



2011



ANNUAL REPORT



CENTER FOR RESEARCH ON SUSTAINABLE FORESTS

2011 ANNUAL REPORT



Spencer R. Meyer
Editor

ABOUT THE CRSF

The Center for Research on Sustainable Forests (CRSF) was founded in 2006 to build on a rich history of leading forest research and to enhance our understanding of Maine's forest resources in an increasingly complex world. CRSF brings together the natural and social sciences with an appreciation for the importance of the relationship between people and our ecosystems. We conduct research and inform stakeholders about how to balance the wise-use of our resources while conserving our natural world for future generations.

Our mission is to conduct and promote leading interdisciplinary research on issues affecting the management and sustainability of northern forest ecosystems and Maine's forest-based economy.



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\$1.7 MILLION IN FUNDING

90 PARTNER ORGANIZATIONS

> 8.4 MILLION ACRES REPRESENTED

34 FACULTY, STAFF, AND STUDENTS ENGAGED

75 PUBLICATIONS & > 120 PUBLIC PRESENTATIONS

EXECUTIVE SUMMARY

CRSF reorganizes into a fully integrated research center to lead Maine's forest resources research.

2011 marks the end of the first five years of the Center for Research on Sustainable Forests (CRSF). Our Founding Director, Dr. G. Bruce Wiersma retired this year, having built a solid foundation upon which to grow. Under the leadership of Director Dr. Robert Wagner, the CRSF team engaged in a year-long visioning process, which resulted in a new plan to provide cutting edge research and outreach about Maine's forest resources. CRSF has now reorganized into three flagship programs: **Commercial Forests**, **Family Forests**, and **Conservation Lands**. In addition to these research initiatives, CRSF hosts the **Northeastern States Research Cooperative** under the United States Forest Service. With these programs and our myriad other initiatives and partnerships, CRSF now leads sustainable forest research in the State.

In 2011, CRSF received \$1.03 million in direct support and leveraged that to generate an additional \$660,000 in extramural support. In total, this nearly *\$1.7 million funded 31 research projects* ranging from developing tree growth models, to understanding the relationships between Canada lynx and forest practices, to evaluating recreation access policies, to developing spatially explicit future land use models. These projects resulted in *75 publications*, including

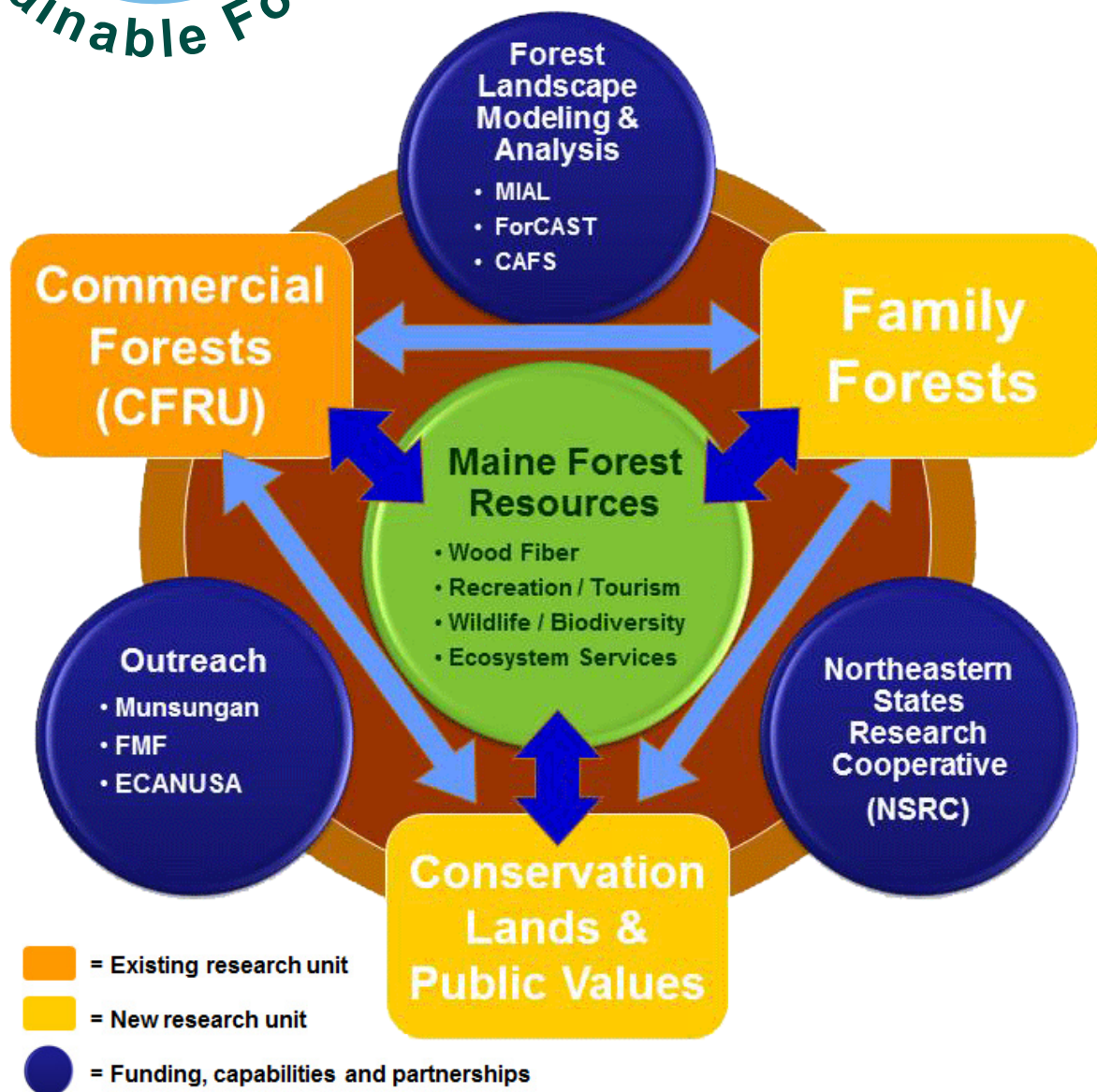
peer reviewed journals, research reports, and graduate student theses, and more than 120 presentations at scientific conferences, stakeholder meetings, and other venues.

The CRSF team includes *34 faculty, staff, and students* with expertise in forest management, ecology, economics, and policy. However, we rely heavily on our colleagues and partner organizations across the State, region, and beyond to conduct our research programs. This year, CRSF researchers partnered with nearly *90 different stakeholder organizations*, including federal, state, and municipal agencies, non-profit organizations, and most of Maine's forest industry leaders. Among our stakeholders are large forest landowners who own and manage over 8 million acres of Maine's forests. Additionally, Maine's approximately 120,000 family forest owners are represented in CRSF programs by more than a dozen partners organizations who primarily focus on these smaller landowners.

Together with all our partners at UMaine and beyond, we strive to provide science-based knowledge that informs the management, protection, and wise-use of Maine's most precious natural resource. Please enjoy the following highlights from this past year.



NEW CRSF REORGANIZATION



- MIAL – Maine Image Analysis Lab
- ForCAST – Forecasting Tomorrow’s Forests
- CAFS – Center for Advanced Forest Systems
- Munsungan – Munsungan Conference Series
- FMF – Forest for Maine’s Future
- ECANUSA – Eastern Canada / USA Forest Science Conference

DIRECTOR'S REPORT

This report marks the end of my first year as Director of the Center for Research on Sustainable Forests (CRSF). It was a year of real change as we saw both a substantial turnover of personnel running CRSF and a significant reorganization of the Center itself.

Dr. Bruce Wiersma, founding Director of CRSF, retired this year. In addition to many years as a successful Dean of the College of Natural Sciences, Forestry, & Agriculture, Bruce got the CRSF off to a great start during its first four years. We very much appreciate Bruce's dedication to the program and providing a great foundation on which to build the Center's future. We wish him the very best in his retirement. In addition, Summer Allen, Communications and Development Coordinator for CRSF, left the Center to pursue new opportunities. We also thank her for her efforts in helping build the Center.

As part of Bruce's and Summer's departures, we embarked on a major effort to re-organize and re-staff the way the CRSF accomplishes its mission. This year also marks several new staff joining the CRSF. As part of the CRSF reorganization, we developed two new research programs (described below) led by Program Leaders Drs. Jessica Leahy and Rob Lilieholm. Jessica and Rob have done a wonderful job this year developing new research programs dedicated to Family Forests and Conservation Lands. In addition, Spencer Meyer moved from the Cooperative Forestry Research Unit



A handwritten signature of Robert G. Wagner in blue ink, written in a cursive style.

Robert G. Wagner, CRSF Director

(CFRU) as Associate Director to take on a new half-time Associate Scientist for Forest Stewardship position supporting the Family Forests and Conservation Lands Programs. As part of this move, Dr. Brian Roth joined the CFRU as Associate Director. Dr. Mohammad Bataineh also joined the CRSF as a Post-Doctoral Fellow in Forest Ecology & Silviculture working with the CFRU and US Forest Service. In addition, Kae Cooney joined the CRSF as a half-time Administrative Assistant for the CRSF. Rosanna Libby continues to support the CFRU as Administrative Assistant. I welcome all of the new and returning CRSF staff and look forward to building on the new initiatives developed for the CRSF this year.

Reorganization of CRSF

The CRSF had been doing an excellent job serving the research needs of large forestland owners (>10,000 acres) across northern Maine, primarily through the CFRU and Northeastern States Research Cooperative (NSRC). However, it was recognized that a more focused research effort was needed to serve more effectively two other Maine forest conditions and stakeholders: small woodland owners (or family forests), and those concerned with conservation lands and public values. As a result, we expanded the vision of the CRSF by developing two new research programs: the Family Forests and Conservation Lands Programs.

Family Forests Program

Under the leadership of Dr. Jessica Leahy, the Family Forests Program conducts research and outreach that contributes to the sustainable management of Maine's family forests for desired products, services, and conditions in partnership with Maine's family forest stakeholders. Maine's family forests (individuals and families holding parcels between 1 and 1,000 acres) have a significant impact on wood supply, ecosystem services, recreation, and other benefits. Family forests account for approximately 34% of the forest area in Maine, and about 25% of timber harvested each year. Major issues facing family forests are related to development pressure, estate transfer, recreation access, and forest management.

The objectives of the Family Forests Program are to: 1) define and identify the over 120,000 private landowners who are the stewards of nearly 6 million acres of Maine's forests; 2) develop a coordinated research effort that increases our understanding about the issues, challenges, and opportunities facing Maine's small woodland owners; 3) model dynamic and complex interactions between landowner decisions and forest ecosystems, including projecting future conditions in a rapidly changing landscape and

society; and 4) develop outreach programs for small woodland owners to increase their understanding about the benefits of forest stewardship and how management and planning can help further their goals.

Conservation Lands Program

Under the leadership of Dr. Rob Lilieholm, the Conservation Lands Program conducts research to better understand, monitor and anticipate important issues regarding Maine's conservation lands, as well as the public values towards forests and forestry issues in the state. In 2010, about 17%, or 3.6 million acres, of Maine's forest was under some form of conservation agreement. These lands, owned and managed by both private and public organizations, are largely managed for ecosystem services (e.g., recreation, biodiversity, natural resources, clean water, etc.) to provide a host of public values for current and future generations of Mainers. Managing these conservation lands across diverse owners and political jurisdictions is complex because of varying objectives and societal pressures. The objective of this program is to identify and address issues that arise on forestland managed primarily for conservation objectives, as well as to increase our understanding about public values of forest resources that affect public policy and regulation on all forestlands.

New Organizational Design

The *conceptual diagram on page 8* shows the new organization model for CRSF and illustrates how the two new research programs interface with existing research efforts using an integrated cooperative research model. Together with the long-standing CFRU that has served the research needs of large forestland owners in the unorganized towns, these three research programs now work together to cover the major issues affecting all uses of forestland and their owners in Maine.

Leadership & Staff

Robert Wagner

Director

Jessica Leahy

Family Forests Program Leader

Rob Lillieholm

Conservation Lands Program Leader

Spencer Meyer

Associate Scientist for Forest Stewardship

Brian Roth

CFRU Associate Director

Wilfred Mercier

CFRU Interim Research and Comm. Coordinator

Matthew Olson

CFRU Post-Doctoral Research Scientist

Mohammed Bataineh

CFRU Post-Doctoral Research Scientist

Kae Cooney

CRSF Administrative Assistant

Rosanna Libby

CFRU Administrative Assistant

PEOPLE



Cooperating Scientists (Affiliation)

Jeffrey Benjamin (CFRU)

Daniel Harrison (CFRU)

Robert Seymour (CFRU)

Aaron Weiskittel (CFRU)

Graduate Students

Ian Foertsch (Family Forests)

Erika Gorczyca (Family Forests)

Gretchen Heldmann (Family Forests)

Michelle Johnson (SSI, Conservation Lands)

Patrick Lyons (Family Forests)

Spencer Meyer (SSI, Conservation Lands)

Michael Quartuch (SSI, Family Forests)

Martha Willand (Family Forests)

Project Scientists

Chris Hennigar (CFRU)

Ted Howard (NSRC)

Kasey Legaard (NSRC)

Rongxia "Tiffany" Li (CFRU)

Andrew Nelson (NSRC)

David Newman (NSRC)

Matthew Olson (NSRC)

Ben Rice (NSRC)

Steven Sadar (NSRC)

Robert Seymour (NSRC)

Aaron Weiskittel (NSRC)

Jeremy Wilson (CFRU)

Ronald Zalesny (NSRC)

Undergraduate Students

Elijah Shank (Family Forests)

Income Sources

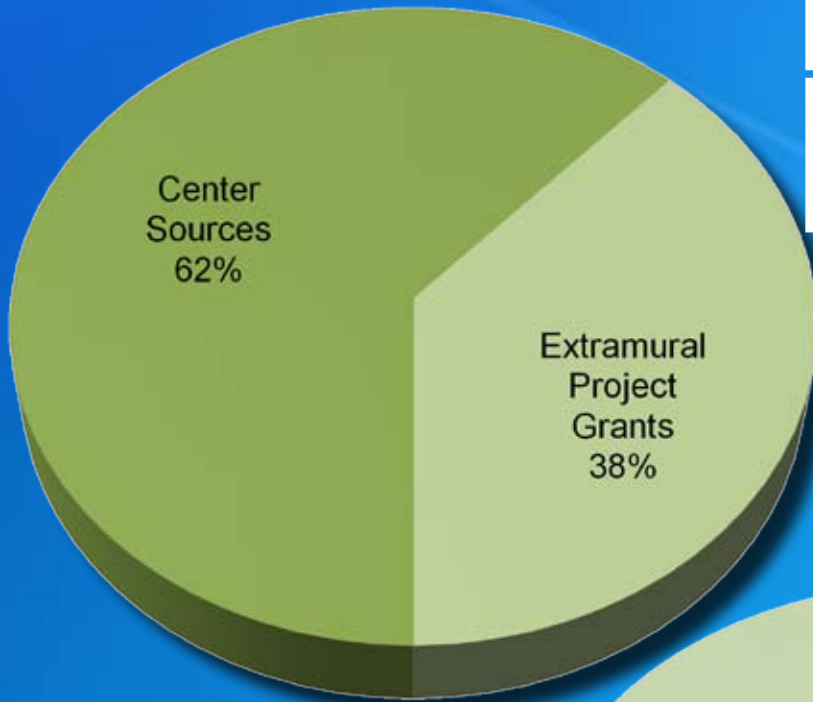


Figure 1. CRSF generated 38% of its income this year from extramural grants.

**\$1.7 MILLION FOR
FOREST RESEARCH**

Overall Expense Allocation

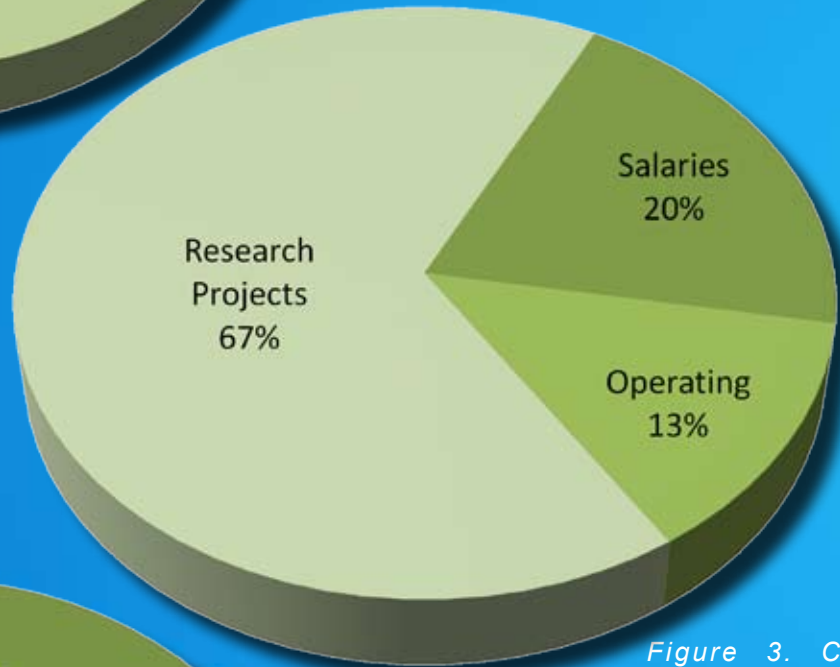


Figure 3. CRSF spends 67% of its revenue on research related to sustainable forests.

Research Program Allocation

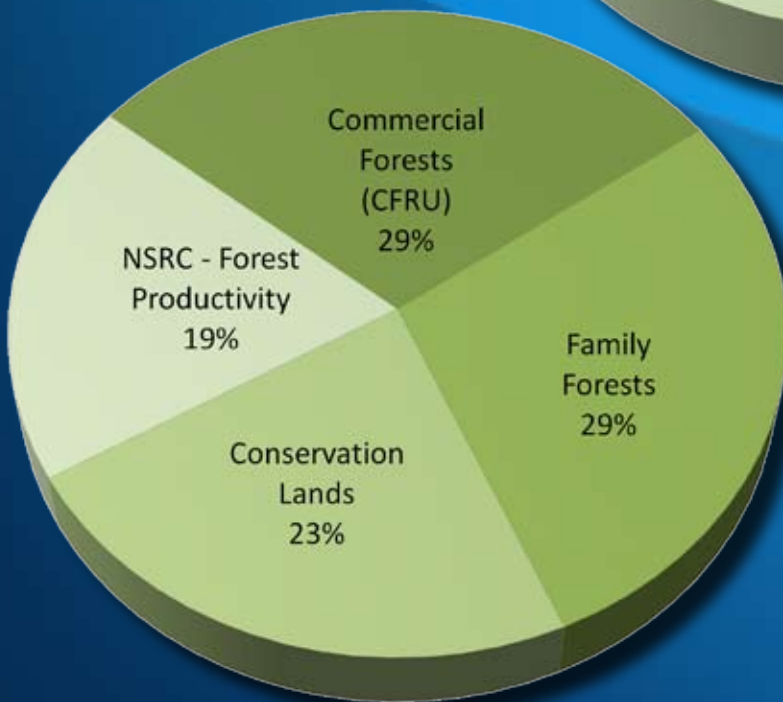


Figure 2. CRSF conducts research on four key areas of sustainable forest management.

FINANCIAL REPORT

The income and allocated expenses for the CRSF are shown in Tables 1 and 2. Income supporting the Center came from programs that are administered by or that support the general operations of the CRSF (\$1,029,234 total), as well as extramural grants supporting specific research projects (\$634,128 total) that were submitted by CRSF scientists for competitive funding to outside agencies. These extramural grants made up 38% of funding supporting the Center and leveraged an additional 62% above the Center's general funding (Figure 1). Total funding supporting the CRSF for FY2010-11 was \$1.66 million.

Over two-thirds (67%) of the funding received by the Center went directly to support the research projects described in this report (Figure 3). The remaining 33% supported personnel salaries (20%) and operating expenses (13%) for the Center. The proportion of total funding allocated to specific research projects was relatively equal (Figure 2) among the four programs making up the CRSF: *Commercial Forests Program* (29%), *Family Forests Program* (29%), *Conservation Lands Program* (23%), and *Forest Productivity & Wood Products through the Northeastern States Research Cooperative* (19%).

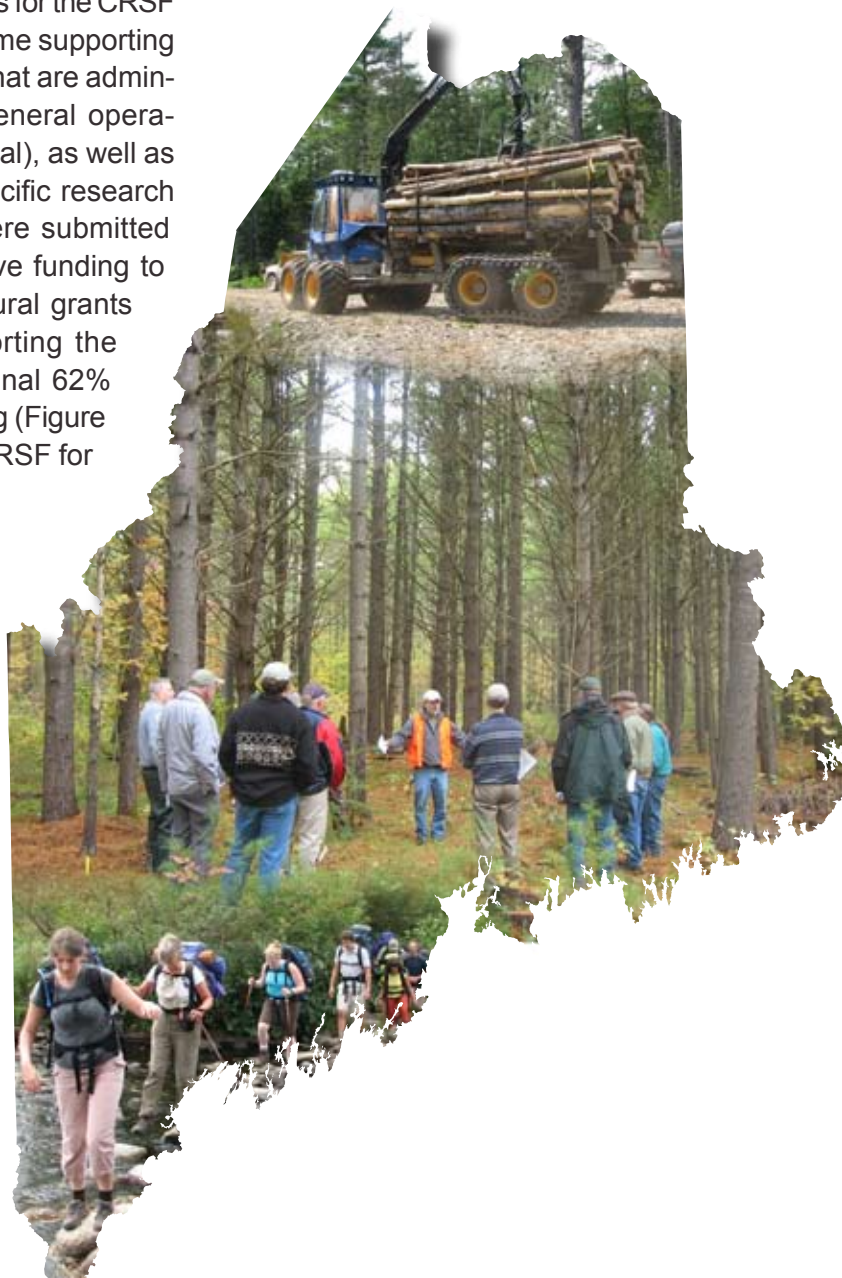


Table 1. FY2010-11 income for Center for Research on Sustainable Forests.

INCOME	
Center Sources:	Amount
Cooperative Forestry Research Unit (CFRU)	\$490,001
US Forest Service – Northeastern States Research Cooperative – Theme 3 (NSRC)	\$278,058
Maine Economic Improvement Fund (MEIF)	\$121,521
National Science Foundation – Center for Advanced Forestry Systems (CAFS)	\$110,405
Maine Agriculture & Forest Experiment Station (MAFES)	\$20,553
UMaine Munsungan Fund	\$8,696
Center Total	\$1,029,234
Extramural Project Grants:	
National Science Foundation – Sustainability Solutions Initiative (SSI)	\$236,865
US Forest Service – Northeastern States Research Cooperative – Theme 1 (NSRC)	\$92,249
Small Woodland Owners of Maine (SWOAM)	\$88,000
US Forest Service, Northern Research Station – Joint Venture Agreement (USDA-JVA)	\$72,921
Colorado State University (CSU)	\$50,000
Maine Economic Improvement Fund (MEIF)	\$48,229
UMaine George J. Mitchell Center	\$45,864
Extramural Grant Total	\$634,128
Total Income	\$1,663,362

Table 2. FY2010-11 Expenses for Center for Research on Sustainable Forests.

