Research Unit at the University of Maine as a large landowner in the State, and the company was a strong proponent of Maine joining the NSRC.

Greg described the direct impact of NSRC-research findings on his work, "In reviewing all the NSRC supported Theme 3 projects, it is hard to overstate the impacts of the research across the breadth of forest management challenges. It's a challenge to understand and address the many forest values critical to improving forest stewardship and retaining our social license to practice good forestry, and the only way we could do that is through the best science. J.D. Irving, Limited staunchly supports and contributes financially to doing the science needed for sound decision-making." He adds, "Funding from the NSRC has been critical to address the many science needs around understanding of landscape function for a multitude of values – all while maintaining wood supplies and high quality products in a global competitive world." At the same time, adaptation to a changing climate adds significant complexity to forest management and targeted science will be required to meet this challenge. "We are coming into a time where adaptation is going to require fundamentally different actions. When I think about the adaptation that will be required over the next three to four decades, more active forest management will be needed and this is going to require significant change. There will be a great need for research funding mechanisms from across industry, universities, and government agencies, and programs with a great track record of meaningful research like the NSRC will be very important to help ensure a resilient forest fifty years from now."

Map of Research Areas

The NSRC has supported research throughout the Northern Forest regions of New York, Vermont, New Hampshire, and Maine and in contiguous states and provinces (Figure 3). In all cases, this research was led by investigators based at institutions in the collaborating NSRC states and at the USDA-NRS.

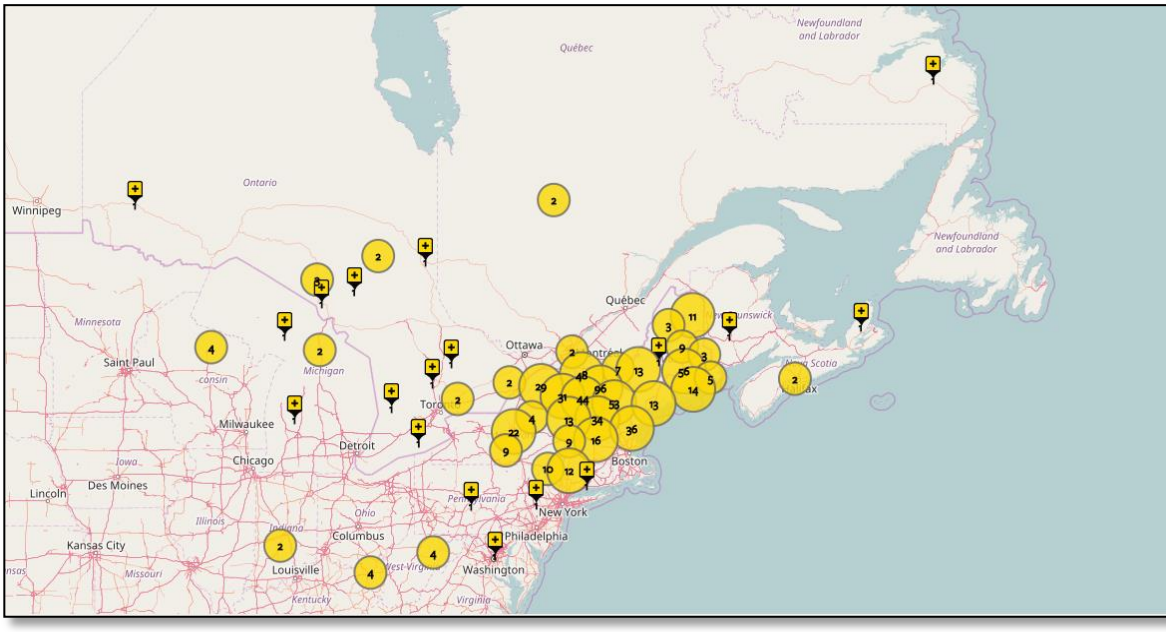


Figure 3. Location of research areas funded by NSRC. The size of each circle roughly indicates the intensity of research in that area. The numbers in each circle are the number of research projects or sites in that area. This interactive map can be accessed at: https://nsrcforest.org/map.

Gristmill Pond, Burlington, ME

Program Fiscal History

Since 2001 the NSRC has provided nearly $24 million (average of $1.6 million per year) in research funding to lead investigators from more than 50 organizations. Project awards have ranged from $1,300 to $275,000, with an average award of $71,671 (Figure 4). To date, the majority of funds have been allocated to projects managed by New Hampshire (42%; Ecosystem Health theme) followed by Vermont (38%; Forest Communities theme), primarily due to their longer histories in comparison with Maine (11%; Forest Productivity & Products theme) and New York (8%; Biodiversity & Protected Areas theme) (Figure 5). Recipient funding has been distributed more evenly across the four states, according to locations of project lead organizations: Vermont (31%), New York (25%), New Hampshire (21%), and Maine (16%) (Figure 6). In addition, states beyond the Northern Forest region received nearly $1.6 million in funding.

Figure 4. Average NSRC funding per project for 2001-2016.

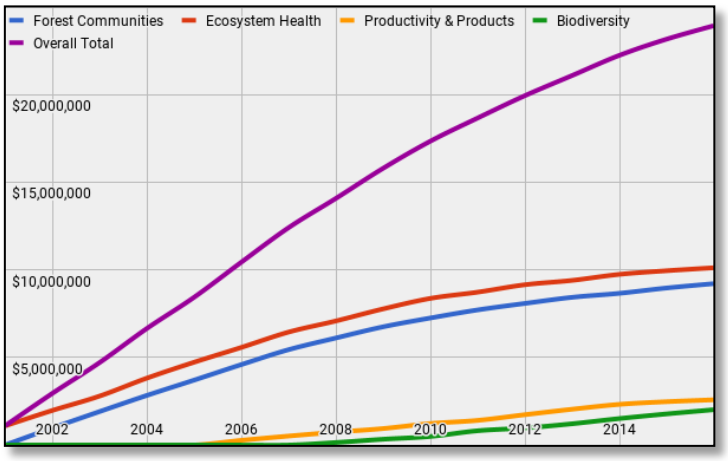


Figure 5. Cumulative allocation of NSRC funding by Theme for 2001-2016. (Note that the Productivity & Products theme and Biodiversity theme did not receive funding until 2006 and 2008, respectively.)

Organizations that have received the most project funding are the University of Vermont (23%), the U.S. Forest Service (14%), the State University of New York (13%), the University of Maine (13%), and the Cary Institute of Ecosystem Studies (6%) (Figure 7). The majority of NSRC project funding was awarded to universities (64%), followed by federal agencies (17%), and non-governmental organizations (16%) (Figure 8). A total of 176 individuals have served as principal investigators on NSRC projects, with an average of $136,000 in funding received per investigator.

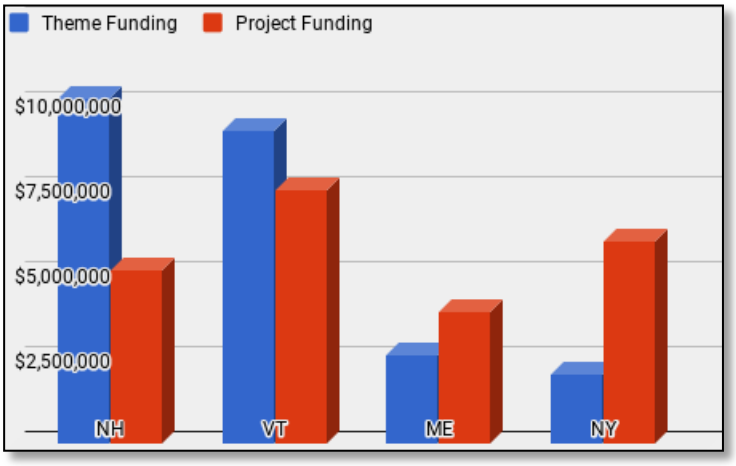


Figure 6. Funding managed (red) and received (blue) by each of the four states in NSRC. Funds managed by one state often supported a project that was located in another state and vice versa, depending on the nature of the research.

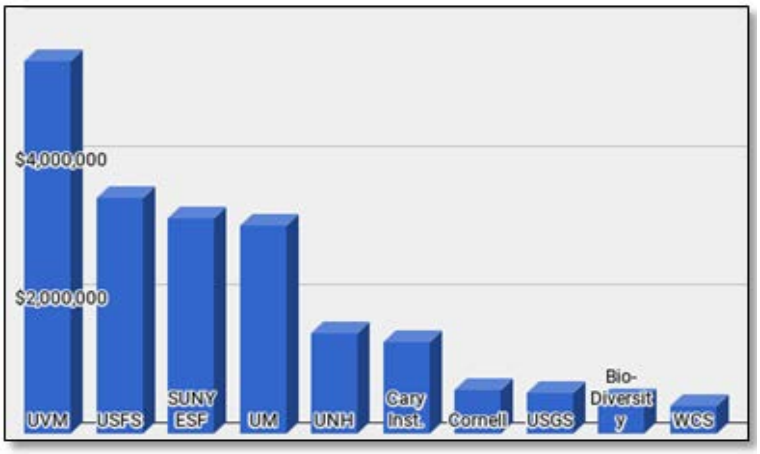


Figure 7. Summary of total project funding received by the top ten organizations for 2001-2016.

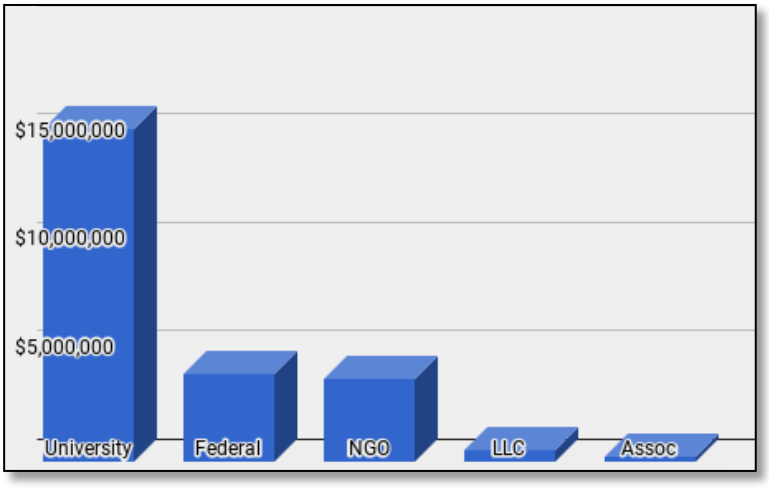


Figure 8. Summary of total project funding received by type of organization for 2001-2016. Assoc: Trade Association; LLC: limited liability company; NGO: non-governmental organization.

Program Outputs

Overview

The NSRC request for proposals process has inspired an extraordinary number of high quality pre- and full proposals (1,215 and 559, respectively; Figure 9), well in excess of available funds. This suggests a critical gap in support for research across the Northern Forest region (Figure 10). USFS-NRS support of the NSRC has been essential to the scholarship and training of graduate and post-doctoral researchers. Due to the downward funding trend since 2006, the number of successful proposals dropped significantly, despite a growing pool of applicants who were well-qualified to address matters of ecological, economic, and social importance in the Northern Forest (Figure 11). Project investigators have collaborated with hundreds of experts and decision-makers from universities, private industry, NGOs, and local, state, and federal agencies (Figure 12). They shared their findings through peer-reviewed and popular press articles, at conferences and meetings (Figure 13), and in webinars, posters, open-access websites, and workshops.

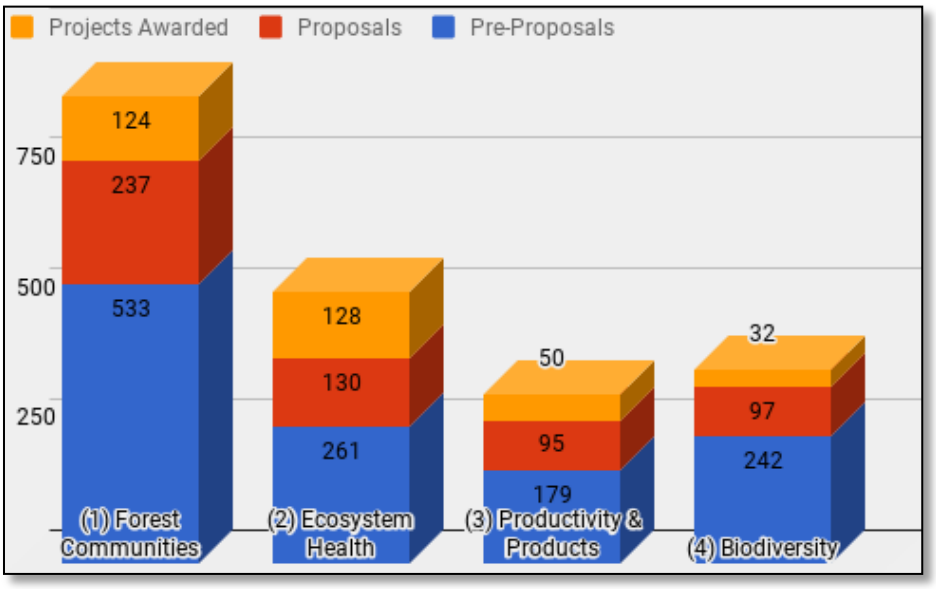


Figure 9. Total number of pre-proposals, proposals, and projects funded by Theme, 2001-2016. (All pre-proposals and proposals submitted to Theme 1 prior to 2006; totals include special projects and grad student projects.)