EXPENSES			
Salaries & Benefits:			Amount
Director, Associate Director, Program Leaders, and Scientists			\$288,464
Support staff			\$47,441
Salaries & Benefits Total:			\$335,904
Operating Expenses:			\$217,968
Salaries, Benefits, & Operating Total:			\$553,872
Research Projects:	Source	Investigators	
Commercial Forests Program (CFRU)			
Improved Growth & Yield Models	NSF	Wagner & Weiskittel	\$110,405
Commercial Thinning Research Network	CFRU	Wagner et al.	\$40,902
Development of Regional Taper Equations	CFRU	Weiskittel	\$35,219
Trends in Habitat Supply	CFRU	Harrison & Krohn	\$34,000
Long-term Monitoring of Snowshoe Hare Populations	CFRU	Harrison	\$28,790
Documenting the Response of Lynx to Hare Populations	CFRU	Vashon	\$26,600
Refinement of FVS-NE Individual Tree Model	CFRU	Weiskittel	\$25,816
Improving the Species Composition of Hardwood Regeneration	CFRU	Wagner	\$13,166
ForCAST Initiative	CFRU	Wiersma et al.	\$10,000
Commercial Forests Program Total:			\$324,898
Family Forests Program			
Identifying Meaningful Incentives-Public Access/Private Lands	SWOAM	Leahy	\$88,000
Maine Sustainability Science Initiative – Yr 2	NSF-SSI	Leahy	\$80,000
Family Forest ForCAST Project	MEIF	Leahy	\$45,000
An Oral History Place Attachment Project	NSRC	Mann	\$37,983
A Long-Term Monitoring Program-Logging Industry Health	NSRC	Benjamin	\$25,000
Estimating Willingness to Accept Recreation Access Policies	NSRC	Leahy	\$21,766
Kennebec Woodland Owners Project	USDA	Leahy	\$9,385
The Forestry Community, Belief Systems and Consensus	NSRC	Leahy	\$7,500
Family Forests Program Total:			\$314,634
Conservation Lands Program			
Alternative Futures Modeling in Maine	NSF-SSI	Lilieholm	\$156,320
Wildebeest Forage Acquisition in Fragmented Landscapes	CSU	Boone & Lilieholm	\$50,000
Protecting Nat. Resources at the Community Scale: Vernal Pools	NSF-SSI	Calhoun	\$36,900
Address Invasive Species Threats: Emerald Ash Borer in Maine	NSF-SSI	Ranco & Lilieholm	\$7,026
Urban Streams Integration	NSF-SSI	Lilieholm & Cronan	\$5,712
Conservation Lands Program Total:			\$255,958
NSRC Theme 3			
Evaluating the Interacting Effects of Forest Management Practices	NSRC	Legaard	\$35,000
Merge Landsat Series – Yr 2	NSRC	Sader	\$33,000
Effects of Climate Change	NSRC	Zalesny	\$30,000
Forest Regeneration Differences	NSRC	Howard	\$25,000
Silvicultural Factors Affecting Environmental Conditions	NSRC	Nelson	\$24,000
Nonselective Partial Harvesting in Maine's Working Forests	NSRC	Rice	\$22,000
Pioneering Growth and Yield Studies	NSRC	Weiskittel	\$20,000
Predicting Dynamics of White Pine	NSRC	Seymour	\$15,000
Response of Tree Regeneration to Commercial Thinning	NSRC	Olson	\$10,000
NSRC Project Total:			\$214,000
Research Project Total:			\$1,109,490
Total Allocation:			\$1,663,362

OUR STAKEHOLDERS

CRSF researchers strive to conduct not just cutting edge forest science, but also real-world, applied science about Maine's forests, forest-based businesses, and the public that supports them. We recognize that Maine is full of organizations who already represent the best interest of forest resources and that each fills its own niche. We build and foster relationships with the best organizations and their people to achieve overlapping goals.

OUR STAKEHOLDERS INFORM OUR RESEARCH, WE SHARE OUR RESULTS WITH OUR STAKEHOLDERS, AND WE ASK OUR STAKEHOLDERS TO SPREAD THE WORD WHEN WE LEARN SOMETHING NEW.

To the left is a partial list of more than 80 organizations with whom we have partnered this year. Suffice it to say, CRSF would not have been able to accomplish all it has this year without each and every one of these partners.



Brian Curry



Spencer Meyer Photos



Acadia National Park
Alliance of Trail Vehicles of Maine
American Tree Farm System
Appalachian Mountain Club
Association of Consulting Foresters
Association of Sporting Clubs
of Cumberland County
Baskahegan Corporation
Baxter State Park
BBC Land, LLC
Boralex, Inc.
Canopy Timberlands Maine, LLC
Central Maine Power Co.
Cianbro
Clayton Lake Woodlands Holding, LLC
Corinth Wood Pellets, LLC
Downeast Lakes Land Trust
Downeast Salmon Federation
EMC Holdings, LLC
Environmental Funders Network
Field Timberlands
Finestkind Tree Farms
Forest Society of Maine
Forests for Maine's Future
Frenchman Bay Conservancy
Frontier Forest, LLC
GrowSmart Maine
Huber Engineered Woods, LLC
Huber Resources Corporation
Innovative Natural Resource
Solutions, LLC
Irving Woodlands, LLC
Katahdin Forest Management, LLC
Kennebec Land Trust
Kennebec Woodland Partnership
Land for Maine's Future Program
LandVest
Land Use Regulation Commission
Lower Penobscot River Coalition
Madison Paper Industries
Maine Bowhunters Association
Maine Bureau of Parks and Lands
Maine Cooperative Fish and
Wildlife Research Unit
Maine Department of Conservation
Maine Department of
Environmental Protection
Maine Department of Inland
Fisheries and Wildlife
Maine Equine Association
Maine Farm Bureau
Maine Forest Products Council

Maine Forest Service
Maine Landowners and Sportsmen's
Relations Advisory Board
Maine Pulp and Paper Association
Maine Snowmobile Association
Maine State Planning Office
Maine Trappers Association
Maine Tree Foundation
Manomet Center for
Conservation Sciences
Mosquito, LLC
National Wild Turkey Federation
New Brunswick Department
of Natural Resources
North Maine Woods Inc.
Northeast Master Logger
Certification Program
Northern Maine Sportsmen
Old Town Fuel & Fiber
Open Space Institute
Plum Creek Timber Company, Inc.
Prentiss & Carlisle Company, Inc.
Quebec-Labrador Foundation
Quebec Ministry of Natural Resources
Robbins Lumber Company
S.W. Cole Engineering, Inc.
SAPPI Fine Paper
Sebastiack Land Trust
Seven Islands Land Company
Small Woodland Owners
Association of Maine
Society of American Foresters
Sportsman's Alliance of Maine
St. John Timber, LLC
Sylvan Timberlands, LLC
The Forestland Group, LLC
The Nature Conservancy
Timbervest, LLC
University of Maine, Cooperative Extension
University of Massachusetts – Amherst
University of New Brunswick
USDA, Forest Service, Northern
Research Station
USDA, Natural Resource
Conservation Service
USDA, Resource Conservation
and Development
Wagner Forest Management
Washington County Council
of Governments
World Resources Institute

PARTNERSHIPS & INITIATIVES

An important dimension of the CRSF's mission is collaboration with other programs that can help advance research on various aspects of forest resources. These initiatives and partnerships strengthen our overall mission by leveraging funds, facilities, and talent, as well as fostering interdisciplinary cooperation on key issues facing forest resources.

Through partnerships with other UMaine research centers, such as the Sustainability Solutions Initiative and the Forest BioProducts Research Institute, CRSF is able to draw on forest-related expertise to strengthen our

research programs. Through partnerships with other universities, such as through the Center for Advanced Forestry Systems and the Northeastern States Research Cooperative, CRSF is able to leverage significant funding to expand the geographic scope of our work. Finally, our partnership in Forests for Maine's Future allows us to convey a unified message about the value of Maine's forest resources to our economic vitality, environmental quality, and cultural identity.

In addition to the aforementioned stakeholders, this year CRSF participated in the following five strategic partnership and initiatives.



**Forests
for Maine's
Future**



Forests for Maine's Future



Forest for Maine's Future (FMF) is a partnership between four organizations: Maine Tree Foundation, Small Woodland Owners Association of Maine (SWOAM), Maine Forest Service (MFS), and CRSF. FMF believes that Maine's 17 million-acre forest resource is a vital part of Maine's economy and the social fabric of yesterday, today, and tomorrow. FMF's mission is to promote sustainable forestry and educate people about the benefits and wonders of the forest that covers some 90 percent of our state.

Under leadership by Sherry Huber (MTF), Spencer Meyer (CRSF), Tom Doak (SWOAM), and Kevin Doran (MFS), FMF builds awareness of Maine's forest resources through public outreach. FMF produces monthly feature articles, dubbed *Fresh From the Woods*, and delivers weekly newsletters with interesting news briefs about the woods in Maine and beyond. FMF strives to find unique stories that appeal to a broad audience and convey the special way-of-life the Maine Woods affords us. For instance, FMF writer Joe Rankin recently wrote a story about celebrated naturalist Bernd Heinrich and his connections to the Maine Woods. Other stories from this past year include profiles on maple syrup producers, Tom Wessels's *Forested Landscape*, wood pellets, vernal pools, and community forests. Other highlights include a feature celebrating Prentiss and Carlisle (a member of the CFRU since its founding in 1975) as the 2010 recipient of the Governor's Austin Wilkens Award for Forest Stewardship.



Joe Rankin



Pam Wells



Joe Rankin

NORTHEASTERN STATES RESEARCH COOPERATIVE



A Research Program for the Northern Forest

The Northeastern States Research Cooperative (NSRC) is a competitive grant program, supporting cross-disciplinary, collaborative research in the Northern Forest – a 26-million acre working landscape that is home to over a million residents and stretches from eastern Maine through New Hampshire and Vermont and into northern New York. The program addresses the importance of the Northern Forest to society and the need for research activities to benefit the people who live within its boundaries, work with its resources, use its products, visit it, and care about it. Funds support a range of research projects that address four themes.

Theme 1 – Vermont

Sustaining Productive Forest Communities: Balancing Ecological, Social, and Economic Considerations

Theme 2 – New Hampshire

Sustaining Ecosystem Health in Northern Forests

Theme 3 – Maine

Forest Productivity and Forest Products

Theme 4 – New York

Biodiversity and Protected Area Management

NSRC is funded through the US Forest Service Northern Research Station and is a cooperative involving four universities that manage each of the four research themes: University of Vermont (Theme 1), University of New Hampshire (Theme 2), University of Maine (Theme 3), State University of New York (Theme 4). A request for competitive research proposals is solicited annually from research institutions across the four state region.

Theme Three at CRSF

Forest Productivity and Forest Products

NSRC Theme 3 is managed by the CRSF. Theme 3 research seeks to quantify, improve, and sustain productivity of the products-based economy of the Northern Forest. Topics include underlying biological processes, management practices, and methods of prediction that will influence future wood supplies and forest conditions.

During FY10-11, Theme 3 supported nine research projects across the Northern Forest. Details of these projects are described in the following abstracts. See the CRSF Financial Report for details on NSRC funding.



Spencer Meyer

Evaluating the interacting effects of forest management practices and periodic spruce budworm infestation on broad-scale, long-term forest productivity

Kasey Legaard (University of Maine)
NSRC Funding: \$35,000

Periodic infestations of the eastern spruce budworm (*Choristoneura fumiferana* (Clem.)) have caused widespread defoliation, growth reduction, and mortality of balsam fir (*Abies balsamea*) and spruce (*Picea spp.*) trees throughout the northeast United States and eastern Canada. The disturbance dynamics of budworm outbreaks are strongly related to host species distribution, abundance, and age, which are in turn affected by forest management. The sustainable management of the Northern Forest's spruce/fir resource will require a clear understanding of how forest management and repeated budworm infestations interact to determine the supply of forest products and ecosystem services over broad spatial scales and long time periods. We propose to implement the LANDIS-II landscape simulation model to evaluate the coupled dynamics of forest management and periodic spruce budworm disturbance across a 10-million-acre northern Maine study area.

By leveraging existing research projects, we will map forest composition, disturbance history (ca. 1973-2009), age, and budworm vulnerability, and use these data to parameterize LANDIS-II to current landscape conditions. We will design simulation experiments consisting of alternative forest management strategies, policy constraints, and budworm outbreak scenarios designed to test hypothesized interactions between management activities and budworm disturbance. Future forest conditions (2009-2109) will be simulated to evaluate the future status of broad-scale forest productivity under repeated infestations. Results will reduce the uncertainty surrounding the long-term economic and ecological outcomes of forest management and budworm infestation in the Northern Forest.

Merge Landsat time-series and FIA data to develop vulnerability maps for spruce budworm defoliation decision support

Steve Sader (University of Maine)
NSRC Funding: \$33,000

Decision support systems will be needed to plan for and manage the impact of the next spruce budworm (*Choristoneura fumiferana* (Clem.)) outbreak, yet the necessary spatially explicit forest vulnerability data are lacking for large, multi-owner landscapes. With the next anticipated outbreak approaching, it is timely and essential that we examine the vulnerability of northeastern forests to this pest. We propose to merge Landsat satellite imagery with field data provided by the USDA Forest Inventory and Analysis (FIA) program to map budworm vulnerability for a 4 million acre northern Maine study area. FIA plot data will be compiled to produce aspatial models of regional budworm vulnerability. Spatial models and maps of budworm host and non-host species relative abundance will be produced using recent Landsat imagery and reference data from FIA plots.

We will map budworm vulnerability by integrating host and non-host relative abundance data with maps of forest age compiled from an existing 37-year (ca. 1970-2007) satellite-derived forest disturbance time series. Models and maps will be validated with independent field assessments at randomly sampled locations, plot-level comparisons of satellite-derived forest characteristics and FIA measurements, and comparisons of area estimates for stand types and vulnerability ratings derived from spatial (satellite-based) and aspatial (FIA-based) models. Budworm vulnerability maps will be used to evaluate the effects of alternative management strategies and outbreak scenarios on forest structure, timber supply, and various non-timber objectives for a 300,000-acre portion of the study area using a Spruce Budworm Decision Support System. We anticipate that this research will establish a method-

ology by which budworm vulnerability and impact can be assessed across large, multi-owner landscapes using low-cost geospatial data.

Effects of climate change on growth, productivity, and wood properties of white pine in Northern Forest ecosystems

Ronald Zalesny (U.S. Forest Service)
NSRC Funding: \$30,000

We propose to identify eastern white pine (*Pinus strobus* L.) provenances with enhanced adaptation to climate change pressures and carbon (C) sequestration potential. Selection of such provenances will help promote biologically and economically sustainable reforestation, afforestation, and gene conservation. To this end, the project directly addresses the prediction component of Theme Three, supporting *improved prediction of how changing management and environmental conditions will influence future wood supplies and forest conditions*. We propose to measure survival, growth, and wood properties at seven test sites of a unique range-wide network of white pine provenance trials established in the early 1960s in the eastern United States and Canada. Combining these data with climate models, our objectives are to: 1) predict the effects of climate change on growth and wood properties of white pine; 2) estimate C sequestration potential of white pine under new climate regimes; 3) quantify the range of genetic variation in climatic response and adaptive traits of white pine; 4) develop seed transfer models from historic climate data and provenance trial data; 5) use validated models from (4) and future climate projections to: a) predict growth response of white pine in the northeastern U.S., and b) contribute to provisional seed transfer recommendations for assisted migration of white pine seed sources.

At each site, height, diameter at breast height, and survival will be recorded for trees belonging to 12-13 provenances. Increment cores from a subset of trees will be used for analyses of

changes in radial growth, stable C isotope signatures, and wood density over time. Carbon sequestration rates will be evaluated at the stand level using FORCARB2. Quantitative genetic analyses will be conducted to examine genotypic variability in productivity and adaptation potential. Growth response and seed transfer functions will be generated using historical climate data for each combination of trial location and provenance. Products and outcomes include: 1) a model to predict growth and wood quality response of existing white pine forests to changes in climate, including C sequestration; 2) a provisional seed transfer guidelines for assisted migration of white pine seed sources as a forest adaptation strategy; 3) a white paper on provenance selection based on climate-induced stresses and forces; and 4) a genetics best-practices bulletin describing genotype selection that enhances ecosystem health and sustainability under climate change. Peer-reviewed journal articles, scientific presentations, and annual progress reports will be produced.

A Concern For Sustainable Bio-Fuel Production?: Forest regeneration differences between whole-tree and conventional harvesting methods in northern hardwoods

Theodore Howard (University of New Hampshire)
NSRC Funding: \$25,000

Whole-tree harvesting (WTH), where all above-ground biomass is removed, is a common harvest method, increasingly used to supply biomass energy plants with wood chips. While several studies have examined the effects of WTH on the nutrient balance of the site, few have directly measured the productivity of the resultant stand. This study will compare the productivity of whole-tree harvested stands with those that have been conventionally harvested (CH), a process that removes less biomass and nutrients from the forest ecosystem. Several patch cuts in the Bartlett Experimental Forest in Bartlett, NH will be studied intensively and the results

compared with a wider sample of sites. Individual tree height and diameter, along with total stand biomass and species composition, will be measured and compared across the varying light intensity present in these gaps. Growing season light availability, slope, aspect, and root competition will be measured and corrected in order to isolate the effects of harvest treatment. Results obtained will give a measure of how biologically sustainable whole-tree harvesting is in the Northern Forest. Economic analyses will evaluate any differences in land and timber value between WTH and CH, and suggest impacts on land use and competition for wood between biomass and traditional forest products producers.

Silvicultural factors affecting environmental conditions and above-ground carbon sequestration of conifers in Northeastern forests

*Andrew Nelson (University of Maine)
NSRC Funding: \$24,000*

Silvicultural practices have great potential to manage northeastern forest species and structures to enhance productivity and carbon sequestration, but the typical focus on stand-level treatment effects can mask the heterogeneous response of individual trees within a stand. Considering the economic importance of northeastern forests for timber and fiber products and their further potential in future carbon markets, understanding how individual species are affected by silvicultural systems is of critical importance. Key to this understanding is how species-specific photosynthetic capacity (PC), a measure of the resource investment in photosynthetic systems and leaf area, is altered by the micro-environmental changes brought about by silvicultural manipulation.

The overall goal of this project is to examine the role of silvicultural intensity and species composition on stand productivity and carbon sequestration using an existing, long-term study on the Penobscot Experimental Forest in Maine. Specifically, we will use an ecophysiological approach

to investigate the influence of silviculturally-mediated biological processes driving aboveground productivity by: 1) determining how the PC of conifers differ when microsite soil conditions, resource availability, and interspecific neighborhood competition are modified by silvicultural intensity and species composition; and 2) quantifying the photosynthetic response of conifer and hardwood species to silvicultural intensity and species composition over the past five years of the experiment using a recently developed approach using tree ring samples to measure past intrinsic water-use efficiency (iWUE, defined as the ratio of carbon uptake to water loss).

Effects of nonselective partial harvesting in Maine's working forests

*Ben Rice (University of Maine)
NSRC Funding: \$22,000*

Maine's long history of forest management has progressed through centuries of changes in equipment technology, market conditions, forest health issues, and silvicultural knowledge. Recently, another shift in harvesting techniques has occurred, moving from a heavy reliance on clearcut harvesting to nonselective partial harvesting. This approach, which accounts for a large proportion of harvested acres in Maine, removes timber from trails but leaves a matrix of unharvested areas. This transition in harvesting practices has taken place within the context of continuing change in timberland ownership patterns and consequently landowner objectives, leading to concerns over the long-term effects on future forest composition and productivity.

Despite this concern, little has been done to quantitatively examine the effects of nonselective partial harvesting on current and future forest conditions. Given widespread use of nonselective partial harvesting, the relative recent advent of this practice, and gaps in our knowledge of stand-level effects of nonselective partial harvesting, we lack the ability to adequately describe the current state of Maine's forest or provide the informa-

tion necessary to make meaningful projections of future forest conditions. With these severe deficiencies, assessments of Maine's wood supply, long-term wildlife habitat viability, and economic forecasts are impossible. In order to begin developing an understanding of the effects of nonselective partial harvesting, three general questions need to be addressed: 1) Given the strong spatial patterns resulting from nonselective partial harvesting, are current sampling schemes adequate? 2) How have patterns of nonselective partial harvesting affected structure and composition of residual stands? 3) How will resulting structures and composition influence future stand development? This project will address these three questions through five research objectives. The proposed research will begin to develop the informational basis needed to better describe the effects of this harvesting practice, information vital to landowner and land manager decisions as well as to policy and economic discussions relevant to Maine's future.

Using pioneering growth and yield studies to inform management and modeling

*Aaron Weiskittel (University of Maine)
NSRC Funding: \$20,000*

Despite more than a century of research in the Northern Forest, many questions about growth and yield remain unanswered. The most important include long-term growth response to silviculture, regional drivers of forest productivity, and the variability of yield. Recently discovered archives from U.S. Forest Service studies established between the 1920s and 1960s in the northern conifer (previously called eastern-spruce fir) forest type present an unprecedented opportunity for addressing these research questions. We propose to re-open and, where possible, remeasure experimental plots from these historic studies, including some initiated by Marinus Westveld, the Father of Spruce-Fir Silviculture. Studies of interest include the now-closed Finch-Pruyn and Paul Smith's Experimental Forests in New York, the Gale River

Experimental Forest in New Hampshire, and a Soil-Site-Growth Study on industrial forestlands in Maine. Archived, unpublished, and remeasurement data will be used to generate new findings about growth and yield in the northern conifer forest type; these findings will inform contemporary forest management and strengthen regional modeling efforts.

Predicting dynamics of white pine advance regeneration under shelterwood silviculture

*Robert Seymour (University of Maine)
NSRC Funding: \$15,000*

In recent decades, eastern white pine (*Pinus strobus* L.) has arguably become the single most important commercial tree species in Maine, perhaps second only to red spruce in commercial value. Managers frequently choose to regenerate white pine through an extended shelterwood system, which best mimics the species' natural regeneration strategies. However, this management is based largely on experienced intuition; specific quantitative targets regarding height growth rates under varying overwood densities, and timing of overstory removal cuttings, are not supported by the published literature. We therefore seek to develop a robust model for understanding and predicting the dynamics of eastern white pine managed under the shelterwood regeneration method.

Study sites will span a soil and environmental gradient across Maine and will be chosen where: 1) pine is a dominant forest type; 2) shelterwood establishment cutting has occurred; and 3) there is well-developed pine regeneration. The understory light environment will be measured directly above saplings across a systematic grid with a LI-COR LAI-2000 (LI-COR, Lincoln, NE) and with digital hemispherical photography. Double light sampling will occur in the lower sapling height classes, allowing for comparison and corroboration between techniques, while only the LAI-2000 will be used for taller saplings that outdistance the camera's tripod. Across the forested stands

of interest, we will subsample saplings to equally represent light gradient groupings. With each measured sapling as a respective plot center, we will collect overstory measurements (basal area, height) as well as sapling data (e.g., the previous five years of terminal leader height growth, measurements to characterize crown size and shape, and presence of disease and white pine weevil).

Analysis will attempt to predict development of the understory as a function of the canopy by modeling height growth from light, and will develop regression equations relating the understory light environment to overstory metrics. We will then compare results to a projected output in both FVS-NE variants. The study will conclude with recommendations for future FVS-NE small-tree model calibration for white pine.

NSRC researcher, Matthew Olson (right) and assistant Erik Nash prepare to conduct a forest inventory.

Response of tree regeneration to commercial thinning in spruce-fir forests of the Northeast

Matthew Olson (University of Maine)

NSRC Funding: \$15,000

Commercial thinning (CT) is a top research priority for industrial landowners in Maine, suggesting this practice will become more important in spruce-fir stands of northern Maine and the greater northeast region. The extent to which CT influences forest regeneration has implications for future stand development in northeastern spruce-fir stands. However, there are few data on the effects of CT on tree regeneration in spruce-fir stands of the northeast. The goal of this project is to increase our understanding about the influence of CT on regeneration dynamics in the northeast, and test the hypothesis that CT is a de facto shelterwood treatment in northeastern spruce-fir stands. We will use sites with and without a history of PCT that are part of the Cooperative Forestry Research Unit's (CFRU) Commercial Thinning Research Network (CTRN) to test our hypotheses on the effect of CT on natural regeneration. Results from this project will help forest managers of the northeast make decisions about the next entries into CT spruce-fir stands, and inform forest planning.



Spencer Meyer

CENTER FOR



ADVANCED FORESTRY SYSTEMS

Drs. Bob Wagner and Aaron Weiskittel completed the second year of a program funded by the National Science Foundation (NSF) Industry/ University Cooperative Research Centers Program (I/UCRC) this year. This ten-year program resulted from a partnership between CFRU members and the I/UCRC to support a University of Maine research site within the Center for Advanced Forestry Systems (CAFS). CAFS unites leading university forest research programs and forest industry members across the US to solve complex, industry-wide problems at multiple scales using interdisciplinary collaborations. The mission of CAFS is to optimize genetic and cultural systems to produce high-quality raw forest materials for new and existing products by conducting collaborative research that transcends species, regions, and disciplinary boundaries.

CAFS is a multi-university center that works to solve forestry problems using multi-faceted approaches and questions at multiple scales, including molecular, cellular, individual-tree, stand, and ecosystem levels. Collaboration among scientists with expertise in biological sciences (biotechnology, genomics, ecology, physiology, and soils) and management (silviculture, bioinformatics, modeling, remote sensing, and spatial analysis) is at the core of CAFS research.

Led by North Carolina State University, CAFS is a consortium of university/industry forest research cooperatives at University of Maine, Oregon State University, Purdue University, Virginia Polytechnic Institute, University of Georgia, University of Washington, University of Idaho, and University of Florida.

CAFS provides \$70,000 per year (Table 2) to the University of Maine and CFRU members to advance growth & yield models for natural forest stands in the Northeast. This funding is supporting a PhD student (Matt Russell) and MS student (Patrick Clune). Matt is developing growth and yield equations for the northern forest and Patrick is analyzing the 10-year results from the CFRU Commercial Thinning Research Network. Funding provided by CAFS is shown in the *Financial Report*.



PARTNER UNIVERSITIES

NC STATE UNIVERSITY

Oregon State UNIVERSITY OSU

PURDUE UNIVERSITY

UF UNIVERSITY of FLORIDA

The University of Georgia

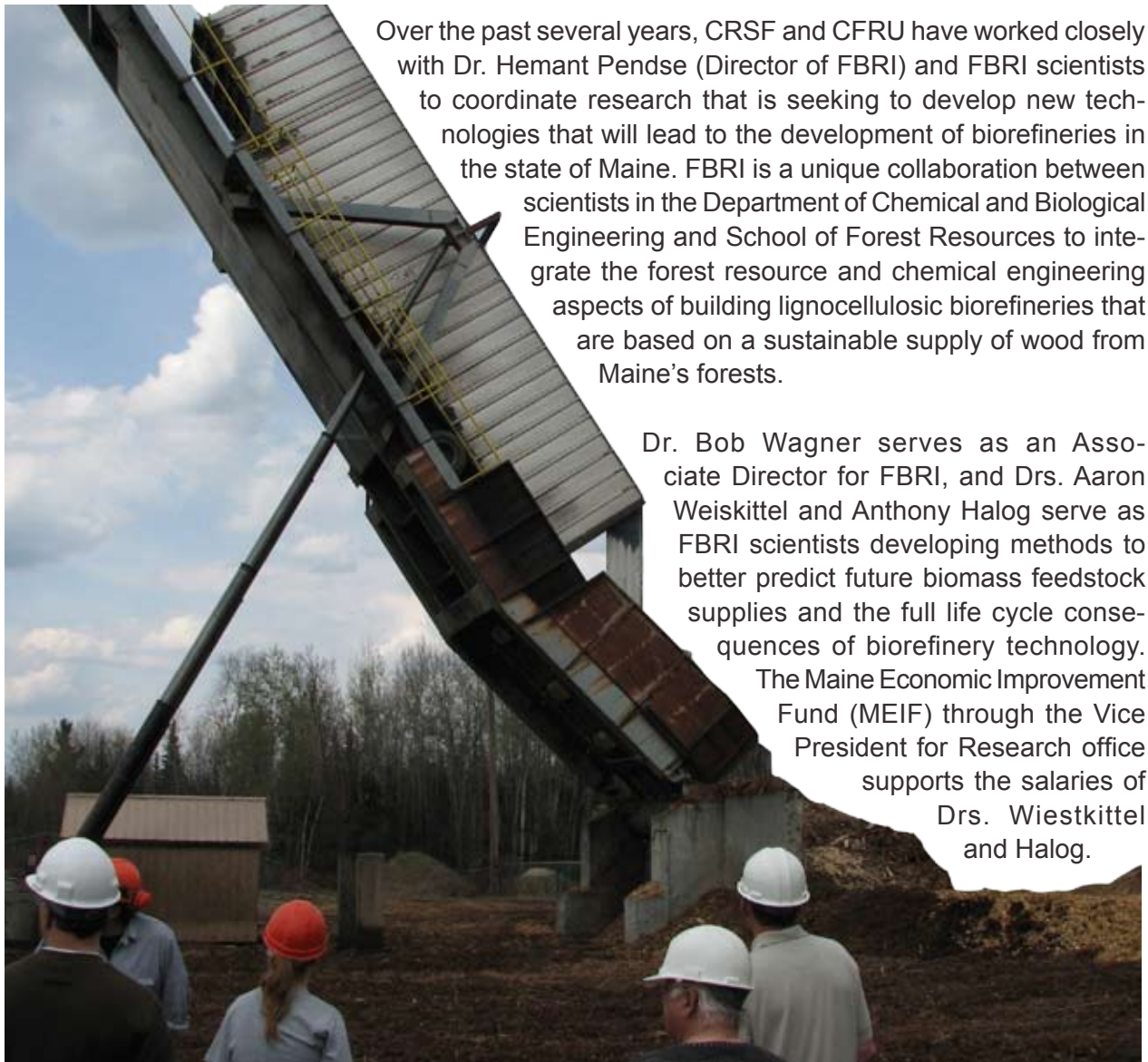
University of Idaho

1865 THE UNIVERSITY OF MAINE

W UNIVERSITY of WASHINGTON

1872 VirginiaTech

FOREST BIOPRODUCTS RESEARCH INSTITUTE



Over the past several years, CRSF and CFRU have worked closely with Dr. Hemant Pendse (Director of FBRI) and FBRI scientists to coordinate research that is seeking to develop new technologies that will lead to the development of biorefineries in the state of Maine. FBRI is a unique collaboration between scientists in the Department of Chemical and Biological Engineering and School of Forest Resources to integrate the forest resource and chemical engineering aspects of building lignocellulosic biorefineries that are based on a sustainable supply of wood from Maine's forests.

Dr. Bob Wagner serves as an Associate Director for FBRI, and Drs. Aaron Weiskittel and Anthony Halog serve as FBRI scientists developing methods to better predict future biomass feedstock supplies and the full life cycle consequences of biorefinery technology. The Maine Economic Improvement Fund (MEIF) through the Vice President for Research office supports the salaries of Drs. Wiestkittel and Halog.

SUSTAINABILITY SOLUTIONS INITIATIVE



Connecting knowledge with action in ways that promote strong economies, vibrant communities, and healthy ecosystems in and beyond Maine.

Through its *Family Forests* and *Conservation Lands* Programs, CRSF partners with the Sustainability Solutions Initiative (SSI) at UMaine. SSI, housed in the *Senator George J. Mitchell Center*, is a National Science Foundation EPSCoR-funded program aimed at cutting across disciplines to tackle the most challenging sustainability science problems.

Producing knowledge and linking it to actions that meet human needs while preserving the planet's life-support systems is emerging as one of the most fundamental and difficult challenges for science in the 21st century. Maine's Sustainability Solutions Initiative seeks to transform our collective capacity for addressing these challenges in ways that directly benefit Maine and other regions.

Building Teams and Partnerships

Solving sustainability problems requires unprecedented levels of program integration characterized by a deep commitment to interdisciplinary teamwork, robust university-stakeholder partnerships, and an innovative institutional culture. These interdisciplinary teams, including CRSF researchers Rob Lilieholm, Jessica Leahy, Jeremy Wilson, Spencer Meyer, Michelle Johnson, and Michael Quartuch, are working in close partnership with diverse stakeholders to maximize the relevance and potential value of research for decision-making.

Understanding Landscape Change

Initially, SSI is focused on understanding three pressing drivers of landscape change—urbanization, forest ecosystem management, and climate change and energy. Landscape change has not only been identified as one of the grand challenges in the environmental sciences by the National Research Council, it is also a central concern in recent reports focusing on the future of Maine's economy and way of life. The *Alternative Futures* project, largely funded by SSI, is also a mainstay of CRSFs Conservation Lands Program.

Generating Solutions

Maine can serve as a valuable model system for exploring more proactive, cost-effective approaches to sustainable development. For example, Maine has a long tradition of developing novel solutions to a variety of sustainability challenges involving water pollution, habitat conservation, and forest management. For instance, the *Sustainability Solutions for Family Forest Landowners* project's goal is to generate solutions to a wide array of challenges facing 120,000 of Maine's landowners who face the decision whether to develop their forestland or manage it sustainably.

ACADIAN INTERNSHIP IN REGIONAL CONSERVATION AND STEWARDSHIP



Large landscape conservation training and service for the next generation of public, private and non-profit conservation leaders.

The inaugural 2011 Acadian Internship in Regional Conservation and Stewardship took place in July and August 2011. This innovative program combines formal coursework, offered for credit through the University of Maine's Summer University, with a four-week paid internship program hosted across the Downeast Maine and southwest New Brunswick region.

Coursework was held at the Schoodic Education and Research Center (SERC) in Acadia National Park. Co-instructors Dr. Rob Lilieholm of the University of Maine's School of Forest Resources and Dr. Megan Gahl of the University of New Brunswick taught an intensive week of coursework in conservation theory, tools, and methods. A diverse set of faculty, local experts, and guest lecturers – including field trips and case studies within the region – exposed students to the environmental challenges within the region. During the following four weeks, Interns worked with a variety of field sponsors, gaining meaningful, hands-on internship experience. Afterwards, interns reconvened at SERC to place what they learned in their field experience within the greater

context of large, landscape-scale conservation. Interns then presented formal project presentations to all stakeholders.

The Program's inaugural class of 11 students included a mix of graduates and undergraduates majoring in natural resource-related programs at American institutions ranging from UMaine to Yale. Also included were four overseas Interns from South Africa and Central America. Intern sponsors for the four-week field component included the Downeast Lakes Land Trust, the Washington County Council of Governments, and the Downeast Salmon Federation.

The Acadian Internship Program was sponsored by the Quebec-Labrador Foundation, Schoodic Education and Research Center, the Frenchman Bay Conservancy, the University of Maine, and Unity College. Partners include Acadia National Park and the Center for Community GIS. Financial support has been provided by the Dodge Memorial Trust, the Harding Trust, UMaine's Canadian-American Center, private individuals, and the Eaton, Island, Horizon, French and Molson Foundations. In total, the Acadian Internship program raised \$106,000.

28 MEMBERS WITH

8.4 MILLION ACRES

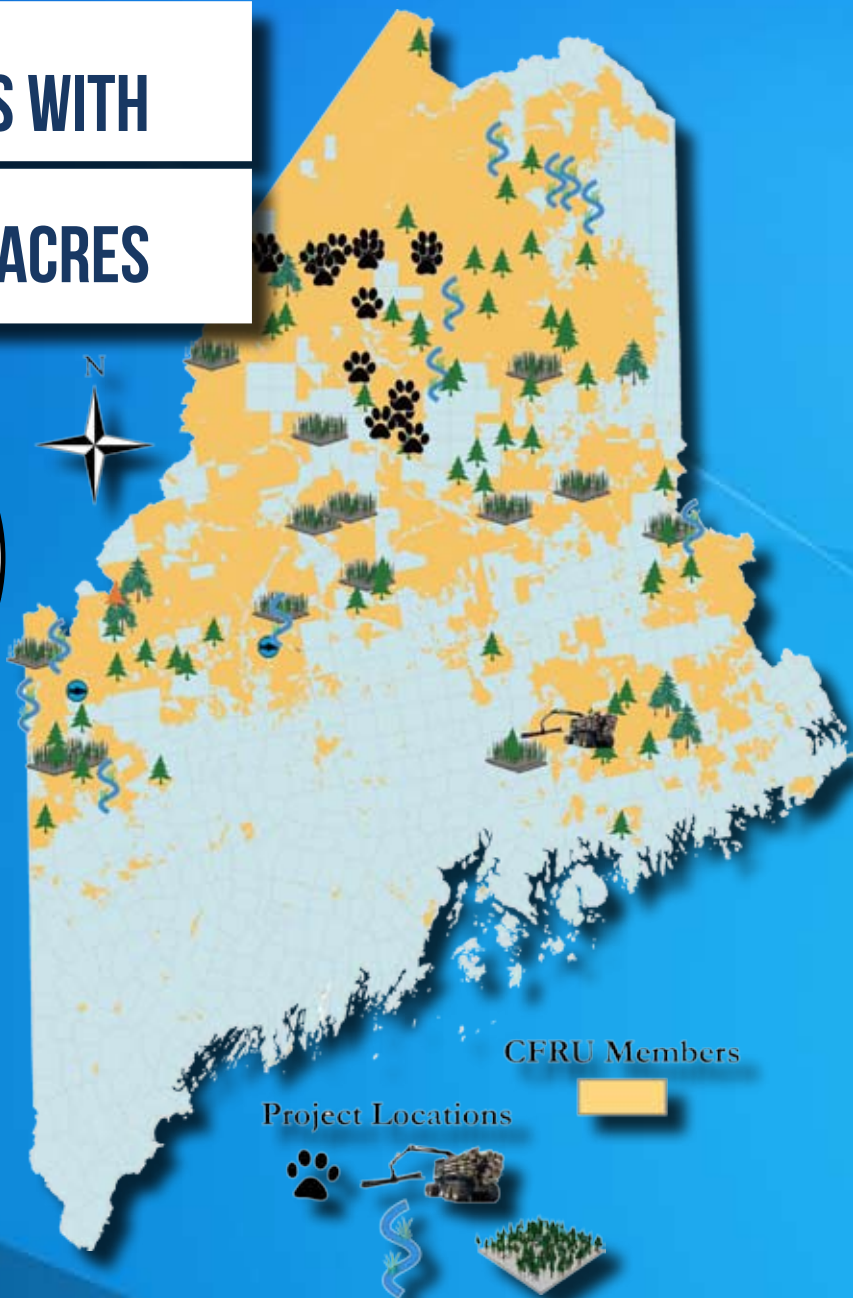


Figure 4. This map illustrates the lands owned by the members of the Cooperative Forestry Research Unit. This map is not exact but is meant to show the overall coverage of the CFRU.

CFRU Members

Appalachian Mountain Club
Baskahegan Company
Baxter State Park, SFMA
Black Bear Forest, Inc.
Canopy Timberlands Maine, LLC
Clayton Lake Woodlands Holdings, LLC
EMC Holdings, LLC
Field Timberlands
Finestkind Tree Farms
The Forest Society of Maine
Frontier Forest, LLC
Huber Engineered Woods, LLC
Huber Resources Corporation
Irving Woodlands, LLC

Katahdin Forest Management, LLC
LandVest
Maine Bureau of Parks and Lands
Madison Paper
Mosquito, LLC
The Nature Conservancy
Peavey Manufacturing Company
Plum Creek Timber Company, Inc.
Prentiss & Carlisle Company, Inc.
Robbins Lumber Company
Sappi Fine Paper
Seven Islands Land Company
Timbervest, LLC
Wagner Forest Management



COMMERCIAL FORESTS PROGRAM

THE COOPERATIVE FORESTRY RESEARCH UNIT

Since 1975, the Cooperative Forestry Research Unit (CFRU) has been working with Maine's large landowners and forest industry to solve the most pressing challenges of forest management, wildlife, and biodiversity.

The Cooperative Forestry Research Unit (CFRU) is the oldest program in the CRSF. Founded in 1975 by leaders from Maine's forest industry, the CFRU is a partnership between Maine's landowners, forest managers, wood processors and conservation organizations. Together, the CFRU partners work to improve our understanding about Maine's forests and how best to use them for all of society's values. With about 30 members and their more than 8 million acres (Figure 4) as a living laboratory, the CFRU aims to provide information needed to solve the most pressing issues facing the managers of Maine's forests regarding silviculture, wildlife and biodiversity.

This year, the CFRU raised \$490,001 (Table 1) in member contributions and leveraged an additional \$503,023 in extramural grants. Research highlights from the past year include studies on commercial thinning, hardwood regeneration, improvements to growth and yield models, evaluation of deer wintering areas, and monitoring of snowshoe hare and Canada lynx populations. More information about these and other projects can be found on the [CFRU website](#).



COMMERCIAL THINNING RESEARCH NETWORK

Robert Wagner, Robert Seymour, Spencer Meyer,
and Aaron Weiskittel



Abstract

The Commercial Thinning Research Network (CTRN) was established by the Cooperative Forestry Research Unit (CFRU) in 2000. This network has the primary goal of providing information about how spruce-fir stands that have or have not been pre-commercially thinned (PCT) respond to various forms of commercial thinning (CT). Study sites that have had a PCT examine responses due to CT timing and relative amount of removal, while those without PCT examine responses due to CT method and relative amount of removal. The network now consists of 15 study sites, including three new installations, across the state (Figure 5). Results from the network will be used to improve growth and yield models for Maine's forests.

Funding

- CFRU: \$40,902
- Center for Advanced Forestry Systems: \$35,000

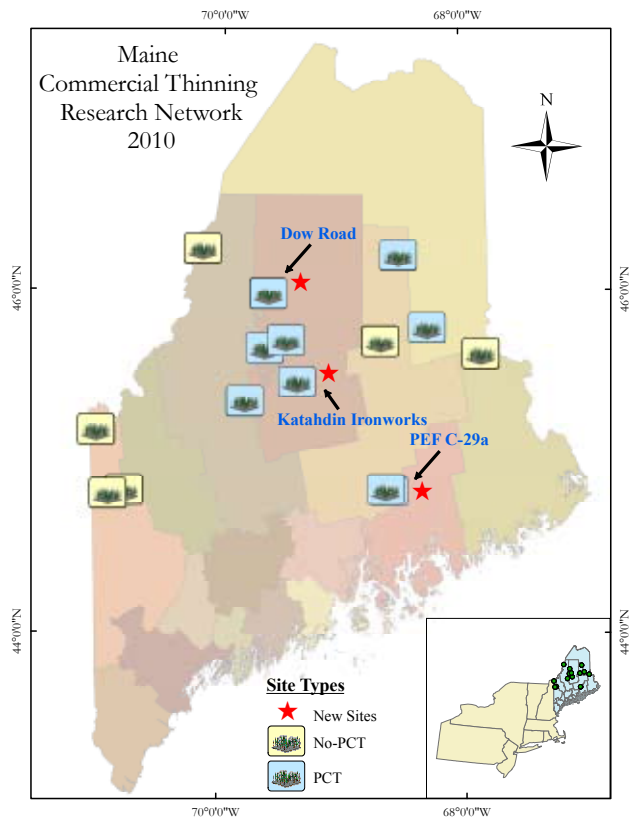


Figure 5. Map showing the location of the 15 CTRN study sites in Maine.

See the CFRU Annual Report for more...



Andrew Nelson

PRODUCTIVITY OF HYBRID POPLAR ON FORESTED SITES IN MAINE

Andrew Nelson and Robert Wagner

Abstract

Over the last decade, interest in growing short-rotation woody crops (SRWC) has increased in the Northeast in an effort to supplement bioenergy production. Hybrids of poplar (*Populus* spp.) are a common component of SRWC plantations in many parts of the world, but their performance in Maine is largely unknown. This study investigated the performance of four hybrid poplar clones grown under contrasting levels of management intensity on a typical forest site in Maine. Overall, performance was greatest under intensive management, with considerable variation among individual clones (Figure 6). However, even with intensive management, the productivity of these clones was significantly lower than hybrid poplar plantations in other parts of the world with better soil conditions and more favorable climates. Therefore, the use of hybrid poplar on typical forested sites for biomass production in Maine is unlikely.

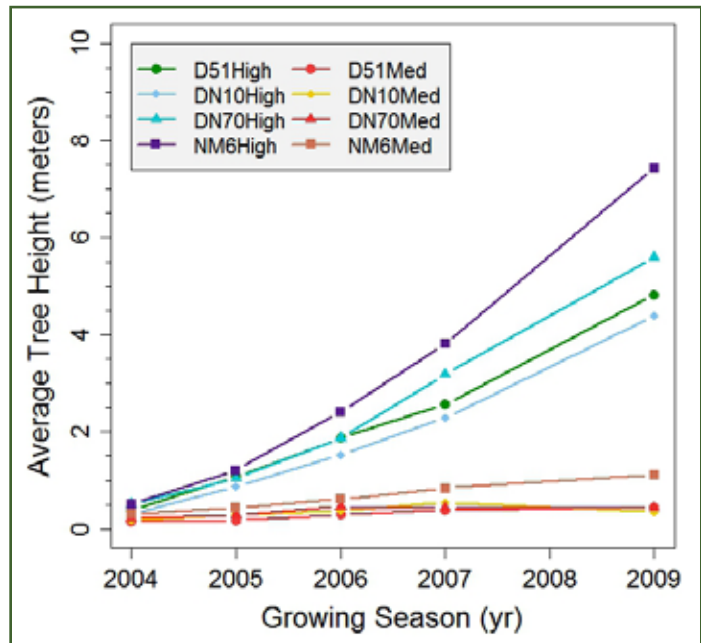


Figure 6. Growth in average tree height for four clones of hybrid poplar in the high and medium intensity treatments.

Funding

- CFRU: \$13,166
- H.W. Saunders Chair: \$ 17,954

See the CFRU Annual Report for more...

REFINEMENT OF THE FOREST VEGETATION SIMULATOR NORTHEASTERN VARIANT GROWTH & YIELD MODEL

Aaron Weiskittel, Robert Wagner, and Robert Seymour



Spencer Meyer

Abstract

Forest managers rely on growth and yield models to assess whether their short-term plans will meet long-term sustainability goals. Forest growth and yield models currently in use in Maine, such as the Forest Vegetation Simulator (FVS), were initially built on data from the 1970s and 1980s and often use older statistical techniques. Subsequent tests have shown that these models may not produce the best predictions of how the forests of Maine will grow. As a result, this project was initiated to develop improved allometric and growth equations through the use of an extensive regional database of permanent growth and yield plots. To date, several equations and a site productivity model have been improved (Figure 7). Next steps are to evaluate the performance of the equations over a range of silvicultural treatments before releasing the improved model. The model will include a relatively simple software interface which will allow for seamless integration into existing software systems.

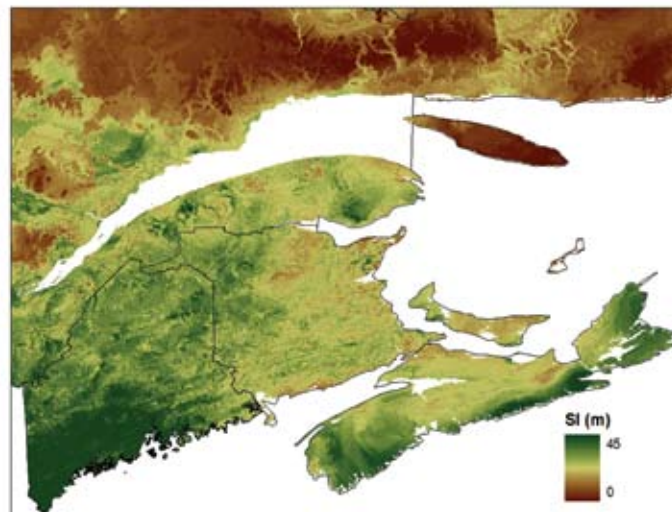


Figure 7. Map of predicted site index (m) predicted from climatic variables at a 1 km² resolution.

Funding

- CFRU: \$25,816
- USFS Agenda 2020: \$81,933
- NSRC: \$84,194
- CAFS: \$35,000

See the CFRU Annual Report for more...



Spencer Meyer

DEVELOPMENT OF REGIONAL STEM TAPER AND VOLUME EQUATIONS

Aaron Weiskittel, Rongxia Li, John Kershaw, and Adam Dick

Abstract

Accurate estimates of stem form and volume are needed for most forest management decisions. Taper equations are important tools as they can reconstruct individual tree stem form, which can be used to estimate total and merchantable volume. The key advantage of a taper equation when compared to a volume equation is that they can be used to estimate merchantable volume to any desired specification. This study developed species-specific taper equations for the primary conifer species in Maine. There were differences in stem-form between planted and naturally-regenerated stands. Planted stands had smaller diameter estimates in the middle section of the tree for a similar DBH and height (Figure 8). The equations for predicting total volume performed well when compared to existing equations and can be incorporated into existing growth and yield models.

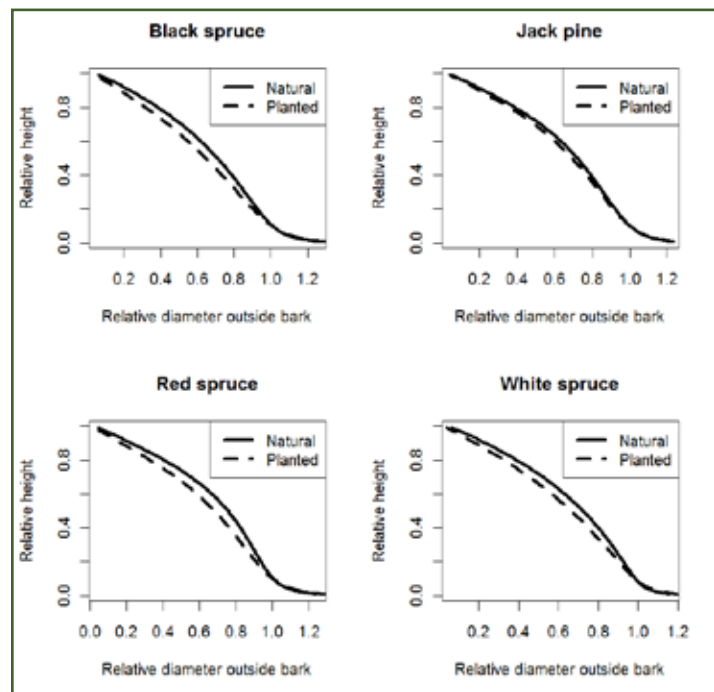


Figure 8. Predicted relative outside diameter over relative height for typical trees with average total tree height and DBH for four species in plantations and naturally regenerated stands.

Funding

- CFRU: \$35,218

See the CFRU Annual Report for more...

THE EFFECTIVENESS OF STATE REGULATION TO PROTECT DEER WINTERING AREAS IN MAINE

Erin Simons, Daniel Harrison, Kasey Legaard, and Steve Sader



CFRU Archives

Abstract

Deer Wintering Areas (DWAs) provide an important component of habitat quality for white-tailed deer (*Odocoileus virginianus*), and Maine is one of a few states that protect DWAs. Despite this protection, loss of deer wintering habitat has been identified as the major limiting factor preventing efforts to increase the size of the deer herd, and additional zoning has been proposed. This project evaluated the current condition of existing zoned DWAs (Figure 9) and concluded current regulations are not achieving desired objectives. Furthermore, additional zoning is not likely to meet the desired deer management objectives for the future. Creative landscape-scale approaches will be needed to increase the future extent, connectivity and functional quality of deer wintering habitat in northern and western Maine.

Funding

- CFRU: \$34,000
- NSRC: \$8,700

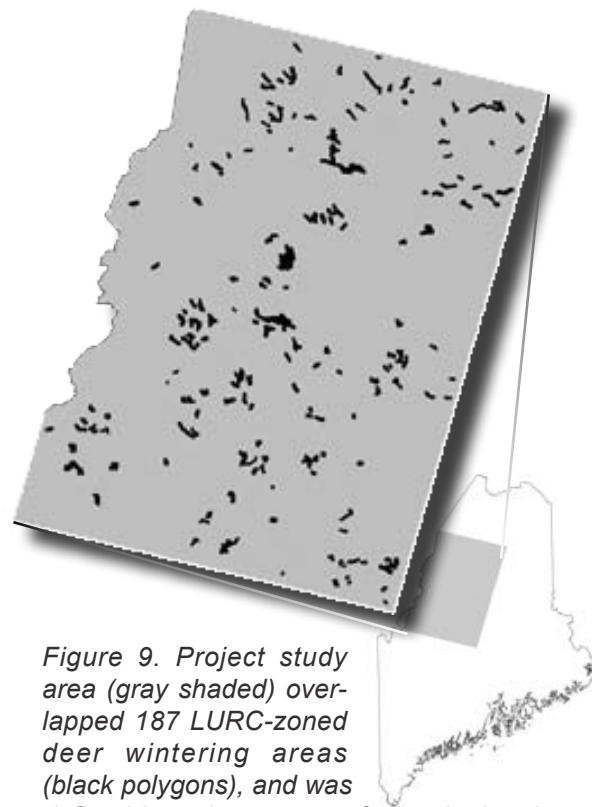


Figure 9. Project study area (gray shaded) overlapped 187 LURC-zoned deer wintering areas (black polygons), and was defined based on extent of the Landsat satellite archive (Path 12Row 28) used to map timber harvests and the Maine state boundary.

See the CFRU Annual Report for more...



SNOWSHOE HARE SPATIO-TEMPORAL DYNAMICS AND IMPLICATIONS FOR CANADA LYNX IN MANAGED LANDSCAPES

Daniel Harrison, William Krohn, Sheryn Olson, and David Mallet

Abstract

The Canada lynx (*Lynx canadensis*), a US Federally threatened species, occurs throughout northwestern Maine. Computer models have predicted that fluctuating snowshoe hare (*Lepus americanus*) densities can influence lynx occurrence at the landscape scale. In order to quantify snowshoe hare densities in the managed forests of Maine, the CFRU has funded a biannual monitoring program since 2001. This research has demonstrated that over the 10-year time series, hare densities were at their lowest during 2009-2010 (Figure 10). Additionally, compared with other stand types, snowshoe hare densities were highest in early successional, dense, regenerating conifer stands with a past history of herbicide treatment.