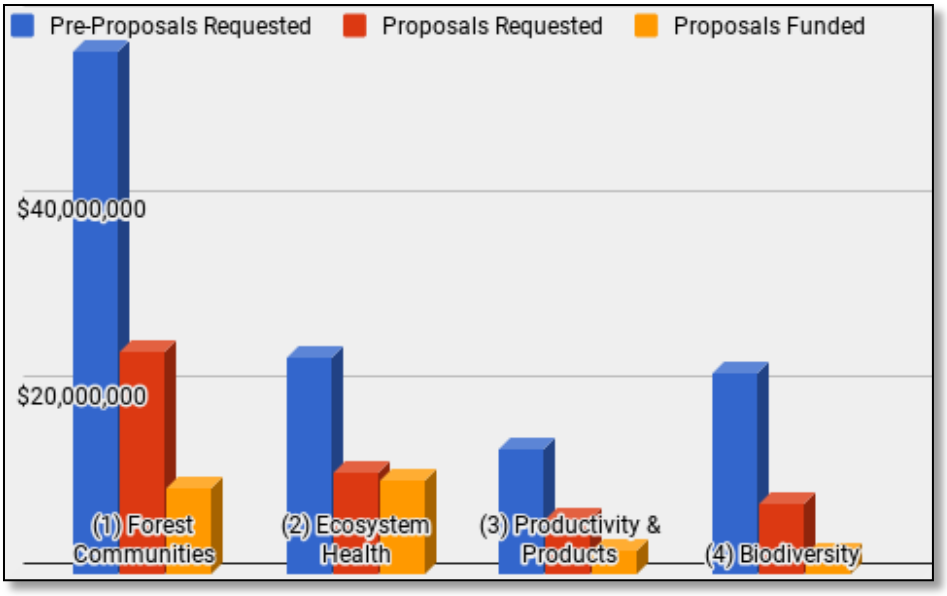


Figure 10. NSRC funds requested and awarded by theme, 2001-2016.

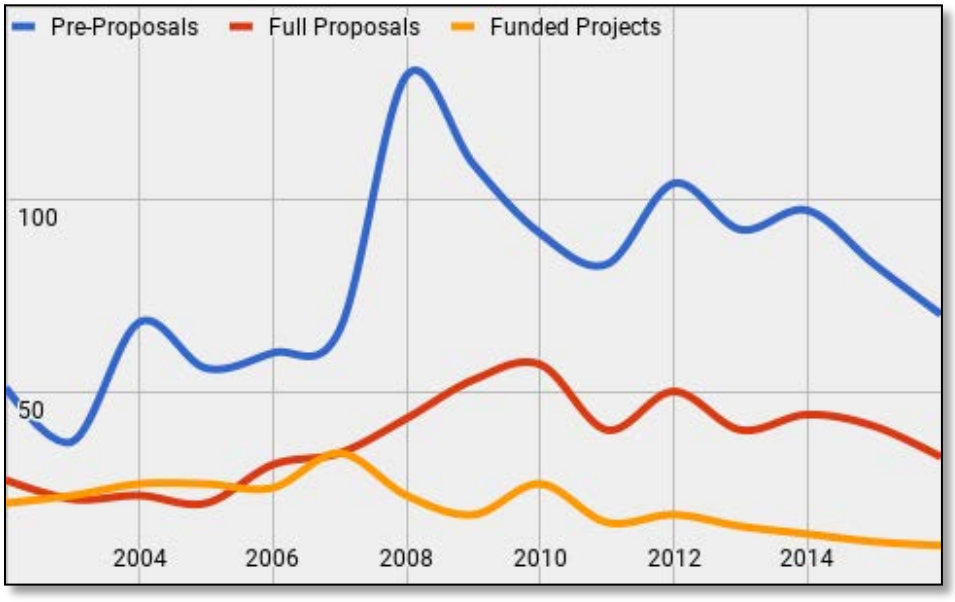


Figure 11. Number of submitted pre-proposals, full proposals, and funded projects, 2002-2016.

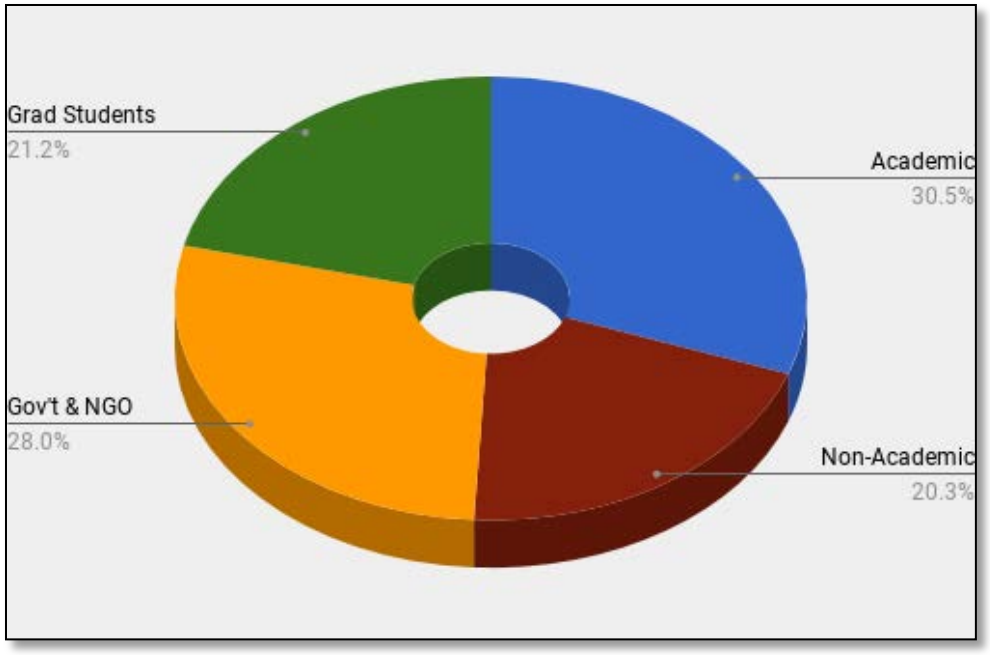


Figure 12. NSRC project collaborators and graduate students, 2001-2016.

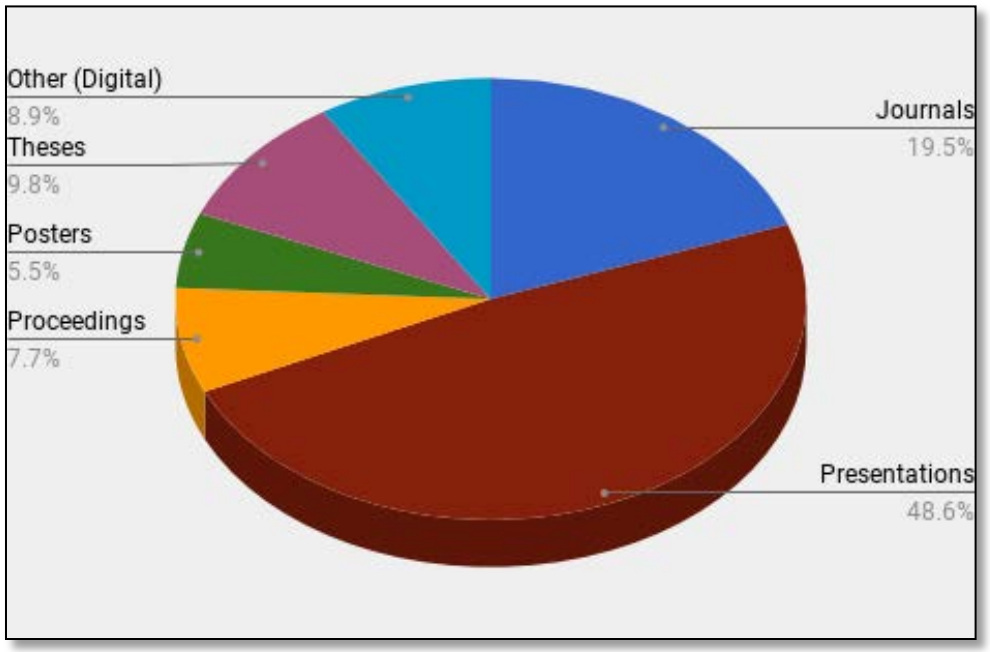


Figure 13. Product output based on NSRC research, 2001-2017.

Kathleen Wanner - Stakeholder

Executive Director of Vermont Woodlands Association and Vermont Wood Manufacturers' Association

Current Interests: Balancing the needs of the wood products industry and forest health in Vermont

NSRC Project Participation: The value of place-based branding among consumers of wood products

Kathleen is a private woodlot owner and tree farmer. She has dedicated her professional life to a vibrant wood products economy that contributes to and benefits from healthy, managed forests. Kathleen participated in an NSRC research project that assessed the value of place-based branding of Northern Forest products. At that time, imported furniture was gaining popularity, and understanding consumer decision-making related to source materials had become a priority among wood products manufacturers. "We wanted to know if the Vermont brand was an indicator of quality as opposed to other brands." The study revealed that consumers did, in fact, make value judgements on the basis of source materials and that the Vermont point of origin was a hallmark of quality. "We now had empirical evidence to bring to the industry to support the notion that a 'Made-in-Vermont' brand was critical. Using that brand would make a difference for that sector in Vermont. When consumers see 'Made-in-Vermont,' they think of quality, integrity, and authenticity. There is a resonance with Vermont and its brand attributes." Kathleen and her collaborators shared results during presentations for congressional delegations from Vermont, in printed and electronic newsletters, and at quarterly meetings with representatives from the wood products industry. "Healthy, working forests are integral to the wood products sector in Vermont. Healthy forests are providing clean air, clean water, AND forest products."

Project Diversity and Productivity

To date, more than 260 projects have been completed (2001-2015) and more than 40 remain ongoing (2012-2016), as summarized on the NSRC website (www.nsrcforest.org). The number of NSRC-funded research projects and resulting publications across the 14 research interest areas are outlined in Table 1. The highest concentrations of research have been in the areas of (1) Forest Management & Productivity; (2) Atmospheric Pollution; (3) Forest Health & Invasive Species; and (4) Climate Change.

NSRC research has resulted in more than 300 peer-reviewed publications (visit the NSRC website for project details). A complete bibliography of these publications can be found and sorted according to Interest Areas on the NSRC website (https://nsrcforest.org/interest-areas).

Table 1. Number of NSRC research projects by interest area, funding level, and number of publications.

NSRC Research Interest Areas	Number of NSRC-funded Research Projects	Allocated Funding	Number of Publications from NSRC Research
Forest Management & Productivity	141	$3,086,297	140
Atmospheric Pollution	86	$5,664,866	101
Forest Health & Invasive Species	76	$1,822,793	64
Climate Change	68	$1,465,276	83
Community & Landowner Engagement	63	$934,660	45
Conservation & Biodiversity	63	$433,318	52
Energy & Carbon	62	$1,564,760	57
Water & Watersheds	62	$622,712	72
Economy of the Northern Forest	60	$565,556	46
Ecology	53	$2,330,211	50
Wildlife	52	$1,159,798	43
Land Use Planning & Development	46	$2,394,478	22
Forest Products	43	$491,561	41
Recreation & Tourism	27	$850,044	21

Outreach

The annual request for NSRC proposals (RFP) emphasized the need for project leaders to extend research results to end-users who can apply them for real-world impact. Review panelists prioritized proposals that articulated robust outreach plans. The projects that the NSRC has funded have facilitated productive dialogue among scientists and practitioners through hundreds of face-to-face meetings and workshops. These efforts have reached a wide and diverse audience across the Northern Forest region.

The NSRC website serves as a source of information about the NSRC and a repository for results from funded projects. From January 1, 2013, to May 16, 2017, the NSRC website received 110,156 page views. Several of the most visited projects during that time period **are noted in the box at right.**

To further aid in dissemination of NSRC-funded results, we began hosting stakeholder webinars in 2012. Over the course of 24 webinars held between February 2012 and February 2017, researchers have shared findings from NSRC funded projects with participants across the region and beyond. More than 700 people attended live webinars, either in person or virtually, over the course of the series. Each webinar was recorded and subsequently posted on the NSRC website. Recorded content has reached an *additional* 1,000 people to date. Attendees represented a wide variety of organizations, disciplines, and sectors. Participants have included state foresters, U.S. Forest Service employees, non-profit professionals, university extension agents, soil conservationists, wildlife biologists, and consultants. Participants often qualified to receive Society of American Foresters continuing education credits.

Most Often Visited Projects on the NSRC Website

Sustainable Tapping Guidelines for Modern Maple Syrup Production
Principal Investigator: Abby van den Berg

Positive Impact Tourism Can Help Sustain Northern Forest Communities
Principal Investigator: Robert Costanza

Growth, Lumber Yields, and Financial Maturity of Isolated Eastern White Pine Crop Trees
Principal Investigator: Robert Seymour

Low-Density Crop-Tree vs. Conventional Management of Eastern White Pine
Principal Investigator: Robert Seymour

Adirondack Study Exposes Evolving Niche of the Coyote in Northeastern Forests
Principal Investigator: Jacqueline Frair

Land Subdivision and Parcelization Trends in Vermont
Principal Investigator: Jamey Fidel

Effects of Winter Climate Change on Growing Season Sap Flow and Carbon Exchange in the Northern Hardwood Forest
Principal Investigator: Pamela Templer

In 2012, the NSRC hosted a round-table workshop lead by the Hubbard Brook Research Foundation entitled *Scientists and Stakeholders: How NSRC Can Bridge the Communications Divide*. Participants included Forest Service program managers, NSRC theme leaders, Vermont state officials, NSRC researchers, and leaders from the Adirondack Ecological Center, the Wildlife Conservation Society, and *Northern Woodlands* magazine. Presenters from the Science Policy Exchange and the Carsey School of Public Policy shared techniques for communicating science in a changing world.

As summarized in this section, we have made efforts to disseminate the findings from NSRC research in a variety of ways that are intended to serve Northern Forest communities. However, it is clear from our self-evaluations that additional efforts need to be developed to ensure that the results of future research lead to desired outcomes for the Northern Forest lands and the communities that depend on them (see, for example, findings from the Carsey Report and 2017 Survey Results in this report).

Dave Struble - Stakeholder

State Entomologist, Forest Health and Monitoring, Maine Forest Service

Current Interests: Pest management

NSRC Project Participation: Sugar maple management in the wake of tent caterpillar outbreak; preparing for the arrival of emerald ash borer across agencies, landowner groups, and tribes in Maine; predicting, mapping, and managing forest vulnerability in anticipation of spruce budworm; natural controls for hemlock wooly adelgid

Since the early days of the NSRC, Dave participated in a wide range of projects exploring the impacts of invasive pests and other events on the health and management of northern forests. “NSRC was an important funding opportunity for productive, pragmatic research. It was a nice structure and got a lot of good work done with direct benefit to the clientele.” Dave’s colleagues at the Cooperative Forest Research Unit at the University of Maine shared project results across forest industry networks. In this way, NSRC project findings informed forest management recommendations and plans. “Back 20 years ago in Maine, people were asking ‘Is management sustainable?’ We went through a couple of referenda, where far more heat than light was exchanged. When we actually got into some forest response and recovery studies, it allowed industry to talk about policy. For some of my colleagues here at the Maine Forest Service who work on policy in addition to monitoring, these were foundational pieces for discussions with the legislature.” Dave described the vital role of the NSRC as seed funding for new projects and in leveraging additional support for research from the forest industry, among other sources. “NSRC funding was foundational. We will suffer from the pending funding lapse. The forest will suffer from the lapse.”

Program Evolution and Evaluation

Evolution of One NSRC

Over the history of the NSRC, the operational framework and structure for the program evolved to meet emerging needs.

The original concept for the NSRC was developed by scientists and managers from the USDA-NRS and the Hubbard Brook Ecosystem Study in New Hampshire. The Hubbard Brook Research Foundation facilitated the initial bi-state research collaborative focused on forest ecology and management and forest economics and community development in Northern Forest lands. Research on forest ecology and management was directed by the Northern Research Station, and research on forest economics and community development was managed by the University of Vermont. The separate budgets and objectives of the two institutional components of the early NSRC were a pragmatic means to establish this fledgling initiative.

Within five years, Maine and New York joined the collaborative, bringing expertise in production forestry and biodiversity, respectively. The University of Maine and SUNY-ESF were designated as the theme managers for these Northern Forest states. At the same time, coordination of the forest ecology and management theme shifted to the University of New Hampshire, with the Northern Research Station taking responsibility for general program oversight. At this point in the NSRC's evolution, the goal was to distribute funding evenly across the four states, with the hope of each receiving approximately $1 million annually. Separate administrative structures were maintained for each of the four states and their associated themes. Initially, this operational model was viewed as an advantage. In each of the four-, high-level, thematic areas of research, it was possible to support coordinated but distinct reviews of pre-proposals and final proposals, relying on disciplinary experts in each of the four separate review panels. This allowed for detailed vetting of each pre- and full proposal and ensured that the overall NSRC program funded research of the highest caliber.

However, a degree of overlap across the four themes created confusion for some principal investigators who were uncertain about which category best suited their proposal. This was especially challenging for investigators submitting interdisciplinary proposals, which were encouraged in the RFP. Furthermore, the full funding envisioned for the four-state, four-theme collaborative was never achieved and, after a peak in 2006 (see Fiscal section), total funding for the NSRC began to decline. The perceptions and realities of thematic silos and imbalanced funding across the four states motivated the directors and managers of the NSRC to revise the operational framework with the goal of creating "One NSRC." This model maintained the four thematic components of the NSRC, which encompassed virtually every topic of research interest identified by state and regional stakeholders, with distribution of funding allocated according to the top-ranked proposals in each theme, regardless of the geographic home institution of the investigator. This effectively eliminated any structural inequity in the distribution of funds.

As the total allocation to the NSRC program continued to decrease, the "One NSRC" model was subject to new challenges. NSRC administrative costs had always been low, despite the four separate thematic components. This was achieved, in large part, through in-kind support from the directors' home institutions for NSRC management. However, as early as 2010, the NSRC directors realized that, in response to declining federal support, the program would benefit from an independent assessment in order to refocus and streamline its goals and administration. To support this process, the NSRC management announced a competitive request for proposals to review the current state of the NSRC and ultimately made an award to the Carsey Institute at the University of New Hampshire to conduct the assessment.

Hubbard Brook area, New Hampshire. Photo courtesy Lindsey Rustad, USDA Forest Service. Used with permission.

The Carsey Report of 2012

A team from the Carsey Institute evaluated stakeholder perceptions of the relevance of research funded by the NSRC grant program. Their 2012 report[1] focused on the first eight years of the NSRC program (2001-2009) and summarized data gathered from online surveys and telephone and in-person interviews of three constituent groups: principal investigators (PIs) who applied for NSRC grants and could speak to the program's implementation; stakeholders who knew of and used research funded by the NSRC and thus had perspectives on the quality, quantity, and relevance of NSRC research products; and individuals who had been unaware of the NSRC but could speak to the need for NSRC-funded research and identify potential means for sharing results with the larger Northern Forest community.

The Carsey evaluation revealed program strengths and areas for improvement. The report concluded with a number of recommendations which informed the management decisions of the NSRC Directors going forward.

[1] Grim, C. and C. French. 2012. Connecting the Dots between Research Priorities and Stakeholder Needs: An Evaluation of Northern Forest Stakeholder Perceptions of the Northeastern States Research Cooperative (NSRC) Grant Program. *Final Report, Vol. I, Narrative*. The Carsey Institute, University of New Hampshire; Durham, NH.

Carsey Report Recommendations and NSRC Responses

Recommendation*: Increase the responsiveness of academic researchers to the needs of stakeholders, for example, by making these issues a funding priority or encouraging researchers to include practitioners as co-principal investigators or collaborators on research teams.*
Response: NSRC administrators and investigators reached out directly to State Foresters, directors, and managers, and modified the NSRC annual request for proposals to encourage collaborations with practitioners on proposed research projects. The NSRC required that principal investigators identify collaborators, specify their roles, and include letters of commitment.

Recommendation: *Increase the production of applied research by requiring project proposals to include plans for the utilization of research products.*
Response: Subsequent NSRC requests for proposals stressed the need to strive for outcomes (e.g., changes in practice and behavior) versus outputs (papers, seminars, and fact sheets). Proposal evaluation panelists were instructed to prioritize projects that included concrete and innovative plans for extension and outreach.

Recommendation: *Increase the dissemination of applied research by requiring that project proposals include a dissemination plan with named media and venues for sharing the research with non-scientist stakeholders.*
Response: In 2014, NSRC began publishing a monthly to bi-monthly research digest as an e-newsletter to researchers and stakeholders who self-subscribed to a mailing list that now includes 263 recipients. The newsletter links to the NSRC website and announces NSRC research findings, NSRC news, links to NSRC research webinar videos and researcher and stakeholder profiles. PIs can also widely share "gray material" (presentations, posters, etc.) from NRSC project research to the Northeastern Forest Information Source website, freely available to all subscribers.

Recommendation: *Identify and facilitate opportunities for grantees to disseminate and communicate their research to stakeholders.*
Response: In 2012, NSRC began hosting up to 6 annual research webinars, with invitations sent to researchers, practitioners, government officials, and others on a mailing list now totaling more than 1,000 recipients in the region. Videos of the webinars are archived and available on the NSRC Vimeo channel (https://vimeo.com/channels/276869), which is linked to the NSRC website. In 2015 and 2016, webinar attendance grew to nearly 100 participants in each of several webinars. Views of webinar videos totaled more than 1,000 by September 2017.

Recommendation: *Improve the NSRC website's visibility and usability, particularly by ensuring that it is linked to other websites and that all documents and emails include the web address.*
Response: In 2012, NSRC completed a redesign of the NSRC website (www.nsrcforest.org) to include 14 searchable interest areas for the public, practitioners, and researchers. The site includes searchable listings and user-friendly summaries of all completed and ongoing funded research projects; links to media coverage of research projects; final reports; and related publications for those seeking detailed information. All documents, including requests for proposals, fact sheets, and posters, incorporate NSRC branding. The NSRC website is also linked to websites managed by the four universities managing the themes as well as the USFS-NRS.

NSRC Survey of 2017

In 2016, the NSRC management and Northern Research Station leadership recognized that it was time to reimagine the program's organization, overall mission, and vision to better address emerging needs. As a part of this process, this Business Report is intended to synthesize the 16-year history and accomplishments of the NSRC, to clarify the importance of new Congressional funding for the NSRC, and to lay the groundwork for a Strategic Plan for NSRC 2.0. To help inform this re-visioning, we conducted a new survey in the spring of 2017 to elicit feedback from researchers and stakeholders and to identify needs, priorities, and potential paths forward. In the following sections we summarize key findings based on this survey. The detailed survey results can be found by following this link: http://bit.ly/NSRC_2017_Survey

Overview

Survey participants included researchers, stakeholders, and students who engaged in NSRC-funded research projects or benefited as end-users of products or results. A total of 315 participants responded to the online survey between May 8th and June 19th, 2017, out of a total of 1,184 working email addresses, representing a 27% response rate.

More than half of the responses (55.8%) came from stakeholders or researchers who had never received direct support from the NSRC. The second largest category of respondents (39.4%) were researchers who had been awarded NSRC funding, and 4.8% were students who received professional training on NSRC funded projects.

NSRC Researchers

Three quarters of researchers (76%) indicated that their projects informed policy or improved management practices. The remainder indicated that their projects were ongoing.

Researchers reported a variety of benefits resulting from NSRC support. Approximately one quarter of researchers (26.3%) indicated that NSRC support advanced their research on a topic area, 23.2% indicated that they had formed new research partnerships, and 16% established new collaborations with stakeholders. Many researchers reported using NSRC funding to support students. Most student support was at the graduate level (69.2%).

Most researchers (81.3%) indicated that they were somewhat or very satisfied with the transparency of the established review process. Suggested improvements included providing more reviewer feedback; striving for a wider variety of qualified reviewers; and emphasizing sound research methods on applied projects. Some respondents recommended wider dissemination of the RFP and an effort to clarify guidelines and expectations. Others recommended a more selective review process. Most investigators (87.7%) indicated that the four broad themes adequately covered research areas most relevant to their work. Several respondents indicated that a theme specifically addressing climate change was needed. Some

respondents recommended reducing or eliminating overlap among the current themes. Most (81.0%) agreed that the NSRC structure should remain a broad, theme-based, general RFP process instead of a more directed, topic-specific approach.

Researchers noted that the loss of the NSRC would affect their work in several substantive ways. Primary concerns included loss of an essential funding source for regionally focused research with an emphasis on applied management. Some investigators expressed appreciation for the collaborative nature of the NSRC as a source for start-up and bridge funding for early-career researchers and students. Some respondents lamented the loss of yet another source of funding for environmental science in general (**see inset**).

"NSRC provides an excellent source of funds for regionally relevant research that can be leveraged for larger proposals / future work. There aren't a lot of funding streams like this, particularly ones with a practical focus."

—NSRC Researcher from New Hampshire

"The themes are critical to the future of the region, especially in the context of climate change and forest fragmentation. The explicit inclusion of stakeholder needs in the RFP (in contrast to say the "broader impacts" of an NSF proposal) provides direct links between research and the livelihoods of those living in the Northern Forest region. As such, loss of NSRC and associated funding would be a significant blow to applied forest research that has direct ties to stakeholders."

—NSRC Researcher from Maine

"The loss of NSRC would be considerable to regional research on key topics in Northeastern forests. It would reduce our ability regionally to understand and respond to effects of environmental change in Northeastern forests, from science, policy, management, conservation, and other stakeholder perspectives. No other funding source integrates research in Northeastern forests from these diverse perspectives."

—NSRC Researcher from New York

Stakeholders

Approximately one third (30.8%) of stakeholders and researchers not funded by NSRC indicated that they rely on NSRC research findings to inform their work in a variety of areas related primarily to forest management and climate change. Many stakeholders (44.2 %) indicated that information generated by the NSRC helped them to update, adapt, or implement policies that enhanced the quality of their products or services by keeping pace with emerging science related to forest management. In general, these respondents indicated that information generated by the NSRC is relevant, useful, and timely.