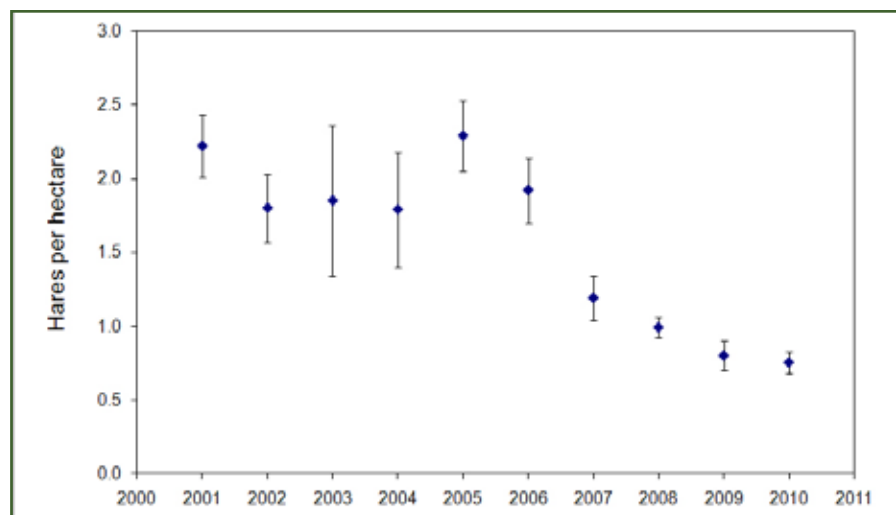


Figure 10. Leaf-off stand-scale snowshoe hare density in regenerating conifer stands that were herbicided one to ten years post clearcut. The lower hare densities may show a plateau at 2009 and 2010, indicating a twenty year fluctuating cycle. Diamonds represent mean densities across regenerating clearcuts following herbicide application, and whiskers represent one standard error.

Funding

- CFRU: \$28,790
- University of Maine Agricultural and Forest Experiment Station: \$18,000
- NCASI: \$4,000

See the CFRU Annual Report for more...

DOCUMENTING THE RESPONSE OF CANADA LYNX TO DECLINING SNOWSHOE HARE POPULATIONS IN AN INTENSIVELY MANAGED PRIVATE FOREST LANDSCAPE IN NORTHERN MAINE

Daniel Harrison, Angela Fuller, David Mallet, Jennifer Vashon, Walter Jakubas, and John Organ



CFRU Archives

Abstract

Northern Maine currently supports the only viable Canada lynx (*Lynx canadensis*) population in the United States east of the Mississippi River. Lynx populations are known to fluctuate in relation to those of snowshoe hare (*Lepus americanus*), which is their primary food source. However, there is limited information about the behavioral and demographic changes in Maine's lynx population during periods when local hare populations trend downward. Telemetry (satellite, GPS and VHF) data were collected to document lynx home range size, territoriality, habitat use and reproduction to look for changes in relation to declines in hare populations. This information will provide insight into the persistence of lynx populations in Maine in the future.



CFRU Archives

This lynx's movements have been followed through radio telemetry by researchers (See photo at top.).

Funding

- CFRU: \$26,000
- University of Maine Agricultural and Forest Experiment Station: \$18,000
- Maine State Wildlife Grant: \$30,000
- NCASI: \$4,000

See the CFRU Annual Report for more...

Spencer Meyer



Spencer Meyer



Rob Liljeholm



Exploring Family Forests

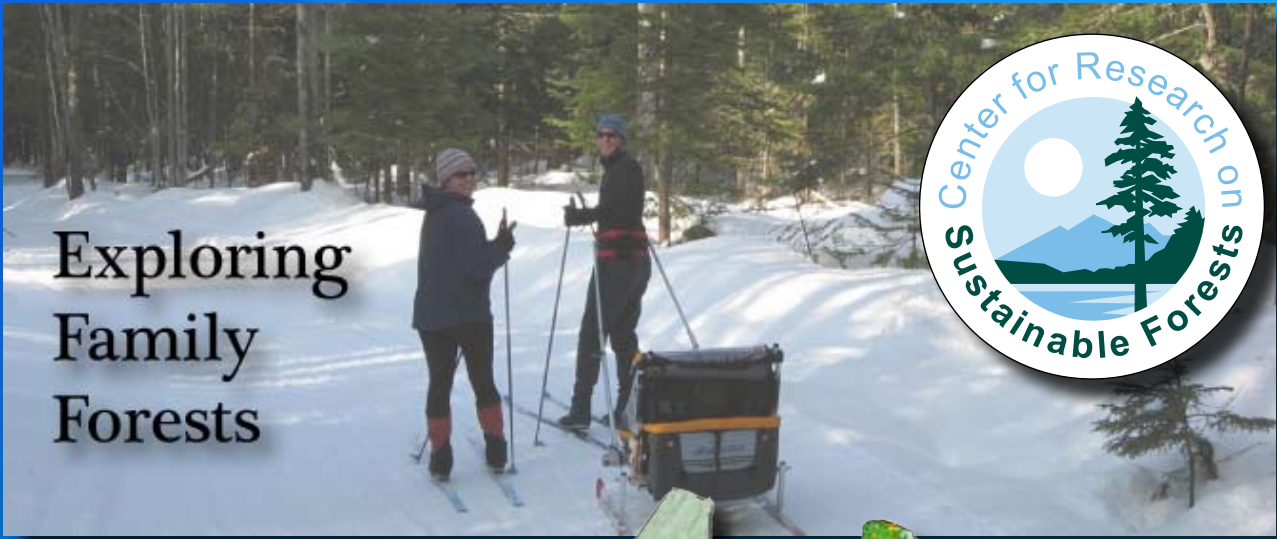
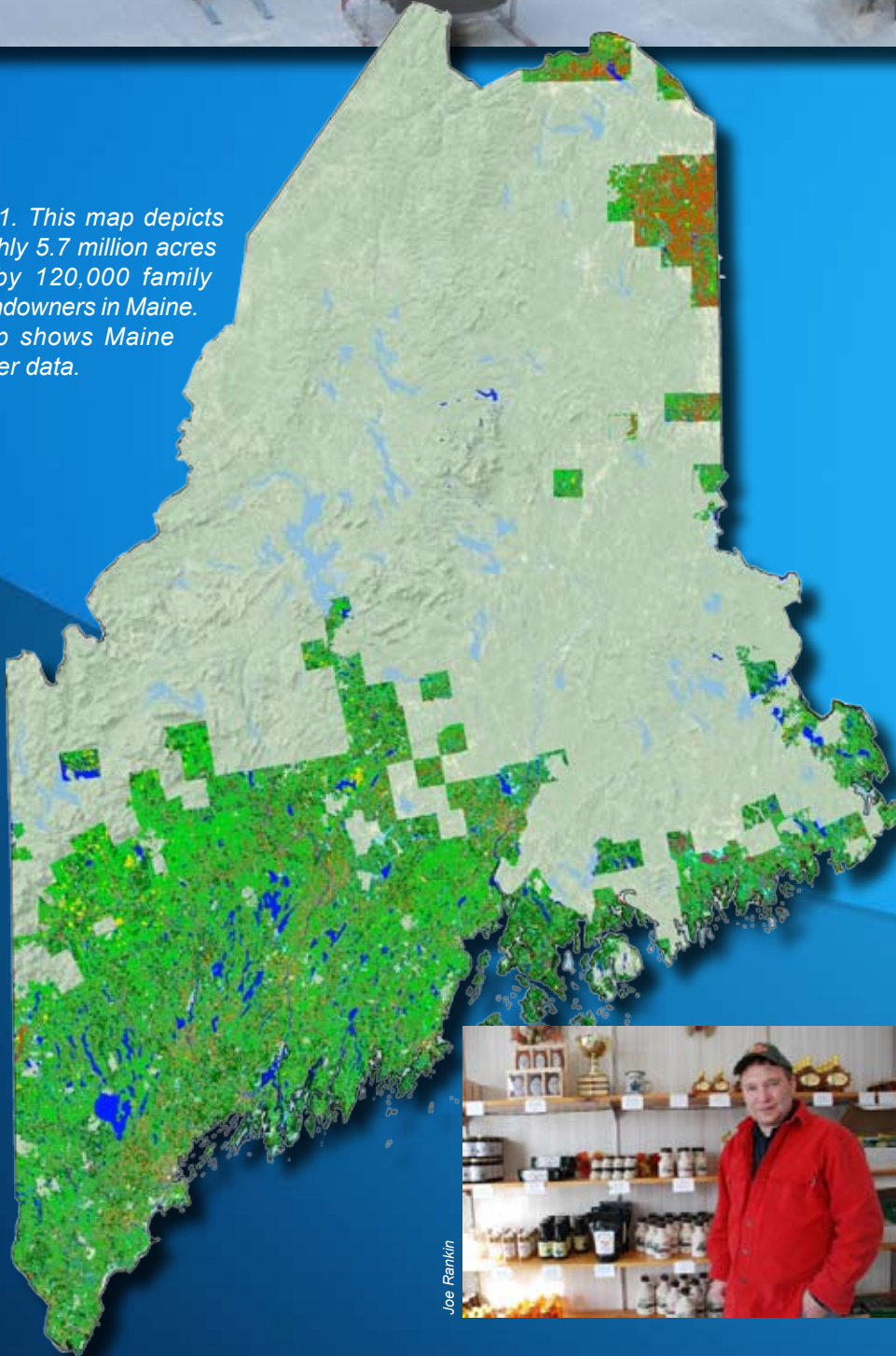


Figure 11. This map depicts the roughly 5.7 million acres owned by 120,000 family forest landowners in Maine. The map shows Maine land cover data.



Joe Rankin

FAMILY FORESTS PROGRAM

Maine's family forest landowners own nearly six million acres of Maine's forests. This new CRSF research program delivers research on the forest management, social, and economic challenges that these landowners face.

The Family Forest Research Unit serves the estimated 120,000 private, individual forest landowners who own 5.7 million acres of forest land in Maine (Figure 11). These landowners, who own between 1-1,000 acres each, have largely been underserved in research and outreach that would enhance their forest stewardship. Therefore, the mission of the Family Forest Research Unit is to conduct applied scientific research and outreach that contributes to the sustainable management of Maine's family forests for desired products, services, and conditions in partnership with Maine's family forest stakeholders (see *Our Stakeholders on page 16*).

The Family Forest Research Unit has pursued four general lines of research and outreach over the last year:

1. Defining and identifying the private landowners who are the stewards of over one-third of Maine's forests;
2. Developing a coordinated research and outreach effort that increases our understanding about the issues, challenges, and opportunities facing Maine's small woodland owners;
3. Modeling dynamic and complex interactions between landowner decisions and forest ecosystems, including projecting future conditions in a rapidly changing landscape and society; and

4. Developing outreach programs for small woodland owners to increase their understanding about the benefits of forest stewardship, and how management and planning can help further their goals.

Accomplishments this year include \$314,634 (Table 2) in research and outreach funding from a variety of sources including the Northeastern States Research Cooperative, Maine Economic Improvement Fund, National Science Foundation (SSI/EPSCoR), McIntire-Stennis, and the Environmental Funder's Network *Quality of Place Initiative*. Each individual project within the Family Forest Research Unit has its share of accomplishments.

To highlight one project in particular, the *Finding Meaningful Incentives to Encourage Public Recreation Access to Private Lands in Maine* project has made a major impact in Maine. Results and recommendations were shared with 70 people at the Landowner Relations Conference, and 100 people at the Annual SWOAM Meeting during the Agricultural Trade Show. We also shared results with the Department of Inland Fisheries and Wildlife Recreational Safety coordinators and volunteer instructors — these people interact directly with 9,500-10,000 recreation users every year through nearly 500 courses (e.g., hunter safety, snowmobile safety, etc.) and will use our information to promote landowner relations and ethical behavior that can help maintain the ability for the public to use private lands. This program supports the use of forests as forests, and promotes Maine's nature-based tourism economy.

COUPLED SOCIAL-ECOLOGICAL SYSTEMS MODELING OF FAMILY FORESTS

Erika Gorczyca, Jessica Leahy, Jeremy Wilson, Kathleen Bell, Wilfred Mercier, and Aaron Weiskittel



Spencer Meyer

Objectives

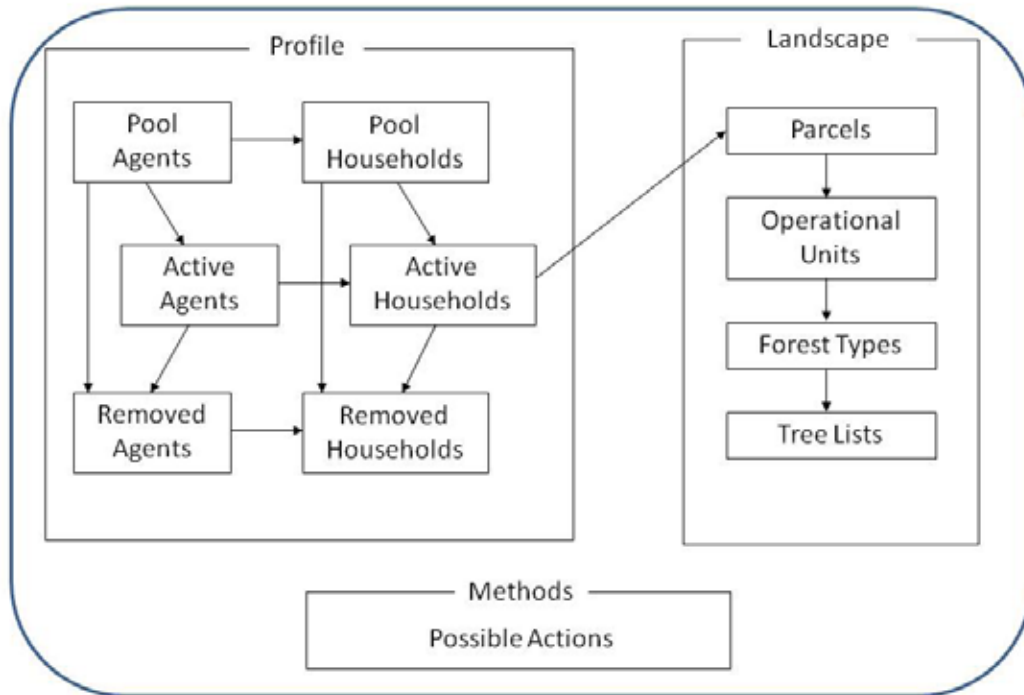
1. Prepare a comprehensive literature review of agent-based modeling with potential applications and challenges to family forests;
2. Discover and document gains from involving stakeholders in the modeling process;
3. Create and present an agent-based model of Maine family forest landowners;
4. Determine how stakeholder knowledge and attitudes change during modeling activities;
5. Simulate, analyze and compare landowner harvesting patterns through three model scenarios: a baseline model output, a social change (increased taxes), and a biophysical change (an invasive insect outbreak by increasing tree mortality); and
6. Identify the key barriers to model adoption among stakeholders.

Approach

A major component of the Family Forests Program this year was the development of a prototype agent-based model that was designed specifi-

cally to examine the behaviors of family forest landowners in the state of Maine. The model was implemented using Microsoft Access database files as the primary storage mechanism of the model data, and the model itself was written in the Python Programming Language (version 2.6.x). This was a unique form of model implementation in that a majority of the data manipulations occurred within the database environment and were executed using SQL rather than within the custom code. In this model, the Python code was used to tap into the power of the SQL engine embedded within Microsoft Access. The Family Forest Agent-Based Model (FF-ABM; Figures 12 and 13) consists of 12 Python modules that provide for agent profile generation, agent decision making, tying the US Forest Service Forest Vegetation Simulator (FVS) into the model, agent communication, and general population dynamics. Each of these components are designed to stand alone, allowing future users to use either the entire model as it was originally designed, or to take portions of the model to incorporate into future models. This design makes it possible to incorporate components of this model into a

Static Model



Dynamic Model

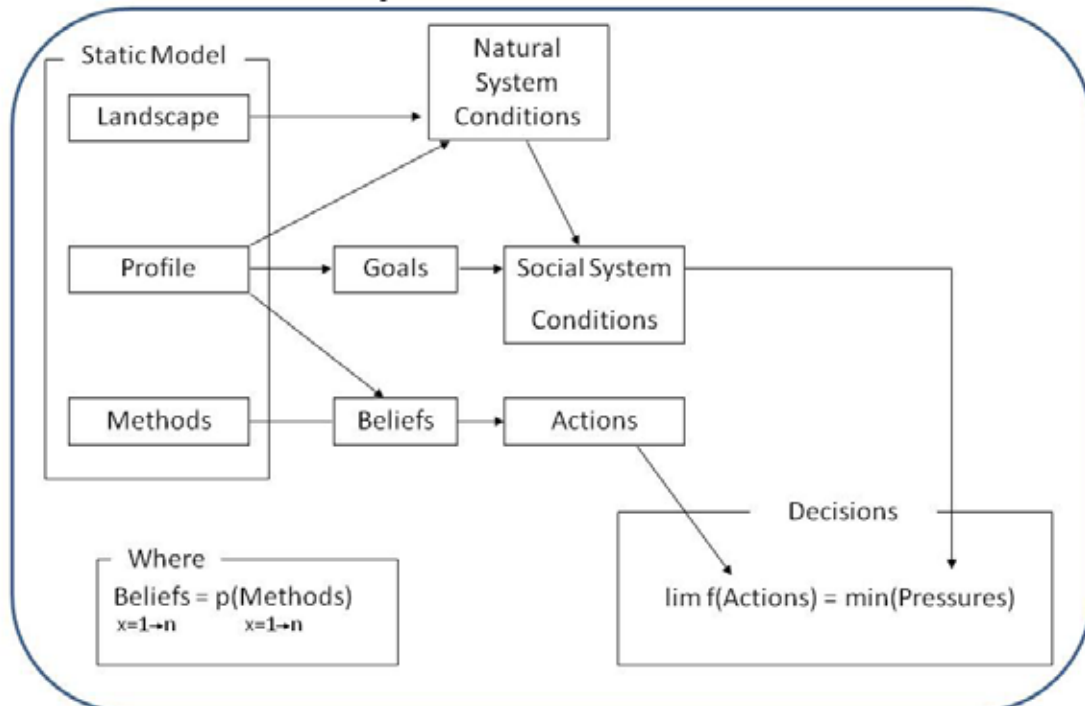


Figure 12. These conceptual frameworks explain the modeling process behind understanding family forest social-ecological systems (SES).

wide variety of other agent-based models. The FF-ABM project has produced over 8,000 lines of custom code within the 12 distinct modules. To

further facilitate the use of this model, the custom Python code has been released under the Open Source “MIT License.” This license allows for

Scheduling

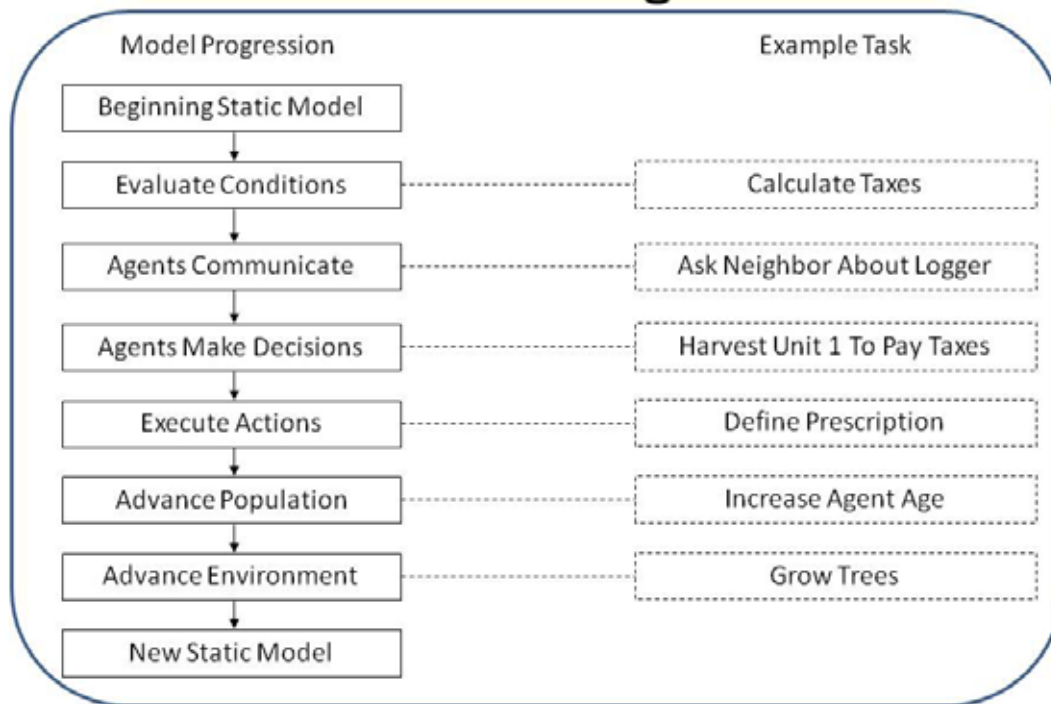


Figure 13. The scheduling framework models the decision process for family forest owners.

future users to take and modify the code as they see fit at no cost, to use in either their open source or commercial products. Also included is a standard liability disclaimer. The model code, and the database structures that it uses, have all been fully documented for the benefit of future users. The end product is a fully functional model targeted at modeling family forest owners in Maine. This open source license will enable many future users to not only use the code created for this model, but also to modify and improve the code, helping to speed the development of agent-based modeling. As an added benefit, the components of this model can also be used individually to aide in the generation of other agent-based models, not just forest-based agent-based models, making this project applicable to a much broader audience within the sustainability science community.

Throughout the building of the agent-based model we held mediated modeling and social learning activities implemented through a series of three focus groups with 13 participants from key family

forest stakeholder groups: Small Woodland Owners Association of Maine, LandVest, GrowSmart Maine, Association of Consulting Foresters, State Planning Office, Maine Forest Service, Natural Resources Conservation Service, Department of Inland Fish & Wildlife and legislators.

Currently, we are performing simulations and collecting data on the FF-ABM. We are striving to calibrate the model and generate data for the three scenarios described in our objectives: a baseline model, a social change (increased/reduced property taxes), and a biophysical change (an invasive insect outbreak by increasing tree mortality). We will also be writing more programming scripts in order to efficiently analyze the 2250+ databases of information generated.

Funding

- National Science Foundation, Maine EPSCoR award EPS-0904155 (SSI)
- McIntire-Stennis



Joe Rankin

RESEARCHER/ FAMILY FOREST STAKEHOLDER RELATIONSHIPS

Erika Gorczyca, Patrick Lyons,
Jessica Leahy, and Teresa Johnson

Objectives

1. Use social network analysis (SNA) as a tool to identify family forest stakeholders;
2. Evaluate existing models of engagement;
3. Target areas for enhanced partnerships between the Family Forest Research Unit and stakeholders;
4. Understand the various implicit models and assumptions researchers hold about stakeholders;
5. Explore the similarities and differences that emerge within and between researchers and stakeholders; and
6. Apply this knowledge to enlarging and refining our stakeholder engagement models.

Approach

In the spring and summer of 2010, a series of structured interviews were conducted with 19 cooperating CRSF researchers and 10 external family forest stakeholders in Maine. As part of the interview, each participant listed up to 15

important stakeholders they shared information with about family forests. The participants were asked to list what organization each stakeholder belonged to and how many years they had been in contact with that person. They were then asked a sequence of questions based on a 5-point Likert scale designed to measure the strength of association and information flow. These questions included: 1) How frequently do you interact with this person; 2) How familiar are you with this person; 3) How trustworthy is this person's knowledge about family forest issues; 4) How trustworthy is this person's organization about family forest issues; 5) How would you describe the flow of information about family forests between you and this person; and 6) How would you rate the technical nature of information exchanged with this person? Key family forest stakeholders were then identified, resulting in 10 structured interviews with stakeholders from various public and private sectors in Maine. They were asked a similar series of structured questions targeting stakeholder and family forest issues. We performed a social network analysis

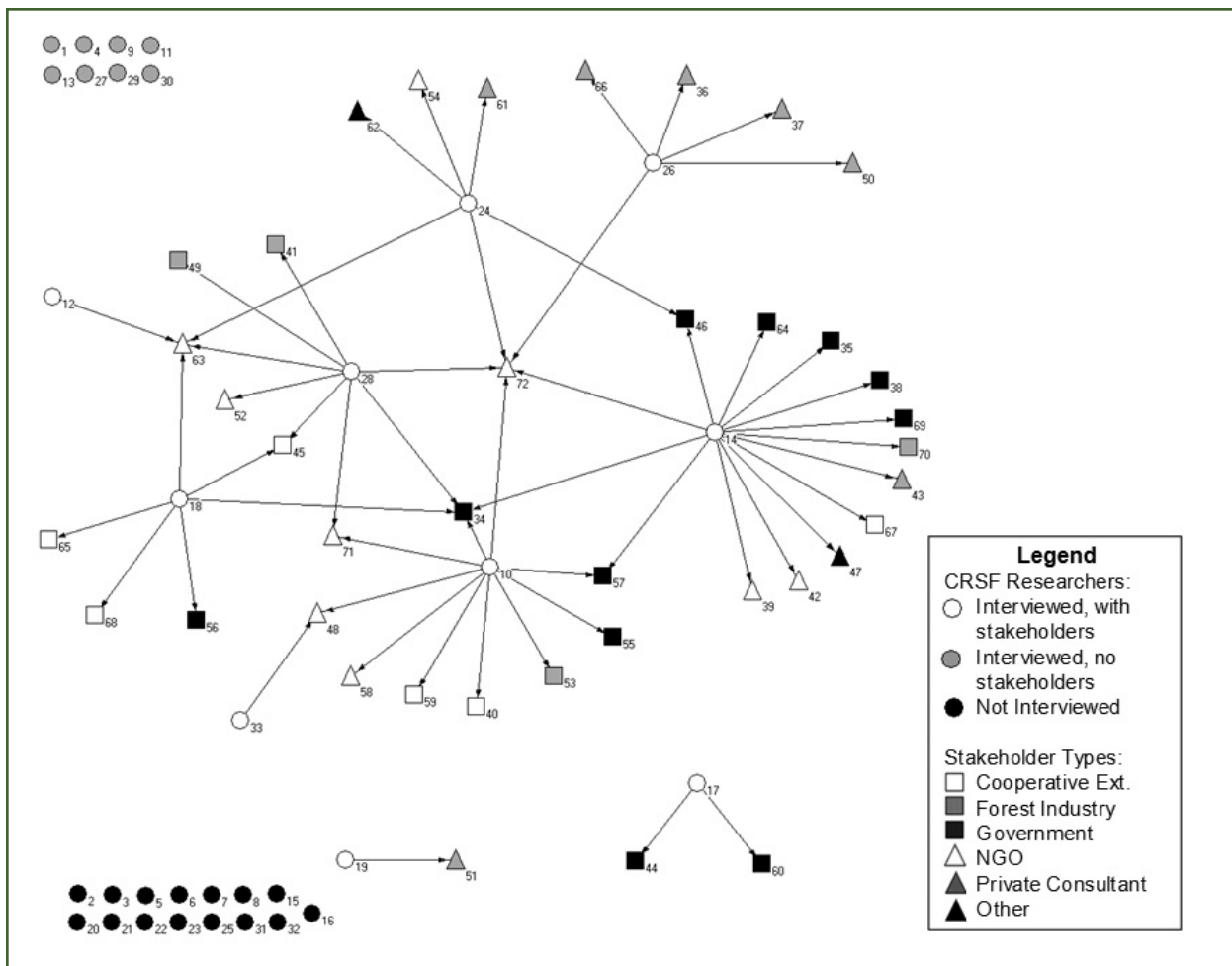


Figure 14. This network displays the results of a Pajek social network analysis of CRSF researcher/stakeholder relationships.

based upon the researcher and first-order stakeholder interview data. The social networks were analyzed and visualized using Pajek.

Results

Results indicated social networks between researchers and stakeholders are developing, but have primarily unidirectional information flow (Figure 14). These results can be used to enable researchers to better engage in a stakeholder-driven initiatives to promote the use of human dimensions research and, inevitably, the sustainability of family forests in Maine.

Impacts

We recommended that the CRSF enhance its role as a boundary organization between researchers, family forest stakeholders and stakeholder organizations (Figure 15). New researchers should be connected to additional organizations already part of the CRSF network. This will help establish stronger relationships outside of the Maine Forest Service and Small Woodland Owner Association of Maine. Faculty should be encouraged to share research information with each other to allow information to disseminate through the full family forest stakeholder network. In addition, frequent communication between researchers and stakeholders should be encouraged throughout research projects in order to increase trust, familiarity,

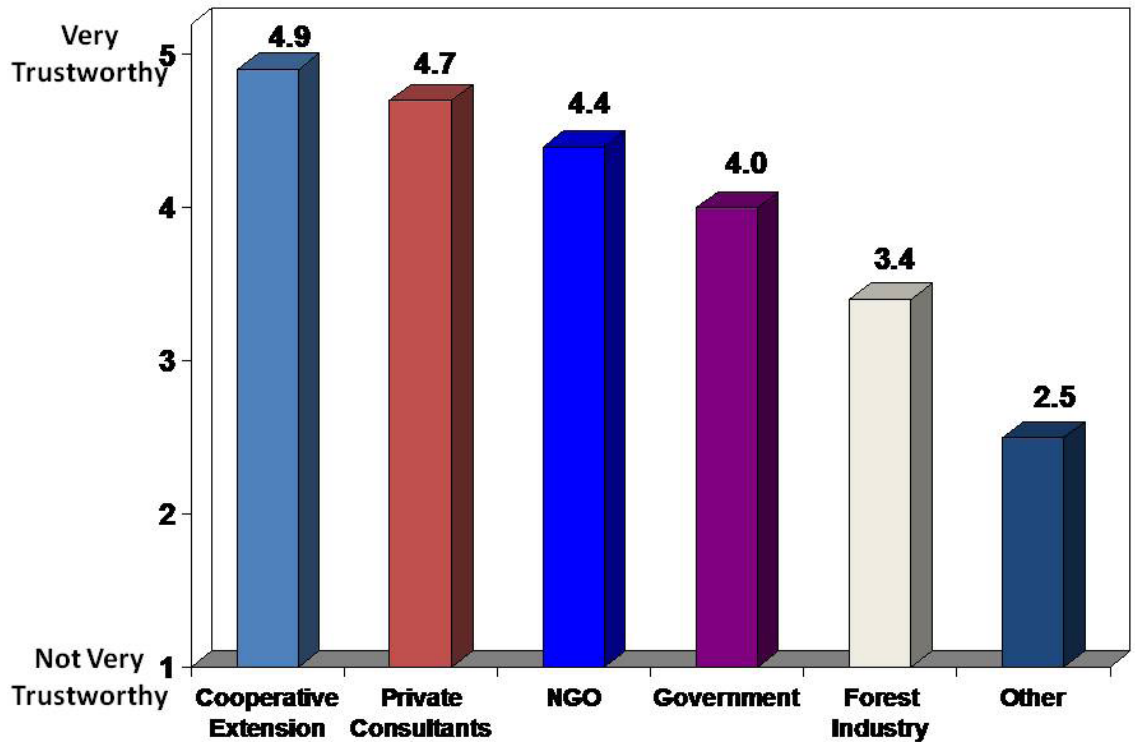


Figure 15. This bar chart illustrates mean researcher trust in individual stakeholder knowledge of family forest issues by stakeholder organization on a 1 to 5 Likert scale from not very trustworthy to very trustworthy.

information flow, and level of technical information shared. Although frequent communication may be beneficial for knowledge transfer and knowledge-to-action, close attention should be

paid to stakeholder fatigue. This is especially true for stakeholders with multiple researcher connections. Finally, it is important to continue to monitor stakeholder engagement through the use of SNA, especially by expanding SNA to partners. As social networks evolve, new stakeholder engagement opportunities may begin to emerge.



Spencer Meyer

Researchers and forest owners gather to discuss management options.

Funding

- National Science Foundation, Maine EPSCoR award EPS-0904155 (SSI)
- Maine Economic Improvement Fund.

THERE'S NO PLACE LIKE HOME: THE ROLE OF PLACE ATTACHMENT IN UNDERSTANDING FAMILY FOREST LANDOWNER BEHAVIOR

Jessica Leahy, Patrick
Lyons, Mark Anderson, and Dave Kittredge



Patrick Lyons

Background

Family forest landowners will have a significant influence on the forests of the United States over the next 30 years. Trends indicate this group of landowners is increasing in numbers, a result of parcelization — a leading cause in forest fragmentation (Stein et al. 2005). Concurrently, these landowners are aging and an unprecedented number of acres are expected to exchange hands through estate transfer and sale over the coming decades (Butler & Leatherberry 2004). Natural resource academics and professionals have employed analytical methods of statistical analysis to identify distinct segments of family forest landowners, characterized by their forest ownership values and attitudes, and have used this information to postulate and form strategies of outreach and communication that accommodate the group's heterogeneity (Butler et al. 2007). *Place* and *place attachment* are concepts that represent a separate paradigm employed by the natural resource community to explore how values and attitudes towards the environment influence human behavior (Vaske & Kobrin

2001). Over the past decade the concept of place attachment has focused on how wilderness areas, open spaces, and recreational experiences influence identity, attitudes, dependence, and satisfaction for individuals and communities (Patterson & Williams 2005). This study posits that place attachment can advance research on family forests by adopting proven conceptual frameworks for operationalizing place, and create a more robust and deeper understanding of how attitudes and values of landowners influence behavior.

Objectives

By adapting the social psychology conceptual framework utilized by Stedman (2002), this study explores the impacts of place attachment and place dissatisfaction on family forest landowners' behavior and the resulting implications for policy and outreach applications. The objectives of this study are to:

1. Identify place meanings and evaluative beliefs held by Maine family forest landowners and how those measured cognitions influence place attachment and place dissatisfaction;
2. Explore the relationships among behavioral intentions, place attachment, and place dissatisfaction; and
3. Determine the relationship between place attachment, place dissatisfaction, and traditional data used in segmentation analysis of family forest landowners.

This theory treats place meanings and evaluative beliefs as separate phenomena from attachment and dissatisfaction, operating under the assumption that cognitions, such as meanings and beliefs, directly influence the evaluations of a place, such as attachment and dissatisfaction. The hypothesis is that stronger place attachment and greater dissatisfaction are associated with increased inclination to undertake place protective behaviors. (Figure 16)

Approach

The CRSF created a Maine family forest landowner database by collecting names and addresses via tax property records over a

two-year period. The final product identified 66,267 landowners, 39,875 in 2009 and 26,392 in 2010, which held 10 to 1000 acres of land in Maine. The 2009 database was acquired with help from the Small Woodland Owners Association of Maine (SWOAM) in a cooperative effort. Landowners were selected using a random number generator in Microsoft Excel, and became recipients of a 12-page survey titled the “Maine Landowner Survey.”

To aid in the creation of the survey, a series of interviews were conducted with 18 CRSF cooperating faculty and 10 external stakeholders from government and non-government organizations in Maine. All interviewees were asked to identify what they considered to be the key issues pertaining to family forest landowners in Maine. External stakeholders also provided iterative feedback in the design of the survey during its formulation. The survey was administered using the four-wave Tailored Design Method recommended by Dillman (2009). The survey was administered by mail to 1000 Maine family forest landowners in September of 2010. The survey had a response rate of 54.9% (n=878), with 54 surveys dropped from analysis due to missing values.

Conceptual Model

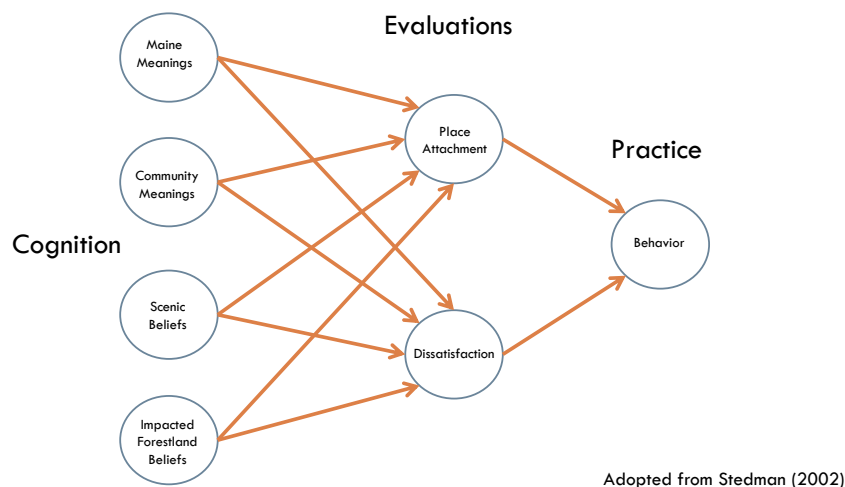


Figure 16. The scheduling framework models the decision process for family forest owners.

Results

In exploring place cognitions' influence on place attachment and dissatisfaction, maximum likelihood factor analysis found a two-factor solution accounting for 50% of scale variation for survey questions measuring place meanings, here called Maine Meanings and Community

Table 3. Least squares regression measuring influence of place meanings and evaluative beliefs on place attachment and dissatisfaction.

ANOVA	SS	df	MS	F	Significance	Adjusted R ²
Attachment						
Regression	10949.078	4	2737.269	64.844	0.001	0.537
Residual	9117.999	216	42.213			
Total	20067.077	220				
Dissatisfaction						
Regression	1836.267	4	459.067	2.031	0.091	0.02
Residual	54206.143	200	226.031			
Total	47042.41	204				

Meanings. Reliability analysis revealed Cronbach alphas of 0.780, and 0.769, respectively. Similarly, factor analysis identified a two factor solution for evaluative beliefs explaining 40% of the variance, here called Scenic Beliefs and Impacted Forestland Beliefs with respective alphas of 0.686 and 0.758. Factor analysis found a single dimension for place attachment, accounting for 69% of variance with an alpha of 0.957 (Table 3). We chose to measure dissatisfaction by asking questions pertaining to levels of concern for land health and ability to use land, as well as questions directly asking about satisfaction and summed them into a single, reliable scale with an alpha of 0.895 (Table 3). Ordinary least squared regression analysis found that these place meanings and evaluative beliefs scales predicted place attachment, but not dissatisfaction, with three of the four cognitive measures showing significant relationships for attachment and none for dissatisfaction.

Using the predicted values of the regression from our first objective, we measured the relationship between place attachment and various landowner behaviors. Because the regression failed to predict place dissatisfaction, the unaltered dissatisfaction scale was used to explore the relationship between dissatisfaction

and behavior. Landowner behavior questions covered topics pertaining to information-seeking behavior, land sales and acquisitions, and land management. Logistic regression revealed that increasing dissatisfaction predicted past and anticipated informationseeking behavior, as well as the likelihood of giving heirs land and buying more land. For land management, we found that higher levels of attachment predicted the likelihood of landowners having a will and higher levels of dissatisfaction predicted the likelihood of landowners enrolling their land in cost-share programs.

To address our third objective of determining the relationship between place attachment, place dissatisfaction, and traditional segmentation analysis of family forest landowners, *k-means* cluster analysis was conducted on ownership objective data. From this analysis four distinct landowner segments were identified, each defined by distinguishing characteristics (Table 4). The landowner groups titled “Heirs of the Woods” and “Salt of the Earth” both placed high importance on passing their land on to their heirs while having the highest levels of place attachment, with our data showing these two groups making up 75% of family forest landowners in Maine.

Table 4. Landowner segmentation and its relationship to place attachment and dissatisfaction. Note: Items measured on a Likert scale, 1 = very unimportant and 5 = very important.

Ownership Objectives	Heirs of the Woods	Uninvolved	Fortress of Solitude	Salt of the Earth
Enjoy the beauty	4.52b	1.47a	4.72b	4.66b
Protect nature	4.20b	1.83a	4.07b	4.22b
Land investment	3.61bc	2.13a	3.44b	4.14c
Part of home	4.50b	1.50a	4.64b	4.57b
Part of farm	3.36b	2.04a	3.17b	4.07c
Privacy	4.42b	1.55a	4.59b	4.48b
Pass on to heirs	4.26c	1.97a	3.08b	4.31c
Non-timber forest products	2.79b	2.04a	1.74a	3.53c
Firewood	2.97b	1.81a	1.97a	4.47c
Timber harvest	2.46b	2.21ab	1.87a	4.31c
Hunting & fishing	3.96b	1.76a	1.54a	4.18b
Other recreation	3.92c	1.65a	2.58b	4.26c
Place Scales	Heirs of the Woods	Uninvolved	Fortress of Solitude	Salt of the Earth
Attachment ¹	51.2b	45.5a	48.7ab	52.1b
Dissatisfaction ²	53.8ab	57.9b	46.5a	56.4b
¹ mean score out of possible 60				
² mean score out of possible 100				

Impacts

Butler & Ma (2011) found family forest ownership objectives are shifting from timber production to aesthetics and family legacy, and over the coming decades millions of acres of America's family forests will change hands and be controlled by a new generation of landowners. Majumdar et al. (2009) found a significant difference in the motivations and management practices between inheritor and non-inheritor family forest

landowners, with an example being inheritors placing more importance on timber harvesting. The study attributes this difference to the inter-generational transfer of human capital, such as land stewardship and sustainability values, while identifying that inheritors have significant differences in their future intentions than non-inheritors. Thus it can be inferred that keeping land in families may reduce parcelization and help maintain timber supply and public access to private lands in Maine. Considering this, the

results of our place attachment analysis suggest that landowner outreach efforts should emphasize the creation of wills to keep land in families. Our analysis also indicates landowners with higher levels of dissatisfaction are more likely to seek advice about their land. We found landowners are most concerned with high property taxes, misuse of land, and keeping land intact for their heirs. Agencies and organizations in Maine that work with landowners could focus on addressing these issues through the continued support and promotion of Tree Growth Tax Law, supporting recreation user organizations such as the Sportsmen Alliance of Maine, and developing programs that aid landowners in keeping land in their family.

Funding

- Center for Research on Sustainable Forests (Maine Economic Improvement Fund)

Literature Cited

Butler, B.J., M. Tyrrell, G. Feinberg,, S. VanManen, L. Wiseman, and S. Wallinger. (2007). *Understanding and Reaching Family Forest Owners: Lessons from Social Marketing Research*. *Journal of Forestry*. 106(7)

- Butler, B.J. and E.C. Leatherberry. (2004). *America's Family Forest Owners*. *Journal of Forestry* 102:7.
- Butler, B.J. and Z. Ma. (2011). *Family Forest Owner Trends in the Northern United States*. *Northern Journal of Applied Forestry* 28:1.
- Dillman, D.A., J.D. Smyth, and L.M. Christian (2009). *Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method*. Hoboken, N.J.: John Wiley & Sons, Inc.
- Majumdar, I. D. Laband, L. Teeter, and B. Butler. (2009). *Motivations and Land-Use Intentions of NIPFs: Comparing Inheritors to Noninheritors*. *Forest Science* 55:5.
- Patterson, M.E. and R.R. Williams. (2005). *Maintaining Research Traditions on Place: Diversity of Thought and Scientific Progress*. *Journal of Environmental Psychology* 35:361
- Stedman, R.C. (2002). *Toward a Social Psychology of Place: Predicting Behavior from Place-Based Cognitions, Attitude, and Identity*. *Environment and Behavior* 34:561
- Stein, S.M. Et Al. (2005). *Forests on the Edge: Housing Development on America's Private Forests*. Gen. Tech. Rep. PNW-GTR-636. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.
- Vaske, J.J. and K.C. Kobrin. (2001). *Place Attachment and Environmentally Responsible Behavior*. *The Journal of Environmental Education* 32(4):16-21.



A wind farm on Mars Hill in northern Maine demonstrates the potential for Maine's landowners to generate revenues from non-timber forest products.



CRSF Archives

SUSTAINABLE SOLUTIONS FOR FAMILY FOREST LANDOWNERS IN MAINE

Michael Quartuch and Jessica Leahy

Introduction

This research attempts to better understand the stewardship ethics of family forest landowners in Kennebec County, Maine (ME) and how such ethics influence behavior. As increased residential development continues to encroach on forest land in Kennebec County (Stein et al. 2005), it is important to better understand landowner behavior. One method to examine this notion is through landowner stewardship ethics. Landowner's stewardship is comprised of various dimensions which have the potential to influence how they view and use their land. Another means to understand forest landowner behavior is by assessing their attitudes toward such actions that result in landscape change (i.e. development, forest fragmentation, parcelization, and acquisition).

Objectives

There are three primary research objectives that guide this ongoing project:

1. To examine the multi-dimensional nature of stewardship ethics held by family forest landowners.
2. To identify the factors that influence stewardship ethics held by family forest landowners.

3. To examine the reliability and validity of stewardship ethics as a multi-dimensional construct and predictor of landowner behavior, through the application to landscape change attitudes and behaviors

Anticipated Approach

Data Collection and Landowner Sample

A mail survey was chosen as the primary data collection tool. Using a mail survey will allow researchers to investigate various attitudinal and behavioral concepts relevant to family forest landowners. Furthermore, surveys allow researchers to obtain large sample sizes which enhance the overall representativeness of the data obtained (Vaske 2008). Two criteria will be used to select potential survey respondents: 1) forest landowners must own between 1-1000 acres; and 2) respondents must own forest land in Kennebec County. A sample of 900 landowners meeting these criteria will be randomly selected from the CRSF property tax database, excluding landowners contacted through other mail surveys conducted within the last 12 months. In order to examine potential differences between respondents and non-respondents, non-respondents will be contacted via telephone calls and asked basic demographic (age, gender, income), land-

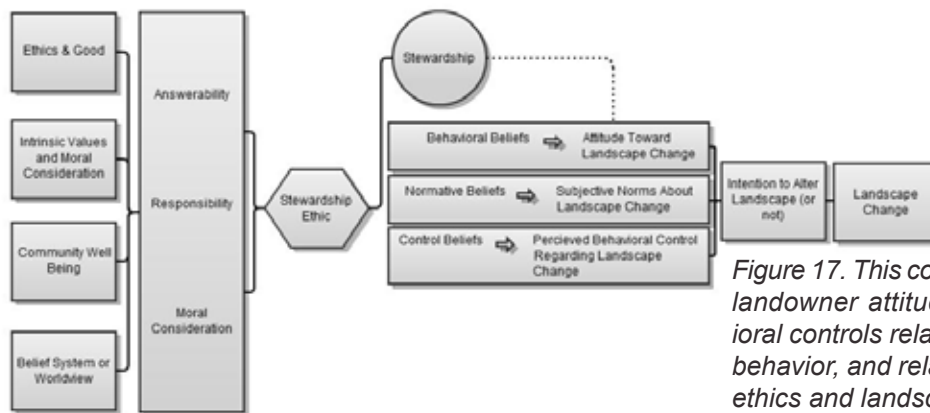


Figure 17. This conceptual model assesses landowner attitudes, norms, and behavioral controls related to landscape change behavior, and relates them to stewardship ethics and landscape change.

owner characteristics (number of acres and parcels owned, type of ownership, etc.), and key stewardship-related questions.

Questionnaire and Conceptual Model

The current survey is comprised of seven sections: questions about you, learning about your land, future options for your land, timber harvesting on your land, questions about your community, questions about stewardship, and about your land. Fishbein and Ajzen’s (2010) theory of reasoned action provides the framework for one portion of the conceptual model (Figure 17). This model is used to gauge landowner attitudes, norms, and behavioral controls related to landscape change behavior. The second portion of the conceptual model examines landowner stewardship ethics and is based on extant literature.

Expected Results

Findings from the Kennebec County Woodland Owner survey will provide a comprehensive understanding of family forest landowners in Kennebec County. Results will lead to the creation of a stewardship ethics index which will be used to quantitatively measure landowner stewardship and its effect on influencing behavior. This survey represents a necessary step in better understanding the attitudes and behaviors of Kennebec County family forest landowners, and

will ascertain the values and behavioral intentions of these individuals and families. Many of the concepts discussed within the survey will offer rich insight into the long-term sustainability of Kennebec County’s forests.

Anticipated Impacts

Based on findings from the Kennebec County Woodland Owner survey, resource professionals will gain insight into the issues and concerns that forest landowners are facing with regard to managing their land. This knowledge will enable the Maine Forest Service and Kennebec Woodland Partnership to better assist landowners in meeting their management objectives and future needs. Furthermore, this research project will contribute new insight regarding landowner stewardship and behavior which will advance human dimensions, natural resources, and forestry literature.

Funding

- Maine Forest Service
- National Science Foundation, Maine EPSCoR award EPS-0904155 (SSI)



FINDING MEANINGFUL INCENTIVES TO ENCOURAGE PUBLIC RECREATION ACCESS TO PRIVATE LANDS IN MAINE

Martha Willand, Jessica Leahy,
Kathleen Bell, Mike Kilgore, Zhao
Ma, and Stephanie Snyder

Objectives

Maine's landscape is one of the most privately-owned states in the nation. Publicly owned land accounts for a mere 6% of the total land area (McWilliams et al. 2003). It is also one of the most heavily forested states in the nation with 90% of the lands acreage covered by forests, totaling 17.8 million acres (McWilliams et al. 2003). Public recreation use of private land is generally assumed to be open and free, unless posted by the property owner. This tradition can be traced to the Colonial Ordinance of 1641-47 that allows public access across private lands for "fishing and fowling and cutting ice." This ordinance was common law when the state of Maine became part of the Massachusetts Bay Colony in 1692, and was later retained with Maine's state inception in 1820 (MSRA Title 17, Ch. 127, § 3860). While this law provided citizens with access to ponds, this tradition of open access has broadened to become a social norm including all private lands, and has become known as Maine's open land tradition.

The privatized nature of the state's resources has made this open land tradition crucial to Maine's economy for recreational, hunting and tourism industries. However, research indicates that there has been an increase in postings within the state. A survey conducted in 2005 indicated that 39.4% of Maine landowners were posting their lands, compared to only 14.9% in 1991 (Acheson and Acheson, 2010). According to the 2008 report to the Governor's Council on Maine's Quality of Place titled, "*Public Access to Maine's Private Lands: A Cultural and Economic Asset*," hunting, snowmobiling, wildlife watching and ATV riding generated more than \$900 million annually for the state of Maine. Most of the opportunities for these activities reside on private lands (p. 4). This increase in postings may have many negative repercussions for recreation considering that 98% of primitive camping, 67% of snowmobiling, 60% of hiking, and 59% of cross-country skiing occurs on private lands in Maine (Irland, 1993). According to state economist, Michael LeVert, "By supporting these recreational activities, private landowners make substantial contributions to Maine's economy," (Maine State Planning Office,

Physical Damages	Crop contamination, erosion, damage to trails, roads, signs, fences and gates, litter and dumping.
Policy Concerns	Burden of proof is placed on landowners, liability concerns, fear of eminent domain, fear of permanency of trails, unauthorized trails published on state maps, and expensive to post.
User Behavior	Trespassing, interference with agricultural and forestry practices, off-trail riding, unauthorized trails, theft, noise, parties, sense of entitlement by users, lack of appreciation and awareness, and disrespect.
Lack of Enforcement	Wardens understaffed, and slow response time.
Social and Psychological Impacts	Lack of privacy, safety concerns, and fear or retaliation for posting or reporting illegal activities.

Table 5. Five key themes emerged from the concerns landowners expressed about public access.

2008). Therefore, family forest landowner recreation access policies directly impact the state's economy.

This trend in increased postings and public recreation access restrictions may be halted or reversed with the development of meaningful policies. If solutions for public recreation access are to be found, it is imperative to understand the factors that impact private forest landowners' decisions to restrict access to their land and their policy preferences. The objectives for this research were to: 1) identify major issues and problems related to public recreation access on private lands in Maine; 2) determine policy and program incentive preferences that would enhance or maintain public recreation access; and 3) make recommendations for future programs or policies to encourage public access on private forests in Maine.

Approach

Focus Groups

Landowner focus group participants were contacted through both print media and by telephone. Local SWOAM chapter representatives were contacted and alerted members of the study and need for participants through personal letters and monthly newsletters. Regional snowmobile and ATV clubs also assisted in participant recruitment. The recreational clubs made recommendations for landowners in the area with whom they held agreements with varying degrees of access.

A total of 70 landowners participated in the focus group sessions throughout Presque Isle, Machias, Farmington, Wells, Baldwin and Bremen. Focus group participants were guided through discussions of their personal public recre-

ation policies, and the problems associated with public recreation use. They were also administered a survey which listed 28 possible programs and policies that could benefit private landowners. Participants used a Likert-scale (1=strongly disagree and 5=strongly agree) to rank their levels of agreement that the policy tool or program would successfully maintain or increase the amount of private land available for recreation use in Maine.

Questionnaire

Landowners were randomly selected from the CRSF family forest tax database, which contains the records for 50,000 landowners in Maine based on property tax records. This data was used in combination with landowner records from the Land Use Regulatory Commission (LURC). Participants were identified by randomly selecting 1,600 landowners owning between 10 and 1000 acres. Identified landowners were mailed a questionnaire and cover letter explaining the study's objectives and emphasizing the importance of their participation and input. The topics included in the twelve page questionnaire were: 1) landowner attitudes and policy preferences; 2) ownership motivations; 3) attitudes towards recreation access issues; 4) negative impacts resulting from public recreation use; and 5) demographics. Respondents were also given fifteen possible programs or policies that could influence a landowner's decision to

Table 6. In the focus groups, the landowners chose these programs as the top six most likely to address their concerns.