> **"Based on my NSRC-funded research, the NYS Department of Environmental Conservation (the land manager), in cooperation with the Summit Steward program, decided to expand the program to a previously un-stewarded peak. This expansion WOULD NOT have happened without the results of the NSRC-funded research. As a result, an additional 44,500 hikers have been educated on the summit of Cascade Mountain and recovery is beginning on that summit."**
>
> ***— Non-profit program leader from New York State***

These stakeholder respondents identified the following as their most pressing research-related needs: (1) forest management under climate change and (2) potential impacts of invasive species.

Most stakeholders (64%) stated that the loss of the NSRC would make it more difficult for them to find current, applied, regionally-focused research results. Most of these respondents (63.3%) indicated that, while they seek other sources, including the peer-reviewed literature, government publications, and direct contact with researchers and outreach professionals, the NSRC provides them with high quality information for making decisions about their work.

Graduate Students

Graduate students who responded to the survey indicated that they worked on NSRC-funded projects for an average of just over four semesters. For most (76.9%) of the students who responded, this work became (or will become) a part of their theses or dissertations. Nearly all (91.7%) of the students are currently employed in their field of study across a variety of academic and applied positions. All indicated that working on an NSRC-funded project was essential to their training and professional development**.** Several stated that, without NSRC funding, their research and training might not have been possible.

"As a graduate student, working under NSRC funded scientists was instrumental in my training. I learned from the best in the field about almost all aspects of conducting research, from experimental design to collaborative analysis and dissemination of results. I continue to collaborate with these scientists today."

"I was able to conduct a large scale research project across all four states that NSRC covers. I have been publishing this research in high impact journals and it has helped me to continue to be successful in my scientific career."

"Without NSRC funding my research and education probably wouldn't have been possible. The fact that NSRC funds research related to forests in the region helps immensely to fund graduate students and researchers."

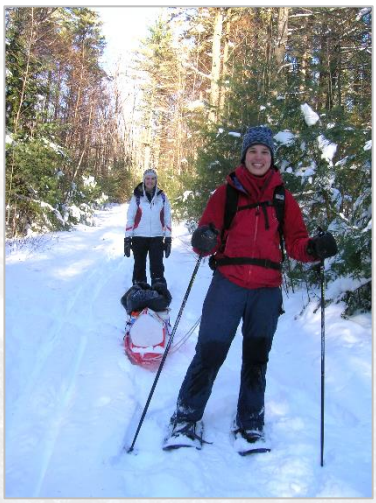
Conclusions

Nearly all (96.7%) respondents expressed support for continuation of the NSRC. They also stated that NSRC research should address a number of specific topic areas including the impacts of climate change, invasive species, land use change, and atmospheric pollution on forest resources.

Fall colors in New Hampshire.
Photo courtesy Michelle Daley Shattuck.

Respondents generally indicated that the NSRC is a necessary program which appropriately focuses its efforts on applied, regional topics. Respondents also noted the need for effective public outreach to make research results accessible to stakeholders and the general public. Suggested improvements included additional transparency in the review process, additional feedback from reviewers, and a more standardized review process across the four states.

In general, the 2017 survey results reflect strong support for the NSRC, with several substantive and constructive suggestions to improve the program and its administration in the future.



Dr. Alexandra R. Contosta – Graduate Student

Post-Doctoral Research Associate
Terrestrial Ecosystems Analysis Laboratory
University of New Hampshire

Current Interests: The relationships between land-use and climate change, soil trace gas emissions, and biogeochemical cycling with a special focus on beneath-snow processes

NSRC Funding: Winter climate change in the Northern Forest; NSRC provided support for Alix's graduate fellowship and current work at UNH as research faculty

As a graduate student, NSRC funding was among Alix's first proposals. "Getting NSRC funding early in my graduate career was empowering. It made me think 'Yeah, I can do this.' My fellowship freed me to go beyond my advisor's research. I was able to explore my own ideas and to start my own research program. It set the trajectory for what I do today." NSRC enabled Alix to engage directly with stakeholders. These formative experiences had a profound impact on her work. Alix described a pivotal moment at a winter climate change roundtable event with local foresters. "It was an aha moment when a forester at the table said 'I think you need to ask yourself what is winter, anyway? Winter doesn't even exist for us anymore.' I realized that, in some very basic ways, we don't always speak the same language. I spent the next several months reading, thinking, and talking with people about how misunderstandings occur when we assume shared meaning."

These experiences with practitioners fundamentally changed Alix's thinking and attitudes about science communication and the methods and techniques for exchanging information with people who live and work on the land. Societally-relevant research is now central to Alix's work.

Program Impacts

Policy and Practice

The Northern Forest is a complex and dynamic region that is highly dependent on its abundant natural resources, particularly its sustainably managed and multi-use forests. The Northern Forest is managed by a variety of landowners, including non-industrial private, industrial private, federal and state agencies, and non-governmental organizations. Management policies and practices vary by state, but are highly dependent on available local product markets, tourism, and recreation. Over its history, the NSRC has maintained a diverse array of research projects across 14 primary interest areas that reflect stakeholder priorities. In this next section, we highlight specific examples of projects in each of these key interest areas, with an emphasis on their implications for the Northern Forest.

Highlighted Projects

Interest Area: Forest Management & Productivity

The sustainable management of forests requires understanding cumulative effects of anthropogenic and natural disturbance over large spatial scales and long time horizons. In the Northern Forest, timber harvesting is the primary disturbance agent, but insect outbreaks are also important. Insect outbreaks reflect the distributions of host tree species, and thus changes in forest composition and stand age resulting from harvesting can influence the development, duration, and intensity of outbreaks. Spruce budworm is the foremost cause of disturbance in Northeastern spruce-fir forests. Prediction of wood supply and forest composition must take into account budworm disturbance. Proactive planning for outbreaks requires knowledge of tree species distributions and forest vulnerability to better understand consequences of infestation and to develop effective policies and response strategies.

In 2009, NSRC researcher Steve Sader began to map budworm host species distributions and predict forest stand vulnerability to defoliation using Landsat satellite imagery and forest data from USFS Inventory and Analysis plots. Steve and colleagues mapped forest vulnerability across 10 million acres in northern Maine and incorporated satellite data into a Spruce Budworm Decision Support System for broad-scale forest planning. In 2014, Mohammad Bataineh and Aaron Weiskittel began to modify the Acadian Variant of the Forest Vegetation Simulator to account for spruce budworm impacts on tree and forest stand development and establish a base stand growth model. Recently, Brian Sturtevant and University of Maine co-researchers designed a spruce budworm population disturbance extension for the LANDIS-II forest landscape computer model. Integrating landscape–climate–budworm effects within the LANDIS-II model can address issues facing land managers such as cumulative effects of management activities on budworm disturbance frequency and intensity, direct influence of climate change on outbreaks, and interactions among these factors as they affect forest resilience to new human-caused change.

Relevant Projects: Forest Management & Productivity

Understanding Landscape Level Factors Influencing Spruce Budworm (SBW) Outbreak Patterns in Maine and Forecasting Future Risk at High Spatial Resolution
Principal Investigator: Parinaz Rahimzadeh Bajgiran

Learning from the Past to Predict the Future: Validation of the Spruce Budworm Disturbance Model in Northwestern Maine
Principal Investigator: Brian Sturtevant

Incorporating Spruce-Budworm Impacts into the Acadian Variant of the Forest Vegetation Simulator
Principal Investigator: Mohammad Bataineh

Evaluating the Interacting Effects of Forest Management Practices and Periodic Spruce Budworm Infestation on Broad-Scale, Long-Term Forest Productivity
Principal Investigator: Kasey Legaard

Merging Landsat Time-Series and FIA Data to Develop Vulnerability Maps for Spruce Budworm Defoliation Decision Support
Principal Investigator: Steven Sader

Interest Area: Economy of the Northern Forest

The economy of the Northern Forest and its rural communities has historically been based on recreation and tourism, forest wood products, and non-timber products, such as maple sugar. Maple sugaring is a traditional use of native forests in the northeastern U.S. that continues to be economically profitable; there has been major growth in the maple product industry in recent years.

In recent decades, maple-producing forest owners have welcomed five-fold increases in harvested sap volume per tap using modern equipment (e.g., new tap designs, vacuum collection systems) over more traditional, gravity-based sap collection techniques. NSRC supported research helped to identify the maximum sap yield that can safely be harvested without jeopardizing the long-term viability of the sugar maple trees. In addition to publishing scientific papers, researchers contributed NSRC-funded data to tapping guidelines for the North American Maple Syrup Producer's Manual (October 2016). Under the direction of principal investigator Abby van den Berg of the University of Vermont, NSRC-funded researchers also developed a downloadable tapping zone model and guidelines to promote sustainable tapping practices among maple producers. Researchers shared findings and recommendations with maple producers at conferences and delivered presentations to staff at the Vermont Agency of Natural Resources. The model and guidelines are available to maple producers and researchers throughout the northeast. The tapping guidelines project receives the most visits of any project page on the NSRC website.

Relevant Projects: Economy of the Northern Forest

Sustainable Tapping Guidelines for Modern Maple Syrup Production
Principal Investigator: Abby van den Berg

Birch Syrup Production May Increase Economic Sustainability of Maple Syrup Production in Northern Forest
Principal Investigator: Abby van den Berg

Sustainable Tapping Guidelines for Birch Syrup Production in the Northern Forest
Principal Investigator: Abby van den Berg

Growing the Maple Industry in the Northern Forest
Principal Investigator: Brian Chabot

Growth Potential of the Maple Syrup Industry in the Northern Forest
Principal Investigator: Brian Chabot

Demerrit Forest - Maple Tapping

Interest Area: Land Use Planning & Development

Privately owned land parcels in the northeast were once of a size that could support working forests and sustain ecosystem services. Increasing pressure from real estate development and land use change is now fragmenting the Northern Forest, with impacts that are not entirely understood and that are likely to alter the ecosystem services on which Northern Forest communities depend. Understanding and managing these changes requires collaboration among diverse groups including forest managers, planners, government officials, landowners, sportsmen, and representatives from colleges and universities, forest products industry, and conservation organizations.

Relevant Projects: Land Use Planning & Development

Land Subdivision and Parcelization Trends in Vermont
Principal Investigator: Jamey Fidel

Reducing Forest Fragmentation through Subdivision and Zoning Strategies
Principal Investigator: Jamey Fidel

Tracking Land Parcelization Over Time to Inform Planning and Policy
Principal Investigator: Jamey Fidel

Predicted Changes in Forest Cover and Fragmentation in Vermont's Northern Forest
Principal Investigator: Austin Troy

Mapping the Economic Value of Services from the Natural Ecosystem
Principal Investigator: Matthew Wilson

The NSRC funded two collaborative research projects led by Jamey Fidel at the Vermont Natural Resources Council, which resulted in a report that documents changes in parcel size in Vermont forest lands over time. The report highlights case studies and provides recommendations for municipal zoning policies that will protect economically and ecologically viable forest tracts. The combined projects generated an 84-page guide for local action, and a community planning toolbox, all on a publicly accessible webpage. In 2017, Fidel provided testimony to the Vermont Senate in support of Act H.233, an act designed to protect working forests and habitat. In his comments, Fidel referenced work supported by the NSRC grants as he advocated support for Act H.233 protections against subdivision and fragmentation. These proposed regulations would augment existing legislation designed to mitigate ecological, community structure, and aesthetic damages caused by real estate development. While the NSRC-supported research focused on parcelization in Vermont, the findings and recommendations are applicable to New York, New Hampshire, and Maine where similar development pressures threaten working forest landscapes.

Interest Area: Forest Health & Invasive Species

Due to the economic and ecological importance of the Northern Forest, maintaining and promoting forest health while minimizing the role of native pests and invasive species is critical. Spruce budworm and forest tent caterpillar outbreaks jeopardize economically important spruce-fir stands and maple sugarbushes. Damage from invasive insect pests and pathogens, such as hemlock woolly adelgid, emerald ash borer, and beech bark disease, is of increasing concern. NSRC research has focused on enhanced detection of invasive species, assessment of their impacts on forest ecosystem health, and development of decision support systems for land managers.

Relevant Projects: Forest Health & Invasive Species

A Decision-Support System for Management of Sugar Maple Defoliated by Forest Tent Caterpillar
Principal Investigator: Ruth Yanai

Damage from Invasive Forest Pests Costs Billions a Year
Principal Investigator: Gary Lovett

Earthworms and Land Use History Affect Soil Carbon Storage in the Northern Forest
Principal Investigator: Donald Ross

ForAgProtect: Mapping Tool for Invasive Species Risk Assessment
Principal Investigator: Ben Machin

Hemlock Woolly Adelgid in Hemlock Forests Affects Small Mammal Communities
Principal Investigator: Nicholas Gotelli

Influence of American Beech Thickets on Biodiversity in Northern Hardwood Forests
Principal Investigator: Stacy McNulty

Sugar maple is a keystone species of the northern hardwood forest. Forest tent caterpillar, a native defoliating insect, is a significant stressor of sugar maple. Most stands recover from defoliation, even after multiple years, but NSRC researchers developed techniques to enhance this recovery from defoliation. Led by principal investigator Ruth Yanai (SUNY College of Environmental Science and Forestry), researchers identified environmental factors that predispose sugar maple to decline following insect defoliation. In the North American Maple Project, researchers assessed the condition of sugar maple stands in Massachusetts, Vermont, and New York following the forest tent outbreak of 2002-07. Sugar maples had higher crown dieback and mortality on sites affected by defoliation. Environmental factors contributing to mortality and crown dieback included concave terrain, drier growing seasons during the outbreak, and soils low in base cations, such as calcium, magnesium, and potassium. Researchers produced user-friendly hazard rating tables to help land managers in the northeast predict which sugar maple stands will be more vulnerable to decline following future defoliation events. Predictions could inform mitigation efforts such as spraying with insecticides or liming to improve soil base cation status.