Focus Group Results	
All Landowners Combined (n=70)	
Programs or Actions (Based on 28 programs and policies)	Mean Score (Rank)
Harsher fines for dumping and littering.	4.79 (1)
Require training in landowner rights and respect when obtaining or renewing ATV license.	4.65 (2)
Broadcasting of public service announcements reminding public of private land use ethics.	4.62 (3)
Create a mitigation fund for landowners to be reimbursed for recreation-related damages and illegal dumping.	4.61 (4)
Support anonymous tip line for illegal dumping and prosecution.	4.49 (5)
Change recreation user habits to 'ask first' before using private land.	4.49 (5)

allow public recreation access on their land. Their responses were based on a Likert scale of 1-5 (1=strongly disagree and 5=strongly agree).

A total of 195 participants were eliminated from the original pool of participants either due to incorrect addresses, the landowner was deceased, or their land ownership did not meet the study objectives. A total of 697 surveys were completed and valid, resulting in a response rate of 50%.

Results

Focus Groups

In Presque Isle, Farmington, Machias, and Bremen, most landowners did not post their land against recreation access, but some had experienced negative incidents with ATVs in the past and no longer allowed their use on their land.

Table 7. Based on the questionnaire, landowners identifies the following program as most likely to influence their decision to allow public access on their land.

Questionnaire Results Programs or Actions (Based on 15 programs and policies)	All Participants Combined	
	n	Mean Score (Rank)
Create an outdoor ethics program that can be used in schools k-12.	648	3.76 (1)
Air public service announcements advocating respect for landowners and their land.	651	3.68 (2)
Eliminate landowner liability when charging a fee for public recreation access.	646	3.66 (3)
Require training in landowner rights and respect when obtaining or renewing ATV license.	653	3.63 (4)
Provide landowners with technical assistance for dealing with land management issues and problems	649	3.60 (5)

Some landowners posted their properties, while others did not post, but indicated that locals were aware of their preferences. Landowners in this Baldwin and Wells restricted recreation use more heavily. Some landowners posted select parcels, while others restricted motorized use through the installation of gates and fences.

Landowners discussed a myriad of problems that were associated with public recreation access, but by compiling the problems and concerns reported by landowners, general themes were identified: physical damages, policy concerns, user behaviors, lack of enforcement, and social and psychological impacts (Table 5). By and large, the most commonly reported problem landowners faced from public use was disrespect and a lack of appreciation. Trailing in second place, the next most frequently reported problem was illegal dumping. Many landowners also felt that current state policies placed burdens on landowners through posting requirements, and created a sense of entitlement for recreation users.

Of the twenty eight programs and policies listed on the survey, landowners' top six choices (5 and 6 are tied) included: 1) harsher fines for littering and dumping; 2) required training in landowner rights and respect when obtaining or renewing ATV license; 3) broadcasting of public service announcements reminding public of private land use ethics; 4) create a mitigation fund for landowners to be reimbursed for recreation-related damages and illegal dumping; 5) support anonymous tip line for illegal dumping and prosecution; and 6) change recreation user habits to "ask first" before using private land (Table 6).

Questionnaire

The average survey respondent was male, 51-70 years old, native to Maine, and works full-time or is retired. Half of the respondents did not post their land against trespass while 8% of respondents posted their land against all activities. The remaining 42% either posted their land or did not post, but may give access with permission. When asked "Do you plan to restrict or

prohibit some types of recreation on your land in the future?" 42.1% of respondents said "no," while 28.5% said "maybe," and 29.3% said "yes." The top five reasons for owning land were: 1) to enjoy beauty and scenery; 2) for privacy; 3) to pass land on to my children or other heirs; 4) to protect nature or biodiversity; and 5) for recreation other than hunting and fishing. The primary activity occurring on the land parcel respondents, their spouses or family was walking and hiking. The primary activity occurring on respondents' land parcels by the general public was hunting. Problems resulting from public recreation use included litter, dumping, damage to trails and roads, erosion, crop damage, damage to trees, fences and gates, theft, and damage to buildings or equipment.

When respondents were asked to rank their level of agreement that a policy or program would influence their decision to allow public recreation access, 69.4% agreed to strongly agreed that a k-12 outdoor education program would influence their decision to allow public recreation access while 64.5% agreed to strongly agreed that public service announcements would influence their decision (Table 7). The policy option that received the least support with only 30.6% of respondents agreeing to strongly agreeing was increased law enforcement.

Impacts

By examining the results from both the focus groups and the questionnaire, a common theme concerning recreation user behavior emerges. Most policy preferences support changing recreation user behavior, increasing authority efforts, and providing landowners with increased capacity-building. For increased recreation access to private lands in Maine, a public media campaign could change recreation user behavior and habits, and could lead to greater landowner appreciation. Efforts to increase law enforcement could also positively impact public recreation access on private lands. Research findings

were reported at the Conference on Landowner Relations hosted by SWOAM and the Sportsman's Alliance of Maine in January. A pilot study is currently being designed will be conducted soon to gauge landowner support and participation.

Funding

- Environmental Funders Network
- Small Woodland Owners Association of Maine
- Northeastern States Research Council
- Center for Tourism Research and Outreach (CentRO) at the University of Maine

References

- Acheson, J.M., Acheson, J.A. 2010. *Maine Land: Private Property and Hunting Commons*. *Journal of the Commons*, 4(1):552-570.
- Irland, L. 1993. *Outdoor Recreation Supply in the Maine Woods: Issues for the Future*. *Renewable Resources Journal*, 11(3):6-15.
- Maine State Planning Office. 2008. *Public Access to Private Lands: A Cultural and Economic Asset*. Available Online At [Http://www.maine.gov/spo/specialprojects/qualityofplace/documents/publicaccesstomainesprivatelands.pdf](http://www.maine.gov/spo/specialprojects/qualityofplace/documents/publicaccesstomainesprivatelands.pdf)
- McWilliams, W., Butler, B., Caldwell, L., Griffith, D., Hoppus, M., Laustsen, K., Lister, A., Lister, T., Metzler, J., Morin, R., Sader, S., Stewart, L., Steinman, J., Westfall, J., Williams, D., Whitman, A., Woodall, C. 2005. *The Forests of Maine: 2003. Resource Bulletin NE-164*. Newton Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station.



Many private landowners allow public access for recreation.

Spencer Meyer

AN ORAL HISTORY PLACE-ATTACHMENT PROJECT

UNDERSTANDING THE CHANGING FOREST LANDSCAPE THROUGH THE EYES OF MAINE'S OLDEST CITIZENS



Marilynne Mann

Marilynne Mann, Debra Kantor, and Jessica Leahy

Research Questions

This oral history study will employ inductive reasoning to understand the human dynamics of place attachment and place meaning for selected residents. Historical analysis will examine causes, trends and related past and current events. Investigation will include:

1. How changes in the northern forest areas have affected the lives of the long-term local residents.
2. The places people are attached to and the meanings places hold for them.
3. How the oldest members of northern forest communities describe their attachment to the place(s) they have lived.
4. What policy and management practices concerning the northern forested areas have held positive or negative consequences for long-term residents?

Objectives

1. Document the oral history of Maine residents who have witnessed changes in the forest landscape by identifying and interviewing the oldest residents of Maine's small towns in the Kennebec River Watershed area.
2. Explore sense of place based connections and place attachment among residents to shed light on the changing way of life in Maine's rural communities.
3. Examine the results of changing agrarian patterns, influence of technology, loss of industrial bases, impact of environmental standards, evolution of recreation activity, and costs and benefits associated with increased landscape change.
4. Identify patterns of social, economic, and cultural change, in the context of challenges and solutions to identify ways to engage people about the future.

Approach

In order to examine trends, patterns, challenges and solution to the changing landscape of the working forest through the eyes of residents, we have conducted 21 semi-structured personal interviews and will conduct approximately 3-4 additional interviews. We are using an oral history technique to document the subjective nature of lived experience and uncover unexpected findings. The Kennebec River Watershed is the perfect location for this study due to a high density of towns in the northern forest area. Lumbering and the culture of the working forest have been the major industry of this region since the early 1900's and the Kennebec was the site of the last river drive in Maine in 1976.

Findings can easily be generalized to other locations in Maine with a common logging and/or agricultural heritage including forested watershed areas such as the Penobscot, Androscoggin, Aroostook and St. John Rivers. The rim counties,

as they are often referred, share commonality in historical, cultural and social attributes. The forest industry has evolved over time impacting the economic well-being of communities in this region and across the state.

Expected Results

The average age of residents for completed interviews is 90. Interviewed residents range in age from 79-105. Geographic location of these residents ranges from Eustis and Moosehead Lake in the north to South Paris on the Androscoggin in the south, and Rumford in the western part of the state.

The Kennebec River Corridor provides highly visible study participants who can identify patterns and speak about place identity, attachment, and meaning. The goal of this project is to capture the depth and complexity of behavior patterns of social, economic, and cultural change in the region and the impact on local sense of place. The study will identify challenges and solu-

Table 8. Anticipated project outcomes.

SHORT TERM OUTCOMES	MEDIUM TERM OUTCOMES	LONG TERM OUTCOMES
<ol style="list-style-type: none"> 1. Greater awareness and respect for knowledge of forest heritage (communities or agencies express interest in learning how to preserve their stories) 2. Greater awareness of the importance of forest as a central component of life in rural Maine (feedback from policy makers, stakeholder, communities, and other researchers) 3. Facilitated dialogue between Maine's wisest and some of Maine's youngest through collaboration with 4-H programming (aid youth in turning the stories and memories of the past into a relevant discussion for today) 	<ol style="list-style-type: none"> 1. Community action focused on preserving heritage through oral history preservation 2. Influence on policy makers to preserve the forest character of rural communities in Maine 3. Stimulate academic discussion about using oral history to inform policy decisions about future sustainability issues 4. Informed discussions about the importance of human factors and interaction with the natural world when setting policies about land and natural resource use (observed shift from preservation to sustainability issues concerning natural working landscapes) 	<ol style="list-style-type: none"> 1. Adoption of sustainable development policy informed from past successes and/or mistakes 2. Increased awareness of the importance of sustainability of forests and associated ways-of-life 3. Informed future research branching out into forest and other nature-based place attachment and sustainability discussions 4. Greater societal effort to preserve the forest heritage stories of the past to inform the future

tions informing future policy and management decisions impacting the sustainability of natural resources as well as the human dynamics of community.

Anticipated Impact

Study results will inform sustainability efforts related to Maine’s forest-based culture, traditional industries, and agrarian landscapes by quantifying quality of life and sense of place in the past compared to the present for some of Maine’s oldest residents. These results will be documented in at least one journal article in print within two years.

In addition, it will inform rural economic development initiatives, destination marketing, and tourism product development. Outputs, such as a community workshop and accompanying manual, hold potential to instruct communities how to use their oldest citizens to find out about the past and apply it to the future to support sustainable development and community planning. The focus will be on sharing the region’s forest heritage and engaging the community in discussions about future rural development.

In order to expand the impacts of the project to youth, 4-H members in Somerset County will create exhibits in the form of posters, Power-Point presentations, and interpretive panels, using stories, photos, and written or audio stories collected from study participants. Possible locations for exhibits include: The Old Canada Road National Scenic Byway, Northern Forest Center “Ways of the Woods” display, and exhibits in Maine historical societies and lumber museums.

Short-term, medium term and long term outcomes are displayed in Table 8. . Anticipated short term outcomes include greater awareness and respect for the role of Maine’s citizenry in policy decision while facilitating a cross-cultural dialogue. Heritage-focused community action, influence on policy makers and academics in favor of rural communities, and discussions of sustainability in connection to landscape are predicted to be medium term outcomes. In the long term, this study will impact informed policy decision and the importance of sustainability of the forest and associated ways-of-life while laying a foundation of future research on place attachment and the importance of using forest heritage stories of the past to inform the future. This study acknowledges certain assumption and external factors which are listed in Table 9. .

Table 9. This study includes these assumptions and external factors.

ASSUMPTIONS	EXTERNAL FACTORS
1. Collaborative efforts lead to more and better solutions	1. Funding is necessary to conduct research
2. All stakeholders should be engaged in the dialogue about issues that impact society	2. Constructive research is informed by a diverse group of collaborators
3. Policy should be informed by successes and mistakes of the past	3. Vulnerable respondent groups require special care to protect their interests
4. Policy should take into consideration social-cultural and socio-economic impacts of land use decisions	4. Socio-cultural and socio-economic pressures on society are dynamic and changeable
5. Change impacts quality of life	
6. Engagement in response to change empowers people	

Funding

- 2010 Northeastern States Research Cooperative, Theme 1 – Funding \$37,740

References

Williams, T. (2004, April 1). *Seeing the Future Through the Trees*. Retrieved October 15, 2010 At [Http://www.nwf.org](http://www.nwf.org).



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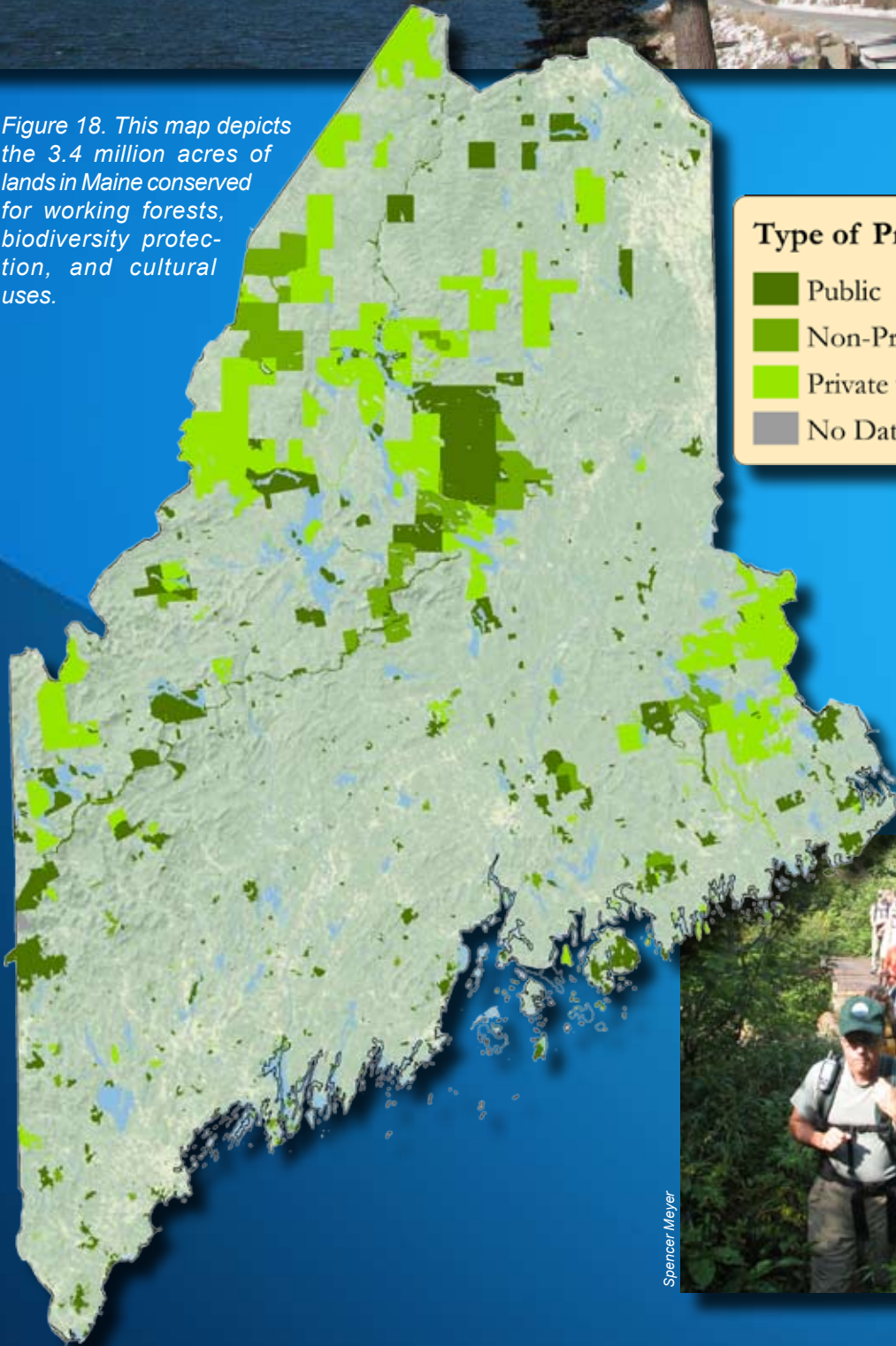
Rob Lillholm

Conserving lands, Preserving a way of life.



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Figure 18. This map depicts the 3.4 million acres of lands in Maine conserved for working forests, biodiversity protection, and cultural uses.



Type of Protection

- Public
- Non-Profit
- Private w/ Easement
- No Data

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CONSERVATION LANDS PROGRAM

Maine has continually led the nation in conservation innovations, particularly for private land conservation. As of today, Maine has conserved roughly 3.4 million acres of land for working forests, biodiversity protection, natural resources, and future generations of Mainers.

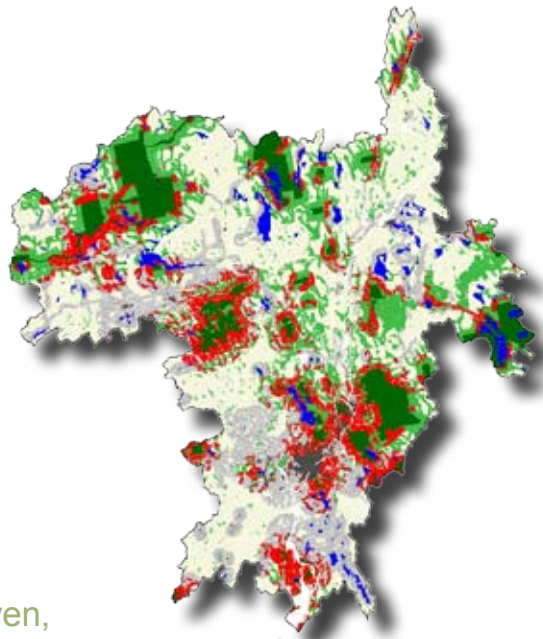
The landscape mosaic of developed and undeveloped lands in the northeastern U.S. has progressively changed at various spatial scales in response to land use and development pressures, socioeconomic influences, expansion of transportation networks, and non-uniform state and local regulatory frameworks. As ongoing processes of urbanization have transformed open spaces and agricultural property into developed land uses, there has been a remarkable counter-balancing expansion of public and private land conservation activities aimed at protecting biodiversity, scenic values, working forest lands, ecosystem services, recreational opportunities, and special natural areas in the remaining undeveloped land base. Because land use changes and conservation efforts in the region have occurred incrementally at multiple scales and in a variety of jurisdictions, it is challenging to assess the aggregate impacts of these cumulative land use decisions on environmental quality, resilience, and long-term sustainability in the overall landscape.

Today, the combined efforts of federal (e.g., Forest Legacy) state (e.g., Land for Maine's Future) and a host of municipal and non-govern-

mental groups including nearly 100 land trusts have worked to protect over 3.4 million acres in Maine from development – roughly 15% of the state (Figure 18).

This new CRSF research program seeks to assist decision-makers and planners as they look to the future and increasingly think strategically about balancing land conservation, working lands protection, and land development activities. Our research will 1) help develop a clear understanding of the current status, extent, and landscape patterns of conserved lands across the region; 2) determine what kinds of values and conditions are represented in conserved parcels; and 3) account for the dominant processes and criteria driving conservation activities across the different states of the Northeast. Understanding how these lands are ultimately protected, managed and valued by current and future generations will significantly affect the sustainability of Maine's communities and related forest-based industries, including forest processors and the recreation and tourism sector.

ALTERNATIVE FUTURES: SPATIAL MODELS OF COUPLED SOCIAL-ECOLOGICAL SYSTEMS



Rob Lilieholm, Christopher Cronan, David Owen, Kevin Simon, Jeremy Wilson, Eric Gallandt, Stephen Hornsby, Richard Judd, Tim Glidden, James Levitt, Michelle Johnson, Spencer Meyer, Thomas Parr and Jill Tremblay

Objectives

Maine's natural resources are highly productive and central to sustaining the State's quality-of-life, but changing ownership and development patterns pose sustainability challenges. Here, we use Bayesian Belief Networks (BBN) to combine spatial data, expert knowledge, and stakeholder values to develop decision tools designed to identify at-risk resources – especially aquatic resources and other significant landscape features. Specific objectives are to:

1. Expand our spatial analysis of alternative futures from the 1-million-hectare Lower Penobscot River Watershed (LPRW) to the State of Maine using BBNs to model how key landscape drivers such as population and climate change affect future land use scenarios and resulting tradeoffs;
2. Use existing and novel data regarding interactions between land use and ecosystem services to parameterize watershed-scale

BBN models that identify aquatic resources at risk of exceeding biophysical and regulatory thresholds; and

3. Engage a range of stakeholders to study how spatially explicit risk assessment maps and knowledge can inform public/private actions to protect at-risk resources. Through these objectives, we investigate the legal possibilities and pitfalls of spatial analysis as a tool for integrating resource protection across jurisdictional scales.

Approach

Objective 1

- Expand our spatial analysis of alternative landscape futures to the entire State of Maine using BBNs to explore the influence of key landscape drivers such as population, regulations and climate change on predicted future land use and conflicts.

- Continue BBN modeling in the LPRW and state-wide via stakeholder focus groups representing interests from: 1) development; 2) forestry; 3) agriculture; and 4) ecosystem protection.
- Generate development footprints for the LPRW based on Maine SPO municipal population forecasts, municipal zoning, and varying levels of development form and density.
- Engage stakeholders to generate and evaluate alternative future development scenarios based on stakeholder-driven assumptions (e.g., various development footprints and conservation initiatives, increased demands for local produce or forest-based bioenergy, etc.).

Objective 2

- Integrate alternative future development scenarios and urban streams research to develop coupled BBN watershed-scale models to identify at-risk waters using biophysical and regulatory thresholds, including the impact of multiple scales.
- Continue streams work in identifying relationships between land use (e.g., impervious surface area), aquatic health, and ecological and regulatory thresholds. We will assess the status of at-risk waters State-wide and explore the sensitivity of biophysical thresholds. Novel analysis of land use influence on ecosystem services yielded by ecosystem functions (i.e., biogeochemical cycling, ecosystem productivity, decomposition) will be combined with existing data on stream community structure used by the State for regulatory compliance to identify biophysical thresholds.
- Using mixed methods (legal research, case studies, etc.), we will explore the coupling of legal, social and ecological systems by analyzing EPA's "residual designation authority" (RDA), whereby EPA can require permits from new stormwater dischargers in impaired waters. We will determine how RDA will affect state and local policy for impaired and non-impaired streams. We will also explore how spatial data and modeling

systems can help bridge federal, state and local environmental regulatory initiatives and foster multi-media environmental protection efforts.

- Quantitatively assess how future development scenarios interact with stream and biophysical/regulatory thresholds across different spatial scales (e.g., stream order, and geographic location such as LPRW vs. Portland).
- Estimate the economic costs associated with crossing regulatory thresholds, as well as the cost savings from implementing alternative development paths.

Objective 3

- Engage diverse stakeholders via mixed methods (e.g., focus groups, meetings, surveys, research collaborations, etc.) to explore how different interests identify and value ecosystem services. This work will help us develop robust stream-based metrics of public values and explore how future development scenarios and associated stream conditions affect public/private stakeholder action. We will facilitate these discussions through community partners and programs like the Acadian Internship Program (see <http://acadianinternship.wordpress.com/>).

Results

Ninety percent of Maine is forested, and just 5% is publicly owned. These characteristics expose the State to a wide and growing range of pressures. Recent work by Foster et al. (2010) has demonstrated that across New England, development pressures are fundamentally altering the region's ability to sustain not only quality-of-life, but also broader ecosystem processes, including the provision of renewable raw materials like timber. Earlier work has assessed the state-wide status and contributions of land conservation efforts in Maine across three broad areas: ecological, social, and economic spheres of interest (see Cronan et al. 2010 and

Lilieholm et al. 2010). In response, a host of governmental and non-governmental organizations have protected over 3.7 million acres – 17% of the State – through a variety of creative actions (Lilieholm et al. 2010). Our focus on the LPRW has pioneered a new modeling approach to engage stakeholders and their expert knowledge in developing land suitability models for various uses (McCloskey et al. 2011a). These models will form the basis for the creation of a series of “alternative futures” for the region depicting the landscape under various policies and drivers of landscape change. The approach is also finding application in other regions of the world (see McCloskey et al. 2011b), and is helping to provide a landscape-level strategy to the protection of working forests across New England (see Foster et al. 2010). Our work in the LPRW has been selected for inclusion as one of three New England watersheds in a \$6 million NSF Macrosystems grant proposal submitted in the spring 2011 under the leadership of the Harvard Forest.

Impacts

Our research addresses coupled social and ecological systems and resilience by focusing on thresholds and landscape change under differing development scenarios. Our research approach allows us to generalize across spatial scales (e.g., stream order, municipality vs. state-level) and geographic conditions (LPRW, the Greater Portland area, and beyond) (McCloskey et al. 2011b). We also actively integrate the social and ecological sciences by focusing on biophysical (i.e., water quality) and social (i.e., regulatory) thresholds, doing so through the integration of spatial data and stakeholder opinion. Our selection of RDA as a threshold enables us to directly link research results to the economic consequences associated with following forecasted trends as opposed to engaging in more integrative development approaches that maintain or enhance water quality and thus avoid RDA mitigation (Owen 2011). Our broad-scale, multi-

pronged approach to engaging varied interests (developers, foresters, etc.), public sector officials, and NGOs through focus groups and other methods – including student interns via the Acadian Internship Program – is intended to create a wide range of models to test the effectiveness of various messages and forms of collaboration.