Interest Area: Energy & Carbon

Forest managers of the northeastern U.S. grapple with competing opportunities to realize economic timber value while preserving wildlife habitat and carbon storage. In the absence of harvesting, forests develop structural complexity – living and dead standing trees of a range of sizes and species, variable spacing among trees, and dead wood on the forest floor – that retains carbon and supports wildlife and plant communities. Old growth forests with these characteristics are rare in New England, as the landscape was clear-cut and farmed in the 1800s. Traditional management and timber harvesting maintain a simplified forest structure by selectively removing trees based on size, species, and vigor.

Relevant Projects: Energy and Carbon

Improving Carbon Storage in Managed Northern Hardwood-Conifer Forests
Principal Investigator: William Keeton

Bioenergy Fuel Harvesting Impacts on Forest Habitat and Carbon Emissions
Principal Investigator: William Keeton

Alternative Forest Management Impacts on Forest Carbon Storage and Methane Emissions
Principal Investigator: William Keeton

Estimates of Carbon Stocks in Old Growth Northern Forests
Principal Investigator: Coeli Hoover

Carbon Impacts of Switching from Oil to Wood Fuel across the Northern Forest
Principal Investigator: Andrew Friedland

Inventory of U.S. Federal and State Forest Biomass Electricity and Heat Policies
Principal Investigator: Robert Malmsheimer

Evaluating Potential Conflicts between Wind Power Siting and Natural Resource Values
Principal Investigator: David Publicover

Results of a model developed with NSRC funding in 2006 suggest that decreasing the intensity of timber harvesting can yield economic profits while maintaining critical wildlife habitats and potential for participation in carbon markets. In 2013, principal investigator William Keeton from the University of Vermont re-measured experimental forest plots which were originally established in 2001 to determine whether timber harvesting that mimics natural disturbance patterns and old-growth characteristics would result in greater species diversity and carbon storage than conventional forestry. Bill and his colleagues discovered that carbon storage increases with stand age and structural complexity when management maintains high stocking levels. These findings indicate that carbon sequestration is compatible with other management goals, including sustainable timber yield and habitat conservation. Researchers shared their conclusions at the Bronx Zoo, the Vermont State Legislature, and meetings of the Congress of Quebec Forest Engineers and the New England Society of American Foresters. Principal investigator Keeton has also shared his research findings through various national and regional media outlets.

Interest Area: Forest Products

Given the number of species present in the Northern Forest, a variety of product markets exist, and different harvesting methods are employed throughout the region. Recent shifts in available markets and harvesting technology require new knowledge about their potential long-term effects, particularly at the regional scale. This is especially true about the highly dynamic bioenergy markets. Consequently, NSRC research has focused on best practices and viability of the logging industry, wood resource supply and availability, and management activities to increase financial value.

Relevant Projects: Forest Products

Strengthening Logging Businesses in the Northern Forest: Innovation and Best Business Practices
Principal Investigator: Jeffrey Benjamin

Wood Resource Availability in the Northeastern United States
Principal Investigator: Jennifer Hushaw

Wood Energy Biomass for the Northern Forest: Connecting Researchers, Policymakers and Communities
Principal Investigator: Cecilia Danks

Northern Conifer Forest Productivity 50 Years after Whole-Tree and Stem-Only Biomass Harvesting
Principal Investigator: Laura Kenefic

Earlier NSRC-led research on forest products revealed that consumers had a strong preference for furniture in the northeast when compared to the three other regions in the nation, with particularly strong brand recognition in Vermont. However, operational costs were cited as the primary barrier to maintaining or expanding forest products industries. More recently Jeff Benjamin and colleagues engaged with logging contractors through workshops designed to improve business practices by providing them with a spreadsheet-based harvest planning model (PATH: Planning & Analysis in Timber Harvesting) to better evaluate potential costs and equipment needs. NSRC researchers also created a regional map of potential harvest limitations, which is available online, highlighting locations with the greatest potential for reduced timber accessibility. The analysis indicated that 41% of the relevant land base in each state, on average, has one or more barriers that may reduce the accessibility to standing timber, which may require additional investment in infrastructure.

Overall, this research highlighted the significant challenges facing the logging industry, the long-term sustainability of even the most intensive forest harvesting practices, and the need for effective regional policies for alternative forest products. A robust Northern Forest economy will require strong and diversified product markets, which NSRC researchers can help to create and sustain.

Flux tower in Hubbard Brook valley. Photo courtesy Lindsey Rustad, USDA Forest Service. Used with permission.

Interest Area: Community & Landowner Engagement

The NSRC has supported research that engaged Northern Forest citizens and landowners in the development of sustainable solutions to the social, economic, and ecological challenges that face rural communities, local businesses, and working forest landscapes. Principal investigators worked with town residents, planners, and leaders to create models and processes for developing sustainable plans for economic growth, working forest lands, recreation and tourism, town forest conservation, community biomass production, and use of culturally important non-timber forest products, among other issues.

As an example, community forests contribute to the regional landscape by keeping productive forestlands in timber management, protecting physical and biological diversity, and maintaining connections among larger forest patches. They also provide community benefits such as economic investment, recreation, and clean water. However, local residents and officials are often unaware of community forests and their ecosystem services, making them vulnerable to development. This lack of awareness was evidenced by the Vermont Conserved Land Database, a statewide digital map of protected lands, which lacked as much as half of the current municipal landholdings. NSRC principal investigator David Capen and colleagues at the University of Vermont Spatial Analysis Laboratory updated the database to include all community forests in the state of Vermont and produced maps of municipal landholdings.

A current map of Vermont town forests generated from this work was displayed during the 2015 public celebration of *100 Years of Town Forests in Vermont* to inform participants and communities of the value and potential of preserved municipal lands for future generations.

Relevant Projects: Community & Landowner Engagement

Inventory of Town Forests in Vermont
Principal Investigator: David Capen

Community-Based Biomass Production and Use for Local Energy
Principal Investigator: Cecilia Danks

Attitudes of Small Woodland Owners Toward Harvesting for Bioenergy Markets
Principal Investigator: Jessica Leahy

Culturally and Economically Important Nontimber Forest Products of Northern Maine
Principal Investigator: Marla R. Emery

Emerging Use of Silvopastures in the Northeastern U.S. for Forage and Livestock Production
Principal Investigator: Joseph Orefice

Vermonters' "Acceptable" Levels of Town Development May Decrease Occurrence of Black Bear and Bobcat
Principal Investigator: Therese Donovan

Influence of Planning and Stakeholder Perceptions in Landscape Linkage Projects
Principal Investigator: M. Margaret Bryant

Interest Area: Water & Watersheds

Water is an essential feature of the Northern Forest landscape, including numerous lakes, streams, and other important freshwater bodies, like vernal pools. The northeast region has a long history of conducting watershed-scale research, with prime examples including the Hubbard Brook Experimental Forest in New Hampshire and Bear Brook in Maine. NSRC research has focused on understanding the influence of roads on water quality, the ecological and economic impacts of shoreline development, and the role of atmospheric deposition on watershed dynamics.

Elevated levels of acid deposition may increase leaching of important base cations, such as calcium, magnesium, and potassium, from forest soils. Low levels of base cations in soil have been associated with tree nutrient deficiencies, growth decline, and increased susceptibility to drought, freezing, and insect defoliation**.**

Relevant Projects: Water & Watersheds

Loss of Soil Calcium and Magnesium in Forests of Eastern North America
Principal Investigator: Shaun Watmough

Assessing Road Impacts on Stream Stability and Health in Forested Watersheds
Principal Investigator: Leslie Morrissey

Estimating Wood Volume in Northern Forest Streams
Principal Investigator: Clifford Kraft

Inputs and Outputs of Nitrogen on Forested Watersheds in the Northeastern U.S.
Principal Investigator: John Campbell

Lakeshore Development Affects Shoreline Habitat in Northeastern Vermont
Principal Investigator: David Capen

Response of Stream Water Chemistry to Climate Variability in the Northeastern U.S. and Southeastern Canada
Principal Investigator: Myron Mitchell

Stream Fishes Sensitive to Acid-Aluminum Levels in Northern Forest Ecosystems
Principal Investigator: Stephen D. McCormick

In the early 2000s, NSRC researchers led by Shaun Watmough (Trent University) developed input-output budgets over time for sulfur, nitrogen, calcium, magnesium, and potassium for 21 forested watershed catchments across 17 regions in the northeastern United States. Sulfate concentration in deposition and in stream runoff decreased in most regions. In contrast, nitrate concentrations in deposition decreased in only 1 of 14 regions. Nitrate runoff decreased at 4 of 17 catchments and increased at 1 site.

Deposition of calcium, magnesium, and potassium decreased at many of the catchments. Base cation concentrations in streams generally declined over time, with significant decreases in calcium, magnesium, and potassium occurring at nearly half of the sites. Export of calcium and magnesium in runoff exceeded input at all 21 catchments. Based on these data in the early 2000s, despite reductions in sulfur emissions, acid deposition continued to acidify soils in many regions, with losses of calcium and magnesium of primary concern.

Interest Area: Wildlife

Biodiversity affects and responds to the characteristics and management of the Northern Forest. Due to the economic and cultural importance of hunting in this region, knowledge of population dynamics and the impacts of management on game species is essential. NSRC research has examined the issues associated with key wildlife species in the region including moose, deer, bear, coyote, and songbirds.

NSRC researchers, led by principal investigator Jacqueline Frair (SUNY College of Environmental Science and Forestry), conducted a study in the Adirondacks of New York to clarify the role of coyotes as potential "deer specialists," filling the vacant niche of the wolf. Researchers also documented dietary overlap between coyotes and other native carnivores. Using coyote scat collections and data from past studies, researchers constructed a timeline of coyote diet from the 1950s to today and corresponding changes in prey abundance.

White Tailed Deer - UMaine Campus

Related NSRC Projects: Wildlife

Adirondack Study Exposes Evolving Niche of the Coyote in Northeastern Forests
Principal Investigator: Jacqueline Frair

Distribution of American Marten in Vermont and the Northern Forest Region
Principal Investigator: James Murdoch

Ecological Impacts of Residential Roads on Songbirds in the Adirondacks
Principal Investigator: Michale Glennon

Effectiveness of Zoning to Protect Deer Wintering Areas
Principal Investigator: Daniel Harrison

Impacts of Recreation Activity on Wildlife Communities in the Adirondacks
Principal Investigator: Michale Glennon

Long-Term Loss of Forest Calcium Expected to Impact Insect and Bird Populations
Principal Investigator: Allan Strong

Predicting Impacts of Housing Density Changes on Black Bear Occurrence
Principal Investigator: Therese Donovan

Researchers discovered that, despite high rates of deer predation, coyotes are not deer specialists. Rather, reliance on deer depends on the relative abundance of primary prey, specifically snowshoe hare (historically) and beaver (currently). As coyotes increasingly exploit beaver populations, researchers expect feeding on adult deer to continue to decline.

Interest Area: Recreation & Tourism

Sustainable Recreation and Tourism on Mountain Summits

Contemporary management and research approaches to sustainability in outdoor recreation/tourism call for formulation of indicators and standards of quality for natural resources and the visitor experience. Indicators of quality are ecological and social variables used to measure sustainability. Standards of quality define the minimum acceptable condition of indicator variables.

In 2006, NSRC-funded researchers led by Robert Manning (University of Vermont) conducted visitor surveys and environmental assessments on three mountain summits (Cadillac Mountain, Maine; Camel's Hump, Vermont; and Cascade Mountain, New York), as these places are highly valued for the recreational opportunities and fragile ecosystems they support.

Relevant Projects: Recreation & Tourism

Indicators of Quality for Recreation and Tourism on Mountain Summits
Principal Investigator: Robert Manning

A Scorecard to Assess Recreation Impacts on Trails in the Northern Forest
Principal Investigator: John Hagan

Impacts of Recreation Activity on Wildlife Communities in the Adirondacks
Principal Investigator: Michale Glennon

Personal Contact Remains Effective Form of Mountain Summit Visitor Education and Stewardship
Principal Investigator: Robert Manning

Photo Analysis to Track Changes in Adirondack Alpine Vegetation Over Time
Principal Investigator: Julia Goren

Private Landowners' Preferred Programs to Maintain Public Recreation Access in Maine
Principal Investigator: Jessica Leahy

Visitors generally preferred low levels of resource impact, low visitor use levels, and little management presence, while preferring more intensive management practices to ensure that visitors stayed on-trail. Visitors to all three summits reported experiencing resource, social, and managerial conditions that were better than what they considered to be minimally acceptable. However, visitors tended to overestimate the amount of vegetation cover present on summits and to underestimate the extent and severity of impacts.