Funding

- National Science Foundation, Maine EPSCoR award EPS-0904155 (SSI): Urban Streams, Conservation Futures, and Year 2 Integration grant (3 SSI projects in total)

Literature Cited

- Cronan, C.S., R.J. Lilieholm, J. Tremblay, and T. Glidden. 2010. *A Retrospective Assessment of Land Conservation Patterns in Maine Based on Spatial Analysis of Ecological and Socio-Economic Indicators*. *Environmental Management* 45(5):1076-1095.
- Foster, D.R., B. Donahue, D. Kittredge, K.F. Lambert, M. Hunter, B. Hall, L.C. Irland, R.J. Lilieholm, D.A. Orwig, A. D'Amato, E. Colburn, J. Thompson, J. Levitt, A.M. Ellison, J. Aber, C. Cogbill, C. Driscoll, and C. Hart. 2010. *Wildlands and Woodlands: A Vision for the New England Landscape*. Harvard University Press. 36 Pages.
- Lilieholm, R.J., L.C. Irland, and J.M. Hagan. 2010. *Changing Socio-Economic Conditions for Private Woodland Protection (Chapter 5)*. Pages 67-98 in S.C. Trombulak, and R.F. Baldwin, Eds., *Landscape-Scale Conservation Planning*. Springer, New York. 427 p.
- McCloskey, J.T., R.J. Lilieholm, and C.S. Cronan. 2011a. (In Press). *Using Bayesian Belief Networks to Identify Future Compatibilities and Conflicts Between Development and Landscape Conservation*. *Landscape and Urban Planning*.
- McCloskey, J.T., R.J. Lilieholm, R. Boone, R. Reid, D. Nkedianye, S. Sader, M. Said, and J. Worden. 2011b. (In Press). *A Participatory Approach for Modeling Alternative Future Land Use Scenarios Around Nairobi National Park Using Bayesian Belief Networks*. *Ecology and the Environment*.
- Owen, D. (In Press). *Urbanization, Water Quality and the Regulated Landscape*. *Colorado Law Review* 82.

MOBILIZING DIVERSE INTERESTS TO ADDRESS INVASIVE SPECIES THREATS: THE CASE OF THE EMERALD ASH BORER IN MAINE



Rob Lilieholm

Darren Ranco, Rob Lilieholm, Theresa Secord, Jennifer Neptune, John Daigle, William Livingston, Erin Quigly, and Molly Lizotte

Objectives

This project seeks to study and facilitate the ways that Wabanaki basketmakers, tribes, state and federal foresters, various university researchers, landowners and others come together to prevent, detect, and respond to the emerald ash borer (EAB), a potentially devastating invasive insect threat to ash trees in Maine. We hope to help these stakeholders work together to manage for potential impacts, so that Maine and the Wabanaki people will not lose the brown ash (*Fraxinus nigra*), a valuable economic and cultural resource. We believe that collaborating knowledge and joining together for collective action with engaged stakeholders will lead to more effective and sustainable action in responding to EAB.

Approach

We recognize that in addressing complex resource management situations such as EAB, a critical piece of effectiveness is struc-

tured dialogue between scientists, resource users, and interested publics informed about human-environment systems – a process often called analytic deliberation. Analytic deliberation “improves the effective use of information, enhances conflict resolution, consensus and adaptive governance, and builds cooperation between local stakeholders and the state” (Robson and Kant 2009). Our initial strategies in bringing together resource users — especially those who are most potentially impacted by EAB — reflect our belief that analytic deliberation will lead to the best knowledge and governance solutions to manage this threat. Therefore, as we develop strategies with stakeholders for research and policy to prevent, detect, and respond to the EAB, we will continue to develop a strategic plan that accounts for and structures these interactions.

At a series of stakeholder workshops we laid the groundwork for our research plan, identifying four areas of collaborative research: 1) mapping ash resources; 2) developing policy guidance; 3) stakeholder engagement; and 4) seed collection.

We consider this collaborative research plan a living strategic planning document, which will be further defined with other structured interactions with key stakeholders over the next few years, to be our collective road map for science, policy and other knowledge-to-action activities.

We are studying how a group of stakeholders develops and interacts over time, with a particular emphasis on how different power positions and forms of knowledge intersect to create barriers and opportunities for sustained collaboration. We are using qualitative research methods such as participant observation, focus groups, and individual interviews to track the barriers/opportunities for collaboration, recognize and integrate different forms of knowledge, and enact policy so that an invasive threat can be prevented, detected, and addressed. We are particularly interested in how the group interacts in a context where power and knowledge are unevenly shared and how we, and the group, are able to create power-sharing.

To address the development of policy guidance, through phone interviews and policy analysis, we plan to analyze management information from state managers and other relevant parties in areas where EAB has already emerged. We will use this information in building a pre-invasion management and emergency response plan. To address the mapping of ash resources, we will integrate the expert knowledge of Wabanaki brown ash harvesters with existing scientific knowledge and spatial GIS data to identify locations in Maine that are more or less likely to be suitable habitat for brown ash. Expert knowledge will be linked with empirical data within a Bayesian Belief Network (BBN) that will be used to map areas having site characteristics that promote ash growth and regeneration, as well as areas that may contain stress factors.

Preliminary Results

Thus far, we have gathered baseline data through participant observation to understand the different ways that stakeholders see themselves participating in the process for sustainable collective action around an invasive threat. Our facilitated workshops with key stakeholders have identified primary areas of research, and spearheaded a response planning process in Maine. The emerging stakeholder group includes a half-dozen tribal members engaged in basket ash harvesting and basketry, as well as representatives from the University of Maine's scientific community, the USDA Forest Service, the Maine Forest Service, representatives from Maine Indian tribal governments, the Bureau of Indian Affairs, the United States Forest Service, the Animal Plant Health Inspection Service (APHIS) of the USDA, and a number of environmental non-profits and indigenous basketmakers from Michigan, where the EAB has already devastated much of the ash resource.

During the Summer of 2010, Native American youth from the Penobscot Nation-Indian Island school participated in a 2-day seed collection workshop that will enable future generations of Wabanaki people to maintain the ash resource. In spring 2011, we developed the Maine EAB Trap Tree Network (TTN) in cooperation with the USDA Forest Service, Maine Forest Service, and the Small Woodlot Owners Association of Maine. TTN is engaging woodland owners from across the state to voluntarily create trap trees (girdled 4-to-6-inch DBH ash trees) to serve as early detection monitors. As our work continues, we will continue to assist Maine and Wabanaki tribal governments in developing EAB response plans. Monitoring and seed collection efforts will continue, along with meetings and workshops to spur dialogue and collaboration between stakeholders.



Jennifer Neptune

UMaine professor John Daigle and forester Mike Benedict discuss the potential impacts of the emerald ash borer on brown ash trees.

Anticipated Impacts

The outcomes of this project will include: the creation of a guidance document to help the state and tribes develop cooperative emergency response plans for the arrival of EAB; continued focus group interviews on stakeholder engagement questions; focus groups for BBN analysis on the location of ash resources in Maine; continued stakeholder engagement in the development of research needs and questions; a stakeholder meeting on research coordination with an emphasis on public education and outreach; the documentation, with key stakeholders, of best practices for invasive species policy; the further development of research strategies with the stakeholder group, including the

use of BBNs to map ash resources in Maine for emergency response planning and seed collection; the development of research strategies with the stakeholder group to help engage publics in the prevention and identification of EAB in Maine; and the continued development of research that demonstrates how diverse groups can work together to develop invasive species emergency response plans that effectively include all key stakeholders.

Funding

- National Science Foundation, Maine EPSCoR award EPS-0904155 (SSI)

PROTECTING NATURAL RESOURCES AT THE COMMUNITY SCALE:

VERNAL POOLS AS A MODEL SYSTEM TO STUDY URBANIZATION, CLIMATE CHANGE AND FOREST MANAGEMENT

Kathleen Bell, Aram Calhoun, Malcolm Hunter, Cynthia Loftin, Charles Colgan, David Owen, Rob Lilieholm, Linda Silka, Laura Lindenfeld, Nuri Emanetaglo, Jessica Jansujwicz, Dawn Morgan, Brittany Cline, Luke Groff, and Vanessa Levesque



Dawn Morgan

Objectives

Our overall goal is to better understand how amphibian movements in complex landscapes are affected by forest management and urbanization. Of particular concern are effects on dispersal and population dynamics of vernal pool-breeding amphibians, and how regulatory and incentive-based policies can be integrated across mixed-use, privately-owned landscapes. Specific objectives include: 1) studying the effects of different land-use and forest management practices on amphibian dispersal and migration, with the goal of understanding how these movement processes affect population dynamics and persistence; and 2) studying the behavior of municipalities and boundary organizations to elucidate opportunities in decision making for promoting sustainable communities.

Approach

Our team is comprised of biophysical researchers and social scientists, and is integrated with an ongoing Vernal Pool Mapping Program (VPMP)

currently in its 4th year. Research on pool-breeding amphibians is driven by the needs of regulators and planners identified through stakeholder meetings. We use the social survey and focus group data in five of the VPMP towns to inform our work, with three model towns chosen from our VPMP municipalities. We will combine findings from the three projects to develop conservation guidelines with our stakeholders.

Using vernal pool conservation in distinct landscapes as an entry point, we are working with and studying municipal and regional decision-makers. Our research addresses three specific aims: 1) identifying how lessons and challenges of vernal pool conservation can be applied to other resource management issues; 2) exploring the extent to which social and ecological feedbacks and thresholds influence municipal decisions; and 3) evaluating how boundary organizations influence municipal decision-making processes. We employ a mixed-methods/theoretical social science approach to achieve these aims. Using case studies of two to three “model towns” working to adopt innovative conservation planning techniques, we examine how towns

approach single species/system conservation as compared to a mixed system approach. The three “model towns” are a subset of towns participating in the on-going VPMP initiative. Building on knowledge gained from this and other team research, we will take stock of lessons learned about vernal pool conservation, compare and contrast decision-making around this and other issues, and focus on what local characteristics serve as indicators of actors that are likely to engage in innovative management. We will employ regression, GIS, network, and EDA methods to examine the influence of demographic, socio-economic, and biophysical characteristics on decisions by municipalities to participate in relevant programs or adopt specific types of regulation. Of particular interest are how changes in landscape attributes (social and ecological) may affect patterns in municipal participation and adoption. Lastly, we will initiate research of interactions between boundary organizations and municipal actors, with a goal of exploring the science-policy-public interface, and the mediation of conflicting values and social goals at local and regional levels.

Results

Our team is dedicated to providing the biophysical and social science that informs vernal pool policy and, more broadly, town conservation planning on private lands. We have engaged in 75 stakeholder events with hundreds of people from dozens of organizations at federal, state, local, NGO, and private citizen levels. We have successfully engaged with two model towns, Cumberland and Orono, where we work on solutions that incorporate human dimensions into local conservation planning. Our specific task is to develop practical town plans that address natural resource conservation on private lands while allowing for economic growth in development zones. Our social survey work with citizens has already led to modifications to our outreach strategies and has also informed our biophysical research, expanding it beyond forestry to include amphibian responses to landscape changes

associated with residential development and farming. Our stakeholder group working on this project includes federal, state (three agencies), and local officials, as well as legal experts from SSI and the College of the Atlantic – all committed to revitalizing underused tools and helping to develop new solutions for marrying conservation with opportunities for growth and development. Our “solution” will be showcased in these two towns as a template for other municipalities in New England. Specific accomplishments include:

We used a new experimental approach to examine the relative effects of different types of urban vs agriculture vs forest habitats on permeability to dispersing juvenile wood frogs. This work has provided an enhanced understanding of the dynamics of the social-ecological systems associated with amphibian population persistence in landscapes influenced by the socio-economic factors that shape land-use (e.g., forest harvest, lawns, hayfields, and row crops).

Our work on the permeability to dispersing wood frogs of different forestry treatments indicates that clear-cut and 11-year regeneration treatments are significantly less permeable than 20-year regeneration and mature forest. This and our other studies indicate that 20-year old forest stands may represent a threshold in forest succession/regeneration, the point at which microclimate and other habitat features for juvenile frogs become similar to those of mature forest.

We are examining multi-scale (both spatial and temporal) components of amphibian habitat needs in complex landscapes that contain many thresholds, such as aquatic/terrestrial edges. This approach is demanded by amphibian’s biphasic life cycles (aquatic eggs and larvae, and terrestrial adult stages), as well as annual movements among different habitat types for breeding, foraging, and hibernating.

We are examining the social “thresholds” and contributing factors that influence stakeholder acceptability of community-based vernal pool conservation planning in four southern Maine towns. For example, we are interested in the circumstances under which a private landowner will permit access to their property for a biological survey. We are also interested in determining what limits on development might be acceptable to landowners, and at what point landowners perceive vernal pool regulations as a “taking” of property rights.

Monitoring the movements of small cryptic animals (too small to carry a radio transmitter) across entire landscapes and for long periods (too long for any small battery) requires new technology. Thus, we have begun collaborating with faculty in the Dept. of Electrical & Computer Engineering at UMaine to develop miniature harmonic transponder technology to track juvenile wood frogs for their entire lives, and are developing grant applications for NSF-EAGER, USDA, etc.).

Our research has facilitated stakeholder participation in framing knowledge-to-action problems and research needs. Data from participant observation, semi-structured interviews, focus groups, and a mail survey across four Maine towns participating in the VPMP has increased awareness and understanding of stakeholder concerns and information needs. For example, our analysis of landowner knowledge, values, attitudes, and behaviors indicates that communication is a significant barrier to successful community-based conservation. We found that landowners are particularly concerned about a lack of information concerning citizen science assessments on their property. We are working to implement an iterative research framework allowing greater opportunity for two-way communication among private landowners, town officials, and university researchers.

In Maine, town-level decision making has a great impact on SES resilience, and therefore, understanding characteristics that facilitate effective governance is essential for the vernal pool team research. Initial meetings with stakeholders have prompted interest in better understanding how scientific information will affect local decision making. We will be doing so both through in-depth case studies of model towns, as well as through modeling characteristics of New England towns that engage in sustainable conservation activities.

Impacts

Vernal pools, designated as Significant Wildlife Habitat under Maine’s Natural Resource Protection Act, are critical habitat for many aquatic organisms, but may be used differently in disparate environmental settings. The importance of landscape context in pool-breeding amphibian habitat choice has important implications for conservation. This research project provides science-based information to facilitate the regulation and conservation of amphibians with complex life histories in Maine’s diverse geographic landscapes, while allowing for economic growth and development. Our research serves to inform the Maine Department of Inland Fisheries and Wildlife, a primary stakeholder, about potential regulatory disconnects between Maine’s diverse landscapes, as well as promote sustainable science to support both healthy ecosystems and strong economies.

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Rob Lilieholm

WILDEBEEST FORAGE ACQUISITION IN FRAGMENTED LANDSCAPES UNDER VARIABLE CLIMATES

Randall Boone, Robin Reid, Robert Lilieholm, Jeffrey Worden, Steven Sader, Joseph Ogulu, Rei Hayashi, and Jesse Njoka

Objectives

Kenya's Athi-Kaputiei Plains (AKP) cover over 2,590 km² of rolling plains that once supported the migration of wildlife populations second in size to only the Mara-Serengeti ecoregion (Gichohi et al. 1996). Nairobi National Park covers a small portion of the AKP system, but serves as a crucial reserve for wildlife during the dry seasons. The Park is fenced on three sides and bordered to the north by Nairobi – one of the largest and fastest-growing cities in Africa (Mundia and Aniya 2005). Nairobi's population has increased from 500,000 people in 1970 to over 3 million today (Mundia and Aniya 2005). This growth has been characterized by residential and commercial expansion and intensified land use. With limited land use planning, growth has outpaced infrastructure and human services to create large slums and unplanned settlements in peripheral areas. Unplanned growth combined with physical constraints and mounting environmental impacts threatens the sustainability of both human and natural systems. These threats include the viability of urban centers and traditional Maasai pastoral livelihoods, as well as

broader landscape-level processes such as globally significant wildlife migration patterns (Mundia and Aniya 2005).

Our core research hypotheses are:

H1. Wildebeest will be more sensitive to fragmentation under increasing variability in inter-annual precipitation

In landscapes with stable climatic patterns, ungulate populations can be constrained by forage production, or some other capacity. Fragmentation can reduce the movement of individuals and limit their forage acquisition, or force animals to feed longer or in less hospitable places to acquire the same forage. However, assuming the population is finding adequate forage, it will continue to do so year-to-year, given the stability in primary production. In contrast, wildlife mortality from droughts in fragmented landscapes may be extreme if animals are unable to move to areas of ephemeral forage production or to key resource areas such as swamps and hillside grasslands that provide forage over long periods. More fragmentation may accentuate the effect of droughts on vegetation through sustained grazing, and leave forage elsewhere

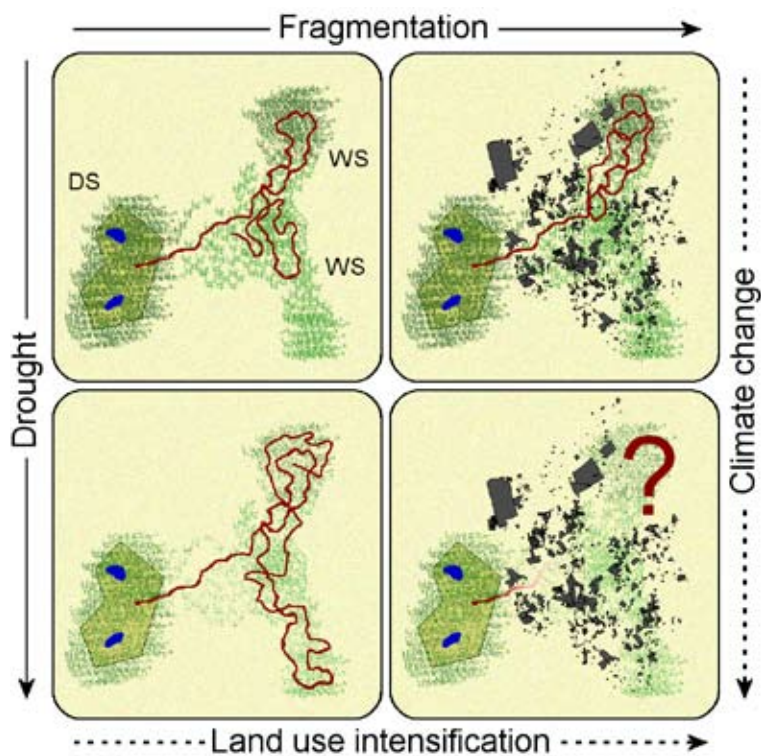


Figure 19. An animal moves (path in red) from dry season (DS; park in gold) to wet season (WS; forage in green) range in an intact landscape (upper left). Under fragmentation (upper right), the pathway is truncated, and in drought (lower left), animals must move farther to acquire sufficient forage. Whether animals can acquire sufficient forage under fragmentation and drought (lower right) is unknown. Regardless, land use intensification and climate change are driving systems toward that condition more frequently.

unused. Observations and anecdotal evidence supports these ideas, although the validity of H1 is by no means certain.

H2. Wildebeest in areas of intermediate productivity will be more sensitive to fragmentation than in areas of very low or relatively high productivity

Wildebeest inhabiting areas of low productivity may, in variable climates, have population dynamics that are loosely linked with primary production. Animal populations in these systems are buffeted by drought, and have insufficient time to recover to approach a forage-based capacity before another drought occurs. Animals in such systems must travel long distances to acquire sufficient forage, such that travel costs to

access all the resources the animal may need are maximized. In such cases, isolation of landscapes at scales broader than the scale at which wildebeest move may not cause changes in forage acquisition. In contrast, wildebeest in highly productive areas may need to travel only short distances to meet their daily requirements. Fragmentation in such productive habitats will only affect wildebeest through habitat loss, rather than limiting their movements. It is in areas of intermediate productivity that we expect to see wildebeest populations most closely linked with habitat isolation.

Approach

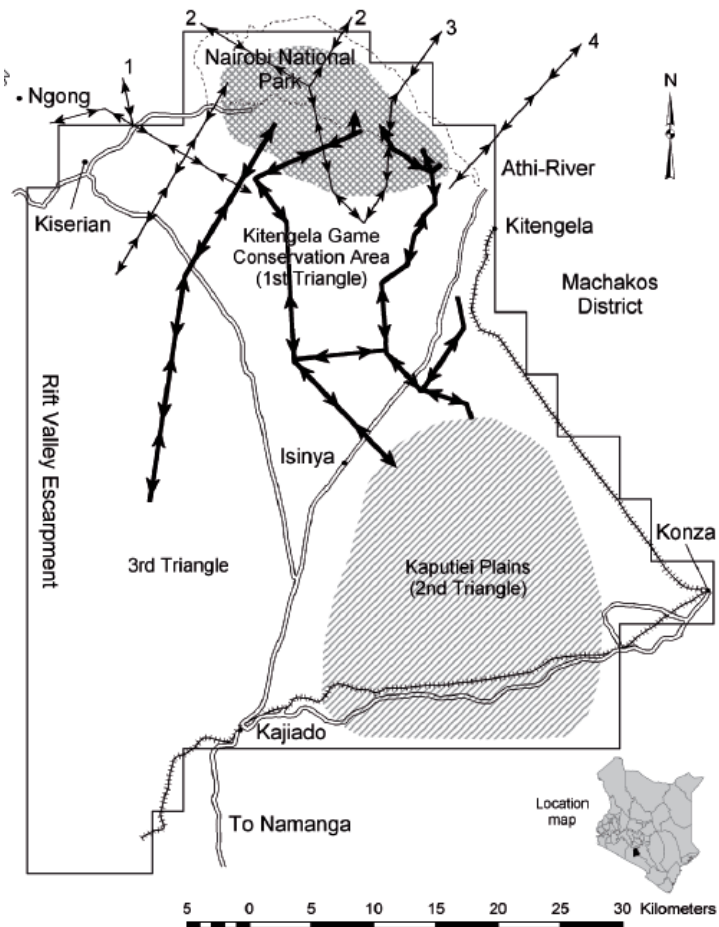
Our methodology has three major components, which link together to address our hypotheses: 1) the movements of wildebeest must be tracked; 2) fragmentation in the study areas must be mapped and future fragmentation projected; and 3) the success wildebeest have at

acquiring forage must be related to fragmentation and climate variability. Movements of animals under different fragmentation regimes (from 1) will combine with literature on wildebeest habitat use to inform a simulation model of wildebeest movements (3). Maps of past, current, and future fragmented landscapes (2) plus changes in primary productivity associated with climate variability, will be inputs into a factorial analysis using the simulation model (3), which will quantify changes in simulated wildebeest populations under different conditions.

We are using agent-based models of wildebeest migration behavior and remotely sensed change detection techniques together with Bayesian Belief Networks to integrate spatial data and socio-economic and ecological vari-

ables in order to model alternative future landscapes to enhance the sustainability of human and natural systems (Figure 19. ; Marcot et al. 2006). We will identify relevant variables by engaging experts and a broad range of stakeholders in the research process through focus groups and other meetings. Stakeholders will identify biophysical metrics that can be used to identify common site characteristics suitable for wildlife and livestock, as well as areas suitable for commercial and residential development.

We will use these techniques to examine similar development patterns around the Maasai-Mara, Amboseli, and Samburu National Reserves. While drivers of development in these areas are different (e.g., ecotourism lodges vs. urban sprawl), the consequences for wildlife may be the same without effective land use planning.



Results

Urban development has grown substantially since 1984. Consequently, historic northern migration routes for wildebeest (Figure 20) have been essentially severed by Nairobi and surrounding settlements. The southern migration path, which contains AKP, is bisected by two major roads that create what the community calls the “three triangles” – Kitergela, Athi, and the Kaputiei Plains. These roads represent corridors of rapidly changing land use patterns thought to be driven by changes in land tenure, urban sprawl, and increasing human populations. These changes also threaten the long-term viability of pastoral livelihoods practiced by the region’s indigenous Maasai people.

Thus far, 36 wildebeest have been collared with GPS trackers across our three study areas (see project website, Gnu Landscapes, at www.nrel.colostate.edu/projects/gnu/). In-depth analyses

Figure 20. Historic (thin solid lines and arrows, numbered) and current (bold solid lines and arrows) wildlife and livestock grazing routes. Migratory species like wildebeest form a critical link in the ecosystem’s food chain.

of wildebeest movement are still pending, but differences in the movements of wildebeest in our three study areas, corresponding to three levels of landscape fragmentation, are evident. The movements of animals in Amboseli are compressed, and regular. Requirements for animals in this relatively unfragmented landscape are nearby. Animals move from wet season grazing areas directly to key resource areas and water sources, with movements quite regular. In the Loita Plains and Maasai Mara region, the landscape is moderately fragmented. All animals seem to move great lengths (e.g., 2000 km/yr), but some do so while roaming over large areas, while others move within a confined home range. Most intriguingly, animals in the highly fragmented Athi Kapatuei Plains south of Nairobi National Park move much less than

those in the other areas. Moreover, wildebeest appear to be avoiding crossing major roads. Our team will analyze the collar data in depth to address this question, given the recent focus on the road proposed to cross northern Serengeti National Park.

Impacts

Six percent of Kenya is in protected status (Groombridge and Jenkins 2002), but three-quarters of wildlife in Kenya are outside protected lands (Western and Pearl 1989; Western 1998). Our research will quantify the level of land use intensification that promotes support for both human needs and conservation of the dominant migratory ungulate in East African rangelands, now and under future climate change. The Kenya-based team has been working with the Athi-Kaputiei Plains, Amboseli, and Mara Ecosystems for 9 years on issues including poverty alleviation, livestock production, land use, and wildlife conservation. For this work, the team won first place in a competition of teams around the world working to make science useful for local communities in December 2006. We will contribute to broader societal goals by providing critical information to local and national policy processes in Kenya, and will train community members and students. A report detailing our results will be provided to the Kenya Wildlife Service, the Friends of Nairobi National Park, the Kitengela Ilparakuo Landowners Association, Councils for the group ranches that surround the conservation areas, and the Narok and Kajiado District Councils. Local community members and protected area managers will be involved in every stage of the field work, as employees or stakeholders. We will ask them to continually interpret our findings and update their community members and management colleagues. The issues facing Kenyan rangelands may be more extreme than most ecosystems in the US and the rest of the world, but they are analogous. Our results will suggest pathways for decision making in other parts of the world.

Funding:

- National Science Foundation (\$688,000)
- Planet Action. 2010. Projecting Land Cover Change and Future Impacts on Wildebeest Migratory Pathways. SPOT Image Corporation and ESRI in-kind donation of high-resolution imagery (Stabach, Lilieholm, Boone, Reid, Worden, McCloskey,) \$20,000.
- The University of Maine. 2010. A Proposal to Develop Natural Resource-related Research and Educational Linkages in East Africa. UMaine School of Policy and International Affairs International Travel, Research and Collaboration Grant. \$4,565.

Literature Cited

- Gichohi, H., C. Gakahu, and E. Mwangi. 1996. *Savannah Ecosystems*. P. 243-270 in T.R. McClanahan, and T.P. Young, Eds., *East African Ecosystems and Their Conservation*. Oxford University Press, Oxford, UK.
- Goodwin, B.J. and L. Fahrig. 2002. *Effect of Landscape Structure on the Movement Behavior of a Specialized Goldenrod Beetle, Trirhabda borealis*. *Canadian Journal of Zoology* 80:24-35.
- Marcot, B., J. Steventon, G. Sutherland, and R. McCann. 2006. *Guidelines for Developing and Updating Bayesian Belief Networks Applied to Ecological Modeling and Conservation*. *Can. J. Forest Res.* 36:3063-3074.
- Mundia, C., and M. Aniya. 2005. *Analysis of Land Use/Cover Changes and Urban Expansion of Nairobi City Using Remote Sensing and GIS*. *Int'l. J. Remote Sensing* 26:2831-2849.
- Western, D. and M. Pearl. 1989. *Conservation Without Parks: Wildlife in the Rural Landscape*. In: Western D and M. Pearl (eds.) *Conservation for the Twenty-First Century*. Oxford University Press, New York, USA. Pp. 158-165.
- Western, D. 1998. *Letters to the Editor*. *Science* 280:1507.