Results from the study were presented at conferences, and decision-makers used them to formulate and implement management strategies for the summits. Cascade Mountain became a focus for restoration efforts in the Adirondacks, including closure of some visitor-created trails, better trail definition, and installation of signs informing visitors of impacts. Additionally, the "Carry A Rock" program was launched in 2009, encouraging hikers to carry and place rocks to stabilize soils, build cairns, and define trails.

Interest Area: Atmospheric Pollution

Atmospheric pollution, particularly acidic rain and nitrogen deposition, is an important issue in the Northern Forest due to the species present and their geographic distribution. NSRC research has addressed a wide range of topics, including water quality, the effects of pollution on key ecosystem properties like decomposition, and potential growth effects on tree species including sugar maple and red spruce.

Relevant Projects: Atmospheric Pollution

Surprising Growth Resurgence of Red Spruce in the Northern Forest
Principal Investigator: Shelly Rayback

Calcium Depletion and Aluminum Toxicity May Contribute to Maple Decline
Principal Investigator: Paul Schaberg

Changing Atmospheric Deposition of Nitrogen & Sulfur Alters Dissolved Organic Matter in Northern Forest Streams
Principal Investigator: Ivan Fernandez

Forest Ecosystem Response to Experimentally Elevated Nitrogen Deposition: An International Synthesis
Principal Investigator: Lindsey Rustad

Predicting Mercury Levels in Lakes Using Landscape Features and Water Chemistry
Principal Investigator: Sarah Nelson

Using Critical Loads to Assess Air Pollution and Its Effects on Forest Ecosystems
Principal Investigator: Charles Driscoll

Acidic sulfur and nitrogen deposition depletes base cations such as calcium from forest soils and has been linked to red spruce's reduced capacity to respond to environmental stress, its increases in foliar winter injury, and growth declines in the northeastern United States. With the decline in atmospheric deposition over the last thirty years, recent evidence from tree rings now shows a reversal of decades of red spruce growth decline.

NSRC researchers, led by Shelly Rayback of the University of Vermont and Paul Schaberg of the USDA Forest Service, examined stem cores from red spruce trees at 40 sites in Vermont, New Hampshire, and Massachusetts. Researchers explored relationships among tree-ring time series, climate, and atmospheric pollutants. Across all sites, recent (2001-2012) red spruce radial growth has been above the long-term average (since 1925). Models suggest that sulfur and nitrogen deposition exceeded the load that red spruce could tolerate during the period of red spruce growth decline (1950-2010). Increases in red spruce growth corresponding with decreases in acid deposition and increases in favorable climate conditions may result in increased growth and greater carbon capture by red spruce in the coming decades.

This work demonstrates the importance of scientific inquiry to identify ecological problems (acid deposition-induced decline), policy decisions to mitigate those issues (the Clean Air Act and amendments), and evidence of biological recovery.

Interest Area: Climate Change

Many plant and animal species in the Northern Forest are at the northern or southern limits of their natural ranges. Consequently, small shifts in climatic conditions can have significant implications for these species. New England is currently expected to warm faster than all other regions of the continental United States, with a projected 3°C increase in mean temperature by 2050 and higher variability in precipitation patterns. As evidenced by the 2018 report *New England and Northern New York Forest Ecosystem Vulnerability Assessment and Synthesis: A Report from the New England Climate Change Response Framework Project* (Janowiak et al., USDA NRS Gen.Tech.Rep. NRS-173), the effects of these changes on the Northern Forest are uncertain. Climate change, and its many consequences, has therefore been an increasingly urgent research topic funded by the NSRC.

Relevant Projects: Climate Change

Effects of Future Changes in Climate and Carbon Dioxide on Northeastern Forest Ecosystems
Principal Investigator: Scott Ollinger

Citizen Scientists Enlisted to Help Track Changes in Forests and Climate
Principal Investigator: Ellen Denny

Impacts of Climate Change on Forests of the Northeastern United States and Eastern Canada
Principal Investigator: Lindsey Rustad

Future Distribution and Productivity of Spruce-Fir Under Climate Change
Principal Investigator: Erin Simons-Legaard

Interaction of Climate Change, Nitrogen Deposition, and Pest Disturbance: A Spatial Management Tool for Predicting Effects on Forest Health
Principal Investigator: Linda Pardo

Some of the earliest NSRC climate change research focused on the creation of a researcher-accessible database and coordinated citizen science for tracking changes in forest and climate. This led to the formation of the Northeast Regional Phenology Network, in which citizen scientists can track the timing (phenology) of important indicators such as leaf-out or leaf fall. In addition, earlier NSRC climate change research led by UNH's Scott Ollinger assessed carbon, nitrogen, and water cycling under a range of environmental and climatic conditions. Results revealed that, with climate change, forest growth rates will increase in the northeastern U.S. through the 21st century, but the effects of CO_2 were as great or greater than the predicted effects of changes in climate. More recently, NSRC climate change research has focused on the spruce-fir forest type, which is of particular economic and ecological importance in the region. The resurgence of growth in red spruce is due to the improved growing conditions (e.g., increased temperature) as well as declines in acidic deposition. Suitable habitat for this forest type will decline in the future as warming continues, but the species will persist on the landscape with appropriate forest management practices.

Overall, this research has important implications for land managers and policy makers given the magnitude of potential changes in the Northern Forest. In addition to improving predictions of climate change effects on these forests, NSRC-led research has developed better technology, online interfaces, and networks for detecting these changes.

Interest Area: Conservation & Biodiversity

With a long history of land management and the wide range of species present, biodiversity is generally high yet spatially variable across the Northern Forest region. This has promoted significant conservation efforts during the last two decades aimed at restoring and protecting important habitat throughout the Northern Forest. NSRC-led research has focused on evaluating the effectiveness of conservation easements, improving methods for assessing and managing for biodiversity, anticipating trends and consequences of forest conversion and conservation, and restoration of species and areas of concern.

In collaboration with the American Chestnut Foundation, NSRC researchers are working to restore the American chestnut to the Northern Forest. Researchers from the University of Vermont and the USDA Forest Service grew American chestnut seedlings from nuts acquired in collaboration with The American Chestnut Foundation and planted them on Vermont's Green Mountain National Forest under three overstory tree density conditions: open, partial, and dense. Although findings varied by seed source, American chestnuts planted in the open grew the tallest but suffered the most winter injury without protection from overstory trees. Plantings will remain a long-term resource for identifying genetic stock and management alternatives to bolster American chestnut cold-tolerance for restoration in the Northern Forest, a region critical to species range extension according to climate change predictions.

Relevant Projects: Conservation & Biodiversity

Testing Cold Hardiness of American Chestnut for Restoration in the Northern Forest
Principal Investigator: Gary Hawley

A New Way to Assess Biodiversity, Forest Condition, and Effects of Tree Harvest
Principal Investigator: David Patrick

Balancing Preservation of Forest Habitat Structure with Sustainable Production of Forest Products
Principal Investigator: Gregory McGee

Do Conservation Easements Promote Sustainable Management of the Northern Forest?
Principal Investigator: David Capen

Impacts and Future Projections from 30 Years of Forest Conversion in the Northeast
Principal Investigator: Jennifer Pontius

Sustainable Management of Northern Forests for Timber, Carbon, and Biodiversity
Principal Investigator: Therese Donovan

Interest Area: Ecology

Northern Forest ecology is complex due to the range of habitats, diversity of species present, and long history of management. Understanding key ecological relationships and their potential interactions can inform forest management, land use, and conservation planning. NSRC research has focused on quantifying late-successional forest structure, determining forest habitat influences on available food for birds, and investigating ecological relationships of forest plants and wildlife to evaluate potential effects of climate change.

NSRC researchers evaluated the effects of climate change on the geographic range and future persistence of the mink frog in the Northern Forest. Led by principal investigator David Patrick, formerly of Paul Smith's College in New York, researchers determined how changes in water temperature and dissolved oxygen influence mink frog egg and larval survival. They also established the current occurrence of this species in the Northern Forest and predicted the future distribution of mink frog in the region.

Researchers used a combination of laboratory experiments, field studies at different elevations and latitudes, and computer models to understand factors driving the occurrence of this frog species. Findings indicate that distribution of the mink frog is linked to water temperature and dissolved oxygen, but other factors are also involved, such as competition for food with other frog species that prefer warmer temperatures. This study established methods that can be applied to assess the ecological relationships of other amphibian species that are at risk due to climate change.

Relevant Projects: Ecology

Effects of Climate Change on the Mink Frog of the Northern Forest
Principal Investigator: David Patrick

A Moose, a Bird, and a Shrub: An Ecological Relationship That May Change with Climate
Principal Investigator: Allan Strong

Developing Management Guidelines to Conserve Old Forests
Principal Investigator: John Hagan

Forest Habitat Type Affects Abundance of Invertebrate Food for Birds
Principal Investigator: Jason Johnston

Imperiled Bats in Northeastern Forests: Balancing Bat Conservation with Forest Management
Principal Investigator: Shannon Farrell

More Tree Species Diversity in Sugarbushes Reduces Maple Pest Levels
Principal Investigator: Bruce Parker

Ebony Jewelwing Damselfly

Dr. William S. Keeton - Researcher

Professor of Forest Ecology and Forestry
University of Vermont

Current Interests: Forest ecosystem sustainability, carbon management, climate change impacts on forest ecosystems, ecologically-based silvicultural systems, and the structure and function of old-growth and riparian forests

NSRC Funding: Forest carbon dynamics and management, carbon markets, disturbance ecology, forest biodiversity, silviculture, sustainable forest management, wood bioenergy, forest-stream interactions, and community forestry

The NSRC supported the development of Bill's research since his appointment at UVM almost 20 years ago. It enabled him to explore innovative forestry techniques and approaches that have attracted national and international attention. Across New England and beyond, his work has shaped the nature of forest management for carbon, biodiversity, and overall forest health and productivity. "NSRC powered my program. It supported graduate and undergraduate student research, public outreach, and networking across the forest sector. From students to senior researchers, NSRC built careers and shaped lives. We carry this impact forward." The NSRC was the ideal funding mechanism for the practical application and dissemination of Bill's results. "I'm motivated to do this work so that I can get the information out, into the hands of user groups where it can have an impact on the world. Through NSRC, I developed strong ties at the Vermont Consulting Foresters' Association, the Agency of Natural Resources, the Vermont Forest Roundtable, and a variety of NGOs including the Nature Conservancy and VT Audubon. I represented the University of Vermont on the State Legislature's Bioenergy and Timber Harvest Assessment Working Groups where my results informed state guidelines for sustainable harvesting." Forestry professionals and policymakers value and rely on Bill's approach to building knowledge sequentially, from experimental research that addresses real-world issues, to stakeholder engagement, to on-the-ground implementation. "Scientists play a critical role when they inform the public about the consequences of policy choices. This requires long-term data, supported by sustained funding sources like NSRC."

Northern Forest Narratives

Additional Personal Impact Spotlights: Stakeholders, Students, and Researchers

Stakeholders

Si Balch - Stakeholder
Certified Forester, Specializing in Forest Care, Management & Education
Society of American Foresters and Maine Licensed Forester #61

Current Interests: Woodlot forestry consulting, management, and education; held positions as Chief Forester and Silviculturalist across New England's forest industry

NSRC Funding: Participated in roundtable events and workshops for stakeholders and scientists

Over the course of his career in the forest industry and through associations with a range of environmental organizations, Si learned to navigate within and across sectors. "Scientists are the look-outs. As foresters, we can suggest to them what to pay attention to, and they can advise us, based on emerging knowledge. There is a give-and-take flow of information." For Si, NSRC workshops with scientists, practitioners, and environmental leaders clarified vexing forest management questions and debates. "People often have either a deterministic or in-deterministic approach to forests. Deterministic managers think 'If I do this to the forest, I will get this result.' Those who are in-deterministic feel that nature knows best, and that it's better not to intervene. When these groups come together, they often have quarrelsome dialogues, but really they are on opposite ends of the same rope. By talking and listening together, we can understand where people are on this scale and why." Si describes the role of scientists as intermediaries in these conversations; they demystify matters of forest health and productivity based on empirical proof and reveal that some of our initial instincts, assumptions, and intuitions about forest management are correct and some are incorrect. "Long-term forest research helps us to see patterns and outcomes over the course of decades and to adjust how we care for forests."

Gordon Gamble - Stakeholder

Forest Certification Manager, Wagner Forest Management Ltd.; Advisory Council Chair, Cooperative Forestry Research Unit, the University of Maine; Executive Committee Vice Chairman, Maine Forest Products Council; Executive Committee Member, Maine SFI Implementation Committee

Current Interests: Responsible forest management for optimal economic and ecosystem performance

NSRC Project Participation: Protection and response in anticipation of spruce-budworm outbreak; forest ecosystem modeling

As a leader in the timber investment management industry, Gordon and his colleagues advise clients across the Northern Forest. In addition to internally-developed modelling tools, Wagner Forest Management turns to NSRC research for information about forest threats, such as spruce budworm, in order to make management recommendations in light of emerging science. “Decision-analysis tools enable us to see what the risks are, evaluate potential losses, and look at various options as part of a protection scenario.” NSRC makes high-caliber, applied forest research accessible to Wagner Forest Management and other forest managers across the industry. “We don’t have the resources to do the research on our own, certainly not at that level of quality. By pooling resources through collaborations with CFRU (Cooperative Forestry Research Unit at the University of Maine) and with matching funds from organizations like NSRC, we can afford this world-class research.” NSRC empowers decision-makers like Gordon to address the many facets of forest management from an integrated, scientific perspective. “What we’re dealing with in our ecosystem, things are always changing. Whether it’s society and our impacts or climate and its impacts on the forest, if we can’t study these things, all we’re doing is reacting to the changes. Through research like this, we can thoughtfully respond instead of emotionally reacting, and I think we’ll have a much better result if we have that capability. It does help us, long-term, to make better decisions that improve the performance of clients’ investments.”

Juniper Ridge – University of Maine Harvest

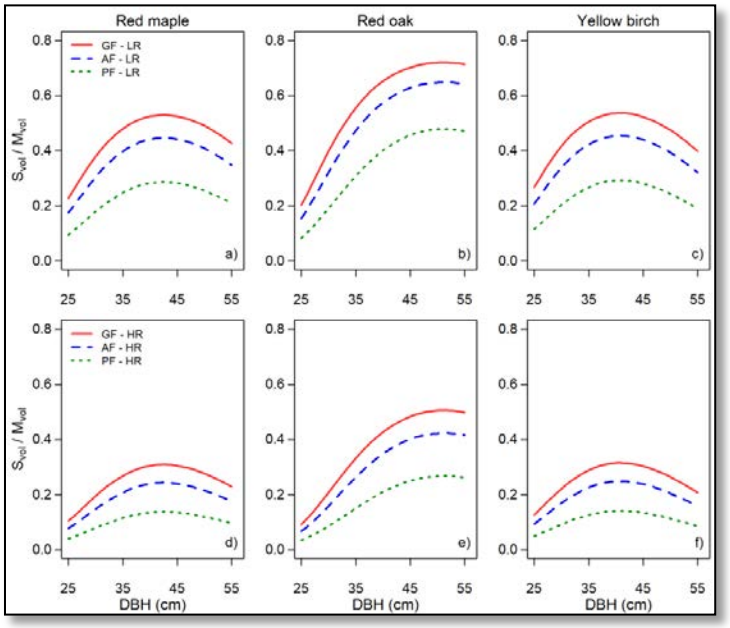
Graduate Students

Mark Castle

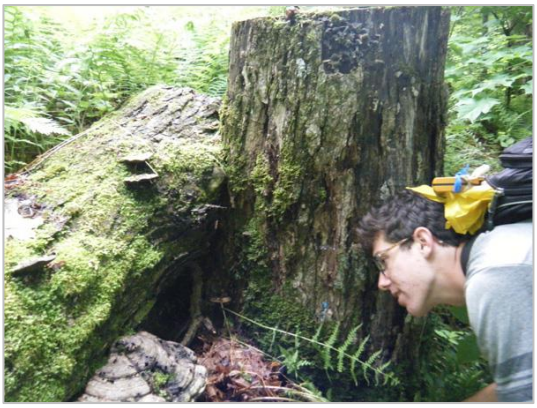
Former University of Maine Master's student

Current Interests: Biometrician for US Forest Service, Forest Management Service Center

The Northeastern States Research Cooperative has played a pivotal role in my Master's program at the University of Maine. In addition to partially supporting my graduate assistantship and tuition costs, funding provided by the NSRC allowed me to be involved in an exciting research project centered around hardwood growth and yield. My involvement with the project encompassed leading field crews to collect forest inventory data across Maine and New Hampshire and using this data to develop quantitative models to determine the influence of stem quality on hardwood product potential, growth, and survival. The experience I have gained through this research has been invaluable and allowed me to further develop my skills in leadership, communication, and quantitative analysis. Finally, the experience that I have gained through this research has helped me obtain a USDA pathways internship position with the Forest Management Service Center in Fort Collins, Colorado.



Predictions of the proportion of sawlog volume to merchantable volume in an individual tree stem across DBH, stem form, and risk classes for red maple, red oak, and yellow birch. From ongoing 2014 NSRC Research Project, "Assessing the Influence of Tree Form and Damage on Commerical Hardowoods Growth, Volume, and Biomass in Maine," Aaron Weiskittel (Principal Investigator), Gaetian Pelletier (co-PI), Jereme Frank (co-PI), and Mark Castle (co-PI).



Nicholas C. Dove

Ph.D. Candidate, Environmental Systems
University of California, Merced

Current Interests: The effects of global change, including climate and fire regimes, on soil microbial communities and their biogeochemical processes

NSRC Funding: Vermont Forest Ecosystem Management Demonstration Project (VFEMD)

Nick was an undergraduate student at the University of Vermont when NSRC funding supported his participation in the VFEMD project as part of his honors thesis. “This was my first experience conducting independent research.” Nick designed and led a portion of the project focused on fungal responses to silvicultural treatments and their effects on forest health. Nick’s results were published in the international journal *Fungal Ecology*, and have informed woody debris retention standards around the world. “This opportunity sparked my interest in research. Completing my undergraduate studies with a peer-reviewed publication made me a more attractive candidate when I was applying to different programs. The NSRC was integral to my development as a researcher. The project was the defining experience of my undergraduate training. I hope that it has a snowballing effect over my whole career.”

Dr. Patrick Hiesl

Associate Professor of Forest Operations,
Paul Smith’s College
Former University of Maine Master’s and Ph.D. student

As a graduate student I received a small grant from NSRC to conduct some additional time and motion studies for a productivity study I did for my master’s project. I think without this grant the work that I did would not have been as detailed as it was. Because of the work I did with the NSRC funds, I basically set the stage for a further study that I used for my Ph.D. project. NSRC funds were the seed money to start a much larger project. Even now that I am working for Paul Smith’s College, I am still involved in a project that continues the work started with NSRC funds. As a student it was great to have NSRC as a grant listed on my CV, and it probably helped to secure my current position as an associate professor.

Dr. Emily Silver Huff
Assistant Professor of Human Dimensions at Michigan State University

Former University of Maine Ph.D. student

I was a recipient of an NSRC grant during my doctoral studies at the University of Maine. Although my research assistantship was covered by NSF, I did not have any funds to design my own research project, collect data, and explore new concepts in coupled human and natural systems within forestry. The NSRC funds allowed me to collect qualitative data that fed into an exciting new model of forest landowner behavior. Moreover, the experience of applying for NSRC funds was critical grant-writing practice that has served me well in the years since my NSRC sponsored research. NSRC fills a very important gap such as allowing a student to develop an independent project, ensuring that they will become a successful early career scientist. I am now an assistant professor at Michigan State University and I will be encouraging my graduate students to look for NSRC equivalents in our region.

Researchers

Dr. Celia Y. Chen

Research Professor, Department of Biological Sciences, Toxic Metals Superfund Research Program
Dartmouth College

Current Interests: Ecotoxicology with a focus on the fate and effects of metal contaminants in freshwater and estuarine aquatic food webs

NSRC Funding: Mercury in forested aquatic ecosystems

Celia investigates the sources and effects of mercury and other metals in aquatic invertebrate communities and their trophic transfer to fish. NSRC funding enabled Celia and her collaborators to provide information on enhanced mercury in reservoir fish that was relevant to mercury policy in the region. “NSRC was a great source of funding for research into landscape-aquatic ecosystem issues. It enabled me to generate pilot data, informing my own thinking about mercury and future studies on reservoirs and estuaries. We were able to answer practical questions and to move the science forward.”

Crayfish - Sunkhaze Stream

Dr. Gary Lovett

Forest Ecologist, Cary Institute of Ecosystem Studies

Current Interests: Forest ecology, invasive forest pests, air pollution, climate change, nutrient cycling

NSRC Funding: Policy and management solutions for forest pests and pathogens, impacts of nitrogen pollution on forest soil decomposition and carbon, carbon and nitrogen in mineral soil layers after forest harvest and re-growth

Perhaps the most pressing threat to forest health, exotic pests colonize North America after travelling internationally and undetected along with imported goods and their packing materials. Gary led an initiative to synthesize knowledge of imported forest pests as agents of adverse economic and ecological impact. “The science on this issue was all over the place, in entomology journals and forestry journals. Our project brought the information together, distilling the science and the policy options into a concise summary with the goal of giving decision-makers what they needed to solve this problem for the Northern Forest.” Working with a team of forest scientists, economists, and policy advisors, Gary and collaborators at the Science Policy Exchange presented a policy-relevant synthesis that provided multiple options for reducing the importation of forest pests. “We specifically designed the NSRC research to address the scientific needs of legislators and policy-makers at federal agencies.” Gary and his colleagues shared results through congressional briefings and meetings with legislators and federal agency staff. Their findings informed current U.S. Customs regulations for wood packing materials and a draft bill that would strengthen enforcement of pest prevention measures in international trade and enhance surveillance for new pest outbreaks. In addition to publications in peer-reviewed journals, Gary’s results attracted national coverage in more than 300 popular print media, including *The Boston Globe*, *The New York Times*, *The Washington Post*, *Associated Press*, and *Newsweek*. “Typical federal science funding wouldn’t have been possible for this scientific synthesis and policy work. The NSRC was willing to support this research because of its importance to the Northern Forest. NSRC funding was essential.”

Luna Moth Caterpillar

Dr. Abby van den Berg

Research Assistant Professor in Plant Biology
University of Vermont, Proctor Maple Research Center

Current Interests: Plant physiological ecology and maple syrup chemistry

NSRC Funding: Maple tree physiology, maple syrup production and sustainability, sustainable birch sap and syrup production

The NSRC provided crucial funding for Abby's applied research into sustainable maple tapping practices using modern methods of sap extraction. Her results helped to inform maple tapping guidelines throughout the region and will be incorporated into the next edition of the North American Maple Syrup Producers Manual. "This publication is considered a standard reference of maple production. NSRC enabled me to provide real-world answers and applicable research data to maple producers." Now, more than seven years after completing her NSRC-funded project, Abby's results continue to inform Vermont's current-use valuation appraisal program and organic maple certification criteria. "It was a huge stepping stone in my early career. I recently received a sizable NIFA grant to expand my research on the impacts of tapping and sap collection on tree growth and health, and I continue to present my NSRC project results at professional and maple industry meetings. Actually, I just presented them in my departmental seminar earlier this week!"

Maple tree tap lines. Photo courtesy Todd Ontl, USDA Forest Service. Used with permission.

Looking Forward

For 16 years, the NSRC has supported high-impact, applied research and outreach across the Northern Forest. The results of the 2017 NSRC survey reflect an urgent need for a comprehensive research cooperative like the NSRC in the region. This is an opportune time to rethink the NSRC's strategic direction in response to limited federal budgets and the Northern Forest's evolving social, economic, and environmental issues. The mission, structure, and operation of an NSRC 2.0 might differ substantially from our previous model. Given the wording in the enabling legislation for the NSRC, the core focus on research remains appropriate. However, it is clear that the research needs of the stakeholder community must be directly addressed by the program. We can accomplish this through enhanced collaboration among managers, policy makers, agency staff, NGOs, community and business leaders, and university researchers.

As a part of our current efforts to develop a new strategic plan for an NSRC 2.0, the leadership of the program reached out to potential partners. For example, recent discussions have highlighted opportunities to partner with the Forest Ecosystem Monitoring Cooperative (FEMC), the Northern Borders Regional Commission (NBRC), and the Northeast Forest Information Source (NEFIS). FEMC serves the Northern Forest region through improved understanding of long-term trends, annual conditions, and interdisciplinary relationships of the physical, chemical, and biological components of forested ecosystems. This is accomplished by efficient coordination of multi-disciplinary environmental monitoring and research activities among federal, state, university, and private-sector agencies with common interests in the long-term health, management, and protection of forested ecosystems. NBRC is a new Federal-State partnership for economic and community development within the most distressed counties of the Northern Forest region. The mission of the NEFIS is to rapidly communicate relevant information to forest managers and researchers through an online, open-access information portal. NSRC-related publications, presentations, and reports could be made more available via NEFIS.

It is crucial to note that the FEMC, NBRC, and NEFIS do not fund new research. Thus, they are dependent on other sources to generate data and new knowledge to support their missions. There is no other region-wide source of research funding for Northern Forest communities. We think this is the most compelling rationale for an NSRC 2.0.

Envisioning NSRC 2.0

On January 18, 2018, the Northeastern States Research Cooperative (NSRC) convened a workshop to generate a strategic vision for the future of the initiative. Participants were directed to imagine a new Northeastern States Research Cooperative (NSRC 2.0) in a manner that is forward-looking, not bound by past decisions and accomplishments. NSRC Vermont Director Breck Bowden and USFS Program Director Chris Woodall called for participants to be open-minded regarding the future direction of the NSRC. Participants included academic researchers, private and public landowners, NGO representatives, and government representatives. Organizers recognized some missing stakeholder groups, including wildlife biologists, local/municipal and regional/county planners, K-12 educators, outdoor recreation industry members, real estate developers, and small landowners.

Vision for the Future of the Northern Forest

Participants offered stories about, and visions for, their favorite places in the forested regions of Maine, New Hampshire, Vermont, and New York, and described what they hope to find there 25 years in the future. The areas described were geographically diverse locations, but not untouched forest sanctuaries; they were functional, productive, working landscapes. By-and-large, participants imagined their forests would be protected, though there was concern about the potential for fragmentation and how current and future trends like invasive species and climate change might lead to dramatically different compositions of tree and bird species.

Challenges and Opportunities: Priority Areas for Future Research

Concerns for the future were both economic and ecological, and included the effects of invasive pests and pathogens like the Emerald Ash Borer on critical tree species, nitrate loss, and homogenization of even-aged forests due to market demand. Additional issues ranged from globalization to local land use and land ownership change. At every scale, there are potential, intractable threats, as well as potential for new markets and more resilient ecosystem development. For example, one participant predicted large-scale transformation of future energy infrastructure to non-fossil fuel sources over the next 25 years. This could be an opportunity for the region, but any energy production can lead to impacts on forests.

A number of key research concerns were raised during the workshop discussion, and are grouped together under the following priority research areas for the future of the Northern Forest (NF).

- **Socioeconomics and Jobs:** *drivers of socioeconomics in forest-based economies; safety of increased mechanization; fossil versus biological fuel potential; desirability of forest industry jobs for future generations; supply chains and value-added processes; compensation for public access and recreation markets; resource analysis;*

transportation of forest products; public perceptions; capital costs and barriers to new firms

- **Invasive Species:** *how to manage to control/prevent spread; how to manage for ecosystem resilience; need to assess long-term impacts; communication of science/impacts to public; social research on public values and how they affect management plans; climate change impacts on native pests and invasives; biological controls and breeding resistance*
- **Science to Policy**: *most effective way to communicate science to NF decision makers or the public; alternative channels of communication; compelling stories that preserve scientific objectivity and precision; range between focused research to synthesis*
- **Silviculture**: *research necessary to increase effective application of forest stand rehabilitation and regeneration; benefits to habitat, resilience, economics, and landscape scale planning; regulatory review and flexibility; markets for low-grade wood; education of foresters; public perceptions of forestry; creation of decision support tools; documentation of habitat conditions, distribution, and patterns across forests.*
- **Land Use and Fragmentation:** *track changes in ownership and aggregate regionally; spatial and statistical analysis of drivers and patterns; fragmentation in relation to recreational and energy impacts, single family development; understanding landowner motivations and successional planning; effectiveness of municipal v. regional v. statewide planning; conservation and proactive land use policies*
- **Ecosystems Services and Energy & Carbon (Source and Sequestration):** *payments for ecosystem services; role of markets, state, feds in getting change to occur; valuation of nonmarket goods; relationship between carbon values and timber values; metrics and mapping of ecosystem services; expectation of landowner/public support; governance; levels of scale; windmills, hydro, and new technologies; social equity in renewable energy development; implications of big data and real-time resource assessment*

Across all of these priority areas, there were two cross-cutting concerns: (1) charting climate change effects on local ecological and economic systems, which are inextricably linked by the forest-based markets of the region, and (2) connecting to the public via outreach and communications.

Structure and Governance of NSRC 2.0

Knowledge Generation vs. Dissemination

Participants addressed where NSRC 2.0 should sit between knowledge generation (quantitative, qualitative, basic, applied) and communicating results. There was broad agreement that, on the continuum between basic and applied science, NSRC should preserve the unique generation of research that cannot find funding elsewhere, but that the initiative needs to incorporate new ways of synthesizing that research. Most concluded that, given limited resources, NSRC 2.0 might do best by focusing its efforts on generating, coordinating, and centralizing knowledge, while leaving knowledge distribution to other expert partners. However, there was also a strong support for the idea that scientific research funded by NSRC 2.0 must be conducted with

end-user stakeholder groups in mind, and written and packaged in a way that is influenced by and accessible to those groups. Several participants expressed support for a coordinated effort across project participants, "Let people who want to do the research do it, and let people who want to deliver it do that." Several other participants indicated support for a co-development model with practitioners, NGOs, and other end-users of the science playing a much more direct role in setting the research agenda in order to achieve both real-world impact and broad support.

Role of Academics, NGOs, Communities and Business

While it is difficult to define future roles for each stakeholder group without knowing the future purpose and scope of the NSRC, there was broad support for research serving Northern Forest communities. Participants discussed concerns related to how that research is initiated, how it gets delivered, and who is involved with delivering it.

One popular governance option that was proposed involved an advisory board including diverse Northern Forest stakeholder groups who would deliver a suite of research objectives that researchers could investigate. Different allocations of funding were proposed to address different stakeholders needs, chiefly breaking down between the pursuit of pure vs. applied science. Participants agreed that a portion of funds could be set aside for each. There was also some disagreement about if and how stakeholders could fairly review scientific proposals. Scoring rubrics with clearly defined criteria were cited as a critical part of maintaining transparency in decision-making. The group voiced the need for a clear understanding of project selection and priority areas of research.

Potential Partners in Funding

Funded parties report that the NSRC is a unique and convenient funding source. The discussion about alternate funders did not generate clear options for replacing the recent loss of federal Forest Service funding. For instance, to appeal to states for funding, the NSRC's programs would likely have to be tied more directly to on-the-ground implementation and job creation. While these are clearly important mission areas for the states, they are somewhat distant from the original mission of the NSRC, defined in public law, to engage the state universities in innovative, regional research on the Northern Forest Communities.

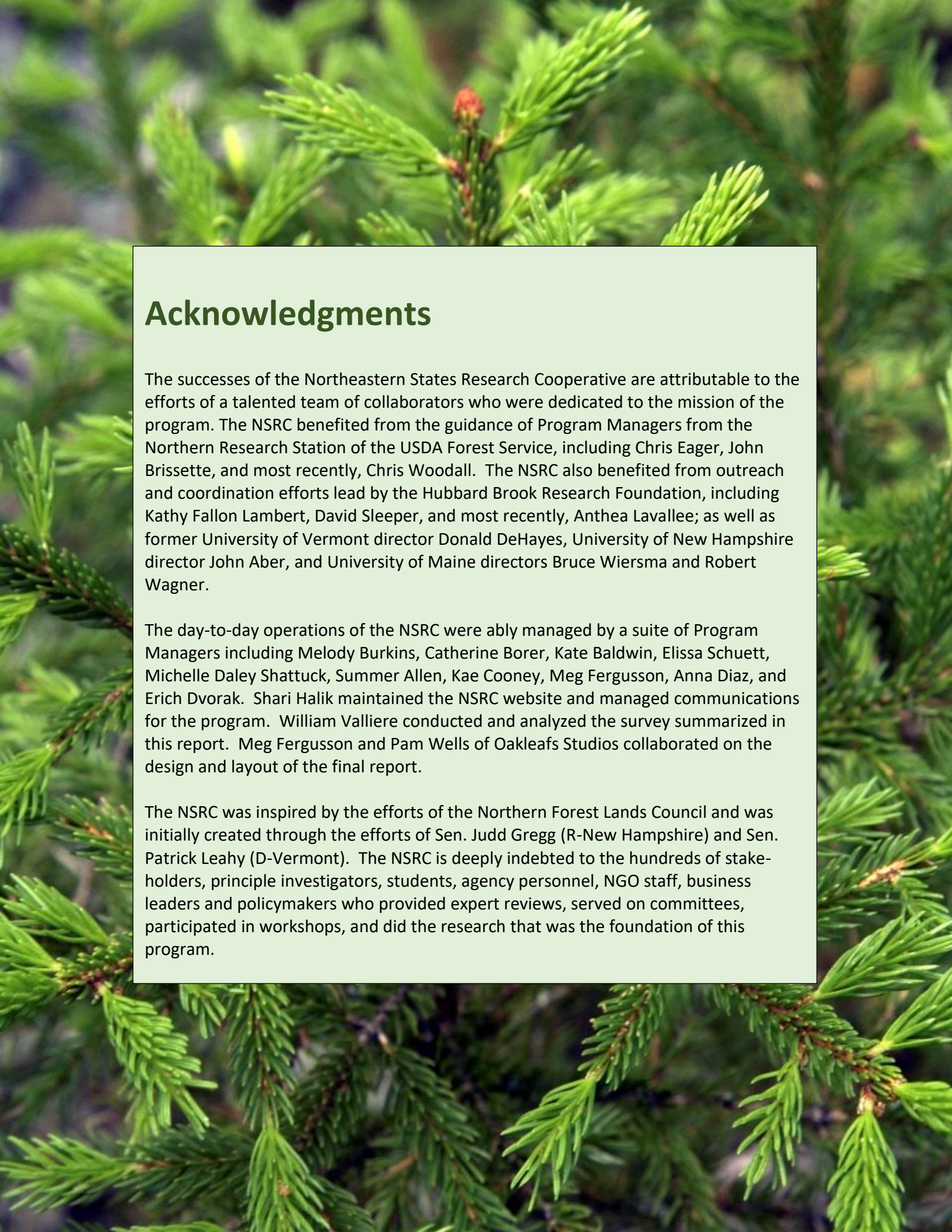
It may be possible to seek further Forest Service funding from Congress, or a federal agency like the Department of Commerce. Private funder networks and family foundations are also an option, although competition for those sources is increasingly fierce. Other options that were suggested include industrial cooperatives, which are a growing source of scientific funding; stumpage fee, like those in Minnesota that have paid for environmental research; and regional groups with similar charges such as the Northern Border Regional Commission.

Conclusions

The NSRC has provided nearly $24 million in research funding for more than 335 individual projects from 50 different organizations. Projects span 14 core research interest areas, particularly Atmospheric Pollution, Forest Management & Productivity and Land Use Planning & Development. This has resulted in an extensive and relevant body of knowledge that applies to a range of stakeholders throughout the region. NSRC research has been the subject of 174 graduate student theses, more than 300 peer-reviewed publications, and approximately 900 professional presentations.

Outreach efforts including the NSRC website, a popular webinar series, events and briefings at state offices, and round-table gatherings have made meaningful connections between NSRC researchers and decision makers. A recent survey indicated strong support and an ongoing need for a regional research program like the NSRC. Follow-up interviews with key stakeholders throughout the region indicated high awareness and appreciation of NSRC research. The numerous highlighted projects in this document reflect the breadth, depth, and general impact of NSRC-funded research. It is clear from a consideration of issues we face and by a consensus of the community leaders with an interest in the Northern Forests that there is a need for a new and revitalized NSRC that is designed to address emerging regional needs. This NSRC 2.0 will put science to work across the Northern Forest in support of a vibrant and thriving economy and culture, rooted in forest health. We envision the future NSRC serving Northern Forest communities through informed forest management that maximizes ecosystem health and economic impact.

Sunkhaze Gorge - Wells Forest



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The successes of the Northeastern States Research Cooperative are attributable to the efforts of a talented team of collaborators who were dedicated to the mission of the program. The NSRC benefited from the guidance of Program Managers from the Northern Research Station of the USDA Forest Service, including Chris Eager, John Brissette, and most recently, Chris Woodall. The NSRC also benefited from outreach and coordination efforts lead by the Hubbard Brook Research Foundation, including Kathy Fallon Lambert, David Sleeper, and most recently, Anthea Lavallee; as well as former University of Vermont director Donald DeHayes, University of New Hampshire director John Aber, and University of Maine directors Bruce Wiersma and Robert Wagner.

The day-to-day operations of the NSRC were ably managed by a suite of Program Managers including Melody Burkins, Catherine Borer, Kate Baldwin, Elissa Schuett, Michelle Daley Shattuck, Summer Allen, Kae Cooney, Meg Fergusson, Anna Diaz, and Erich Dvorak. Shari Halik maintained the NSRC website and managed communications for the program. William Valliere conducted and analyzed the survey summarized in this report. Meg Fergusson and Pam Wells of Oakleafs Studios collaborated on the design and layout of the final report.

The NSRC was inspired by the efforts of the Northern Forest Lands Council and was initially created through the efforts of Sen. Judd Gregg (R-New Hampshire) and Sen. Patrick Leahy (D-Vermont). The NSRC is deeply indebted to the hundreds of stake-holders, principle investigators, students, agency personnel, NGO staff, business leaders and policymakers who provided expert reviews, served on committees, participated in workshops, and did the research that was the foundation of this program.

Appendix A

NSRC Congressional Authorization (Public Law 105-185)

Authorization (from Public Law 105-185, Forest and Rangeland Renewable Resources Research Act of 1978 section 1642 (d) (3) as amended in 2003

"At the request of the Governor of the State of Maine, New Hampshire, New York, or Vermont, the Secretary may cooperate with the northeastern States of New Hampshire, New York, Maine, and Vermont, land-grant colleges and universities of those States, natural resources and forestry schools of those States, other Federal agencies, and other interested persons in those States to coordinate and improve ecological and economic research relating to agriculture research, extension, and education, including —

(A) research on ecosystem health, forest management, product development, economics, and related fields;
(B) research to assist those States and landowners in those States to achieve sustainable forest management;
(C) technology transfer to the wood products industry of technologies that promote efficient processing, pollution prevention, and energy conservation;
(D) dissemination of existing and new information to landowners, public and private resource managers, State forest citizen advisory committees, and the general public through professional associations, publications, and other information clearinghouse activities; and
(E) analysis of strategies for the protection of areas of outstanding ecological significance or high biological diversity, and strategies for the provision of important recreational opportunities and traditional uses, including strategies for areas identified through State land conservation planning processes."


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