APPENDICES

PUBLICATIONS

AND OUTREACH

This year, CRSF researchers published 75 articles, including peer-reviewed journals, book chapters, research reports, proceedings, and theses. Additionally, our scientists and students delivered 120 presentations at scientific conferences, stakeholder meetings, and other venues.

Journal publications

Arseneault, J.E., M.R. Saunders, R.S. Seymour, and R.G. Wagner. (In Press). *First Decadal Response to Treatment in an Expanding Gap, Disturbance-Based Silviculture Experiment in Maine*. *For. Ecol. Manage.*

Benjamin, J.G., R.J. Lillieholm, and C.E. Coup. 2010. *Forest Biomass Harvesting in the Northeast: A "Special Needs" Harvest Operation?* *Northern Journal of Applied Forestry* 27(2):45-49.

Briedis, J.I., J.S. Wilson, J.G. Benjamin, and R.G. Wagner. (In Press). *Logging Residue Volumes and Characteristics Following Integrated Roundwood and Energy-Wood Whole-Tree Harvesting in Central Maine*. *Northern Journal of Applied Forestry*.

Cronan, C.S., R.J. Lillieholm, J. Tremblay, and T. Glidden. 2010. *A Retrospective Assessment of Land Conservation Patterns in Maine Based on Spatial Analysis of Ecological and Socio-Economic Indicators*. *Environmental Management* 45(5):1076-1095.

DeRose, R.J. and R.S. Seymour. 2010. *Patterns of Leaf Area Index During Stand Development in Even-Aged Balsam Fir-Red Spruce Stands*. *Canadian Journal of Forest Research* 40: 629-637.

Guiterman, C.H., R.S. Seymour, and A.W. Weiskittel. (In Press). *Influence of Contrasting Thinning Regimes on Leaf Area Index of Pinus Strobus: Long-Term Trends Predicted from Allometric Equations and Litterfall Data*. *Forest Science*.

Guiterman, C.H., R.S. Seymour, and A.W. Weiskittel. (In Press). *Influences of Conventional and Low-Density Thinning on the Lower Bole Taper and Volume Growth of Eastern White Pine*. *North. J. Appl. Forestry*. Gomben, P.C., and R.J. Lillieholm. 2011. *Impact of Demographic Trends on Future Development Patterns and the Loss of Open Space in the California Mojave Desert*. *Environmental Management*.

Hearn, B.J., D.J. Harrison, A.K. Fuller, C.G. Lundrigan, and W.J. Curran. 2010. *Paradigm Shifts in Habitat Ecology of Threatened Newfoundland Martens*. *Journal of Wildlife Management* 74:719-728.

Hennigar, C.R., J.S. Wilson, D.A. MacLean, and R.G. Wagner. (In Press). *Applying a Spruce Budworm Decision Support System to Maine: Projecting Spruce-Fir Volume Impacts Under Alternative Management and Outbreak Scenarios*. *Journal of Forestry*.

Hofmeyer, P.V., L.S. Kenefic, and R.S. Seymour. 2010. *Historical Stem Development of Northern White-Cedar (Thuja Occidentalis L.) in Maine*. *Northern Journal of Applied Forestry* 27(3): 92-96.

Hofmeyer, P.V., R.S. Seymour, and L.S. Kenefic. 2010. *Production Ecology of Thuja Occidentalis*. *Canadian Journal of Forest Research* 40:1155-1164.

Li, R. and A.R. Weiskittel. 2010. *Comparison of Model Forms for Estimating Stem Taper and Volume in the Primary Conifer Species in the Acadian Region of North America*. *Annals of Forest Science* 67(3): 302.

McCloskey, J.T., R.J. Lillieholm, and C.S. Cronan. (In Press). *Using Bayesian Belief Networks to Identify Future Compatibilities and Conflicts Between Development and Landscape Conservation*. *Landscape and Urban Planning*.

Noone, M.A., S.A. Sader, and K.R. Legaard. *Are Forest Disturbances Influenced by Ownership Change, Conservation Easement Status and Land Certification*. *Forest Science*

Olson, M.G. and R.G. Wagner. 2010. Long-Term Compositional Dynamics of Acadian Mixedwood Stands Under Different Silvicultural Regimes. *Canadian Journal of Forest Research* 40: 1993-2002.

Weiskittel, A.R., R.S. Seymour, P.V. Hofmeyer, and J.A. Kershaw, Jr. 2010. Modelling Primary Branch Frequency and Size for Five Conifer Species in Maine, USA. *Forest Ecology and Management* 259: 1912-1921.

Whitesell, S., R.J. Lillieholm, and T.L. Sharik. 2010. A Global Survey of Tropical Biological Field Stations. Pages 5-14 in *BioScience Topics in Biological Field Stations*, University of California Press (ISBN 978-0-9817130-4-5). 72 Pages

Wilkerson, E., J.M. Hagan, and A. Whitman. 2010. The Effectiveness of Different Buffer Widths for Protecting Water Quality and Macroinvertebrate and Periphyton Assemblages of Headwater Streams in Maine, USA. *Canadian Journal of Fisheries and Aquatic Sciences* 67: 177–190. CFRU At the New England Society of American Foresters Meeting in Nashua, NH.

Book Chapters

Day, M.E., and M.S. Greenwood. 2011. Vegetative Growth and Reproductive Development in Temperate Conifers and Regulation of Ontogenetic Strategies. Chapter 4. In C. Meinzer, T. Dawson, and B. Lachenbruch, Eds. *Size- and Age-Related Changes in Tree Structure and Function*. Volume in *Springer Tree Physiology Series*, Springer-Verlag, NY

Lillieholm, R.J., L.C. Irland, and J.M. Hagan. 2010. Changing Socio-Economic Conditions for Private Woodland Protection (Chapter 5). Pages 67-98 in S.C. Trombulak, and R.F. Baldwin, Eds., *Landscape-Scale Conservation Planning*. Springer-Verlag, New York, NY. 427 Pages.

Articles in Periodicals

Benjamin, J.G. 2010. Take It Or Leave It: Maine's New Woody Biomass Guidelines Take a New Approach to Biomass Harvest. *Canadian Biomass*. Nov/Dec 2010. Pp. 10-12.

Benjamin, J.G. A Forest Operations Perspective on Harvesting Woody Biomass. 2010. *Atlantic Forestry Review*. 16(6):35-36.

Benjamin, J.G. 2010. Lessons Learned from Early Commercial Thinning Treatments in Maine Forests. *Forest Resources Association – Technical Paper*. Rockville MD. TP-10P-11

Benjamin, J.G. and R. Berthiaume. 2010. Logger-Built Mobile Chipper for Energy Wood Harvests. *Forest Operations Review*. 12(4):21-22. *Forest Resources Association Inc.*, Rockville MD. TR-10R23.

Meyer, S.R. 2010. *Partners in Science: Maine's Cooperative Forestry Research Unit and Spruce Budworm: What's Past Is Prologue*. *North Maine Woods Magazine*. North Maine Woods. Pp. 34-35.

Research Reports

Benjamin, J.G. (Ed.). 2010. *Considerations and Recommendations for Retaining Woody Biomass on Timber Harvest Sites in Maine*. University of Maine, Maine Agriculture and Forest Experiment Station. Orono, ME. Miscellaneous Publication 761. 68p.

Benjamin, J.G. and R.W. Rice. (Eds.). 2010. *Operational Assessment of Logging Residue Bundles As a Bioenergy Feedstock – Preliminary Results*. Report to E.J. Carrier and Nortrax Equipment Co. January 2010.

Benjamin, J.G. and R.G. Wagner. 2010. *Energy-Wood Harvest Systems for Improving Low-Value, Beech-Dominated Hardwood Stands in Maine*. Final Report to the Cooperative Forestry Research Unit. February 9.

Day, M.E., M.S. Greenwood, S.L. Adams, and K.J. Spencer. (In Press). *Understanding Patterns and Regulatory Pathways in Conifer Ontogeny: The Role of the Penobscot Experimental Forest*. In: Kenefic, L.S. and J.C. Brissette, Eds. *The Penobscot Experimental Forest (1950-2010): Sixty Years of Research and Demonstration*. General Technical Report. Department of Agriculture, U.S. Forest Service, Northern Research Station. Newtown Square, PA.

Foster, D.R., B. Donahue, D. Kittredge, K.F. Lambert, M. Hunter, B. Hall, L.C. Irland, R.J. Lillieholm, D.A. Orwig, A. D'Amato, E. Colburn, J. Thompson, J. Levitt, A.M. Ellison, J. Aber, C. Cogbill, C. Driscoll, and C. Hart. 2010. *Wildlands and Woodlands: A Vision for the New England Landscape*. Harvard University Press. 36 Pages.

Leahy, J. and L. Lindenfeld. 2010. "NEWBio Stakeholder Survey and Workshops," Northeast Woody Biomass Consortium, Technical Report. 76 pages.

Li, R., and A.R. Weiskittel. 2010. *Development and Assessment of Regional Stem Taper Equations for Eleven Conifer Species in the Acadian Region of North America*. Cooperative Forestry Research Unit Technical Report. 20p.

- Li, R. and A.R. Weiskittel. 2010. *Estimating and Predicting Bark Thickness for the Primary Conifer Species in the Acadian Region*. Cooperative Forestry Research Unit. Technical Report. 15p.
- Li, R. and A.R. Weiskittel. 2010. *Comparison of Stem Taper Equations for Predicting Diameter and Volume of Balsam Fir, Red Spruce, and White Pine in the Acadian Region*. Cooperative Forestry Research Unit. Technical Report. 18p.
- Liliehalm, R.J., P. Lammert, G. Lord, and S. Troster. 2011. *2010 Directory of Primary Wood Processors in Maine*. University of Maine School of Forest Resources and the Maine Forest Service. 143 Pages.
- Liliehalm, R.J. 2010. *A Report of Accomplishments from Support Through the E.L. Giddings Chair in Forest Policy, 2006-2010*. University of Maine, Orono. 54 Pages.
- Meyer, S.R. (Ed.) 2010. *Cooperative Forestry Research Unit Annual Report – 2009*. University of Maine. 82 Pp.
- Quartuch, M., J. Leahy, and G. Heldmann. 2011. "Summary Statistics for Penobscot County Landowner Survey." Technical Report.
- Quartuch, M., J. Leahy, and G. Heldmann. 2011. "Penobscot County Landowner Survey: Final Technical Report." Technical Report.
- Ranco, D., R.J. Liliehalm, J. Daigle, J. Neptune, E. Quigley, T. Secord, and M. Lizotte. 2011. *Protecting Ash for Future Generations II: Symposium Report*. Sustainability Solutions Initiative, University of Maine. 21 Pages.
- Russell, M.B., S.R. Meyer, and R.G. Wagner. 2009. *Capturing the Value of 30 Years of Research: Long-Term Data Management and the Cooperative Forestry Research Unit*. Cooperative Forestry Research Unit Research Report RR-09-03. 36p.
- Simons, E., D. Harrison, A. Whitman, and J. Wilson. 2010. *Quantifying Biodiversity Values Across Managed Landscapes in Northern and Western Maine*. Final Report to the Maine Cooperative Forestry Research Unit, University of Maine, Orono. 29p.
- Simons, E., D. Harrison, K. Legaard, and S. Sader. 2010. *The Effectiveness of Zoning to Protect Deer Wintering Areas During the Period 1975-2007: Does Compromising Forest Productivity to Protect Deer Habitat Achieve Desired Ecological Objectives?* Pages 51-56 in Meyer, S.R. (Ed.): *Cooperative Forestry Research Unit: 2009 Annual Report*. University of Maine, Orono.
- Weiskittel, A.R., Wagner, R.G., Seymour, R.S., 2010. *Refinement of the Forest Vegetation Simulator, Northeastern Variant Growth and Yield Model: Phase 1*. In: Meyer, S.R. (Ed.), *2009 Annual Report*. University of Maine, Cooperative Forestry Research Unit, Orono, ME, Pp. 44-48.
- Weiskittel, A.R., Wagner, R.G., and Seymour, R.S. 2011. *Refinement of the Forest Vegetation Simulator Northeastern Variant Growth and Yield Model: Phase 2*. University of Maine CFRU 2010 Annual Report. 23-30.

Theses

- Scott, S.A. 2009. *Spatio-Temporal Dynamics of Snowshoe Hare Density and Relationships to Canada Lynx Occurrence in Northern Maine*. M.S. Thesis, University of Maine, Orono. 190p.
- Spencer, K.J, 2010. *Addressing Age-Related Growth Decline in Red Spruce Productivity: Integrating Physiological and Genomic Approaches*. MS Thesis. The Graduate School, University of Maine, Orono Maine. 71 p.
- Tero, Nal. 2010. *History, Composition and Structure in Mature Second-Growth Acadian Forest Stands Managed With Irregular Shelterwood Silviculture*. M.S. Thesis, University of Maine, Orono. 97 p.
- Waskiewicz, Justin. 2011. *Growth and Development of Mixed Red Oak-White Pine Stands in Maine: Influence of Stand Structure and Spatial Heterogeneity*. Ph.D. Dissertation, University of Maine, Orono. 133 p.
- Zellers, C. 2010. *Growth, Lumber Yield, and Financial Maturity of Isolated Archetype Eastern White Pine (Pinus Strobus L.) Trees*. M.S. Thesis, University of Maine, Orono. 73 p.
- Zellers, K. 2010. *Patterns of Regeneration of Eastern White Pine (Pinus Strobus L.) As Influenced by Large Isolated Crop Trees and Precommercial Thinning*. M.S. Thesis, University of Maine, Orono. 86 p.

Presentations

- Benjamin, J.G. 2010. *Developing Woody Biomass Retention Guidelines in Maine*. Presentation to the Maine Cooperative Forestry Research Unit At Lessons From the Past – Research for the Future: A Workshop for CFRU Members, Orono, Maine. May 20.
- Benjamin, J.G. 2010. *Operational Considerations for Harvest and Transport of Woody Biomass*. Invited Presentation At the NCASI Northern Regional Meeting. Portland, Maine. May 13.

- Benjamin, J.G. 2010. *Woody Biomass: A Pile of Topics*. Invited Presentation At the Workshop on *Woody Biomass Guidelines*. Somerset County Soil and Water Conservation District. Skowhegan, Maine. June 2.
- Colgan, R.J. Lilieholm, Kartez, Kim, Bell. March 2011. *Sustainable Urban Futures for Maine*. Maine Water Conference, Augusta Civic Center.
- Day, M.E., M.S. Greenwood, and K. Spencer. 2010. *Development and Growth-Limits in Temperate Conifers: An Evolutionary Stable Perspective*. p. 23. ECANUSA Forest Science Conference, Conference Proceedings. 14-16 October University of Moncton, Edmonston, NB, Canada.
- Fuller, A.K., D.J. Harrison, and W.B. Krohn. 2010. *Applications of Habitat Modeling for Wildlife Umbrella Species to Landscape Planning on Commercial Forestlands*. Presentation to the Maine Cooperative Forestry Research Unit, Orono, Maine. April 14.
- Gorczyca, E. "A Family Matter: The Use of Agent-Based Modeling and Social Learning to Promote Sustainable Family Forest Management in Maine," for the School of Forest Resources Noontime Seminar, December 2010. Orono, ME.
- Gorczyca E., Leahy, J., and Mercier, W. "A Family Matter: The Use of Agent-Based Modeling and Social Learning to Promote Sustainable Family Forest Management in Maine," for the Small Woodland Owners Association of Maine Annual Meeting, January 2011. Augusta, ME.
- Gorczyca, E., Leahy, J., Wilson, J., Bell, K., and Mercier, W. "An Application of Agent-Based Modeling: Harvest Decisions of Family Forest Landowners in Maine," for the International Symposium on Society and Resource Management, June 2011. Madison, WI.
- Harrison, D., E. Simons, A. Fuller, and W. Krohn. 2011. *Habitat Planning and Assessment for Forest Vertebrates in Northern Maine*. Invited Presentation At Annual Coordinating Committee Meeting of the U.S. Geological Survey, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, Orono, April 12.
- Harrison, D.J., E. Simons, A. Whitman, J. Wilson. 2010. *Present and Future Status of Biodiversity on Managed Forest Landscapes in Maine*, U.S.A. Presentation At the Annual Meeting of the Society for Conservation Biology, Edmonton, Alberta, July 7
- Harrison, D., W. Krohn, and S. Scott. 2010. *Spatio-Temporal Relationships of Snowshoe Hare Populations to Forest Harvesting, Succession, and Natural Population Cycles: Implications for Forest Managers*. Final Project Report Presentation to the Maine Cooperative Forestry Research Unit, Orono, Maine. January 27.
- Harrison, D., W. Krohn, and S. Scott. 2010. *Snowshoe Hares, Forestry and Canada Lynx: A Dynamic Interaction*. Presentation to the Maine Cooperative Forestry Research Unit At Lessons From the Past –Research for the Future: A Workshop for CFRU Members, Orono, Maine. May 20.
- Harrison, D. J., E. Simons, A. Whitman, and J. Wilson. 2009. *Quantifying Biodiversity Values Across Managed Landscapes in Northern and Western Maine*. Presentation to the Maine Cooperative Forestry Research Unit, Mars Hill, Maine, October 28.
- Hennigar, C.J. Gunn, L. Amos-Binks, R. Cameron, D. MacLean, and M. Twery. 2010. *Tracking Carbon in the Forest*. Presentation to the Maine Cooperative Forestry Research Unit At Lessons From the Past –Research for the Future: A Workshop for CFRU Members, Orono, Maine. May 20.
- Jansujwicz, R.J. Lilieholm, A. Calhoun. May 2011. *Communicating Sustainability Through Citizen Science: Challenges and (Missed) Opportunities*. Citizen Science Symposium, University of Maine, Orono
- Jansujwicz, R.J. Lilieholm, A. Calhoun. March 2011. *Spanning Boundaries and Disciplines: Integrating Social and Natural Sciences for Effective Water Resource Management*. Maine Water Conference, Augusta Civic Center.
- Johnson, R.J. Lilieholm, Cronan, Owen, and Meyer. March 2011. *Using Bayesian Belief Networks to Identify At-Risk Aquatic Resources Under Alternative Future Development Scenarios*. Maine Water Conference, Augusta Civic Center.
- Kenefic, L., Wilson, J. Brissette, R. Nyland, and R.J. Lilieholm. October 2010. *Silvicultural Rehabilitation of Cutover Mixedwood Stands*. ECANUSA Forest Science Conference, Edmundston, N.B.
- Leahy, J. "Finding Sustainability Solutions through Family Forest Dynamics," for the Forest People Fire Seminar Series at Oregon State University, January 2011. Corvallis, OR. (Invited, including travel costs paid for by Oregon State University)
- Leahy, J., E. Gorczyca, K. Bell, and J. Wilson. "Improving SES with SES: Considering the Suitability of Engaging Stakeholders in Forest-based Socio-ecological Systems Modeling," for the International Symposium on Society and Resource Management, June 2011. Madison, WI.
- Li, R. and Weiskittel, A.R. 2010. *Modeling the Occurrence, Frequency, and Composition of Ingrowth in the Acadian Region*. FIA and Southern Mensura-

- tionists Joint Symposium. Knoxville, TN. October 5-7. Lilieholm, R.J. Invited Participant. Land Conservation Leadership Dialogue, Members Room, U.S. Library of Congress, Washington, D.C., March 2011
- Lilieholm, R.J. International Scientific Advisory Panel. 8th International Conference on Ecosystems and Sustainable Development, University of Alicante, Spain, April 2011.
- Lilieholm, R.J. June 2011. Building Successful Collaboration: Lessons from UMaine's Sustainability Solutions Initiative. Convergence 2011, University of Maine, Machias.
- Lilieholm, R.J. February 2011. Maine's Sustainability Solutions Initiative. Living on Earth II, Anchorage, AK (with Lindenfeld, Kartez and Daigle).
- Lilieholm, R.J. February 2011. Emerald Ash Borer Research At UMaine. Maine Audubon, Penobscot Valley Chapter, Bangor Public Library, Bangor.
- Lilieholm, R.J. January 2011. Alternative Futures for the Lower Penobscot River Watershed: An Update on Research. Maine's Sustainability Solutions Initiative, Smith Hall (with Cronan, Owen, Meyer, and Johnson).
- Lilieholm, R.J. October 2010. Undergraduate Enrollment Trends in Forestry and Related Natural Resources Fields, 1980-2009. Society of American Foresters' House of Society Delegates Meeting, SAF National Convention, Albuquerque, NM (Sharik Presenting).
- Lilieholm, R.J. October 2010. Undergraduate Enrollment Trends in Forestry and Related Natural Resources Fields, 1980-2009. National Association of University Forest Resource Programs, Albuquerque, NM (Sharik Presenting).
- Lilieholm, R.J. October 2010. Undergraduate Enrollment Trends in Forestry and Related Natural Resources Fields, 1980-2009. USDA Forest Service, Human Resource Management, Albuquerque Service Center (Sharik Presenting).
- Lilieholm, R.J. October 2010. Public Views Toward Forest-Based Biomass and Bioenergy. Cooperative Forestry Research Unit Fall Meeting. University of Maine, Orono (with Marciano, Leahy and Porter).
- Lilieholm, R.J. July 2010. Sustaining Maine's Brown Ash Resource. Presentation to the Maine Indian Basket-Makers Alliance, College of the Atlantic, Bar Harbor, Maine (Ranco Presenting, With Lilieholm, Daigle, Secord and Neptune).
- Lilieholm, R.J., C.S. Cronan, J. McCloskey, S.R. Meyer, M.L. Johnson, J. Tremblay, R. Judd, J.S. Wilson, E.R. Gallandt, S.J. Hornsby, E. Mallory, and T. Glidden. 2010. Analysis of Alternative Futures in the Maine Landscape Using Spatial Models of Coupled Social and Ecological Systems. Maine EPSCoR State Conference. Orono, ME. November 8, 2010.
- Lilieholm, R.S., Foster, September 2010. Wildlands and Woodlands – A Vision for the New England Landscape. BIOECON Conference, Venice, Italy (Lilieholm Presenting, With Foster and Others).
- Lilieholm, R.S., S.R. Meyer, and M.L. Johnson. Alternative Futures for the Lower Penobscot River Watershed. Lower Penobscot River Coalition. Audubon Fields Pond Center, Holden, ME. April 19, 2011.
- Lilieholm, R.J. April 2011. Forestry and Sustainable Development in Maine. Invited Lecture in REP 581 Sustainable Resource Systems and Public Policy (Professor Stewart Smith, Instructor), UMaine, Orono.
- Lilieholm, R.J. April 2011. Alternative Futures for Maine's Forest Industry. Invited Lecture in REP 381 Sustainable Development Principles and Policy (Professor Tim Waring, Instructor), UMaine, Orono.
- Lilieholm, R.J. January 2011. An Introduction to Resource Issues in Uganda. Invited Lecture to INT 475: Tropical Ecology in Uganda, UMaine (Hunter, Calhoun and Seward, Instructors).
- Lyons, P. "There's No Place like Home: The Role of Place Attachment in Predicting Family Forest Landowner Behavior," for the School of Forest Resources Noontime Seminar, December 2010. Orono, ME.
- Lyons, P., and J. Leahy. "There's No Place like Home: The Role of Place Attachment in Understanding Family Forest Landowner Behavior," for the Small Woodland Owners Association of Maine Annual Meeting, January 2011. Augusta, ME.
- Lyons, P., J. Leahy, D. Kittredge, and M. Anderson. 2011. "There's No Place like Home: The Role of Place Attachment in Understanding Family Forest Landowner Behavior," for the International Symposium on Society and Resource Management, June 2011. Madison, WI.
- Meyer, S.R. and M.L. Johnson. (Invited). Co-Presenter and Facilitator Representing Sustainable Solutions Initiative Alternative Futures Project to University of Maine Course Entitled, "Designing and Managing Conservation Projects." Orono, ME. January 3-7, 2011.
- Meyer, S.R., R.J. Lilieholm, C.S. Cronan, M.L. Johnson, J.T. McCloskey, J.W. Wilson, E.G. Gallandt, J. Tremblay, D. Owen, T. Glidden, R. Judd, S. Hornsby, and S. Savage. 2011. Conservation Futures. A Pecha Kucha Presentation to the Maine EPSCoR Conference. Orono, ME. April 15, 2011.

- Meyer, S.R., R.J. Lillieholm, C.S. Cronan, and M.L. Johnson. 2011. *Temporal and Spatial Distributions of Conserved Lands in Maine*. Maine Water Conference. Augusta, ME. March 16, 2011.
- Meyer, S., R.J. Lillieholm, Johnson, Cronan, Gray, Hunter, Lyons, Ravana, Robertson, Vickery. April 2011. *Using the Open Standards for the Practice of Conservation to Assess Future Land Use in the Lower Penobscot River Watershed*. NESAF Annual Meeting, Fairlee, Vermont (Meyer Presenting, With Johnson, Cronan, Gray, Hunter, Lyons, Ravana, Robertson and Vickery).
- Meyer, S., R.J. Lillieholm, Johnson, Lillieholm, and Cronan. March 2011. *Temporal and Spatial Distributions of Conserved Lands in Maine*. Maine Water Conference, Augusta Civic Center.
- Meyer, S. 2010. *Overview of the CFRU. Presentation to the Maine Cooperative Forestry Research Unit At Lessons From the Past—Research for the Future: A Workshop for CFRU Members*, Orono, Maine. May 20.
- Meyer, S. 2010. *Spruce Budworm: Lessons from the Trenches. Presentation to the Maine Cooperative Forestry Research Unit At Lessons From the Past—Research for the Future: A Workshop for CFRU Members*, Orono, Maine. May 20.
- Meyer, S.R. *Invited Talk: Forging Relationships: Conservation, Challenges and Collaboration At the Center for Research on Sustainable Forests*. Maine Society of American Foresters Annual Meeting. Orono, Maine. October 19, 2010.
- Meyer, S.R. and M.G. Olson. 2009. *Project Learning Tree Field Tour At the Penobscot Experimental Forest – Understanding Tree Growth and Regeneration Are Essential to Achieving Sustainable Forest Management*. Bradley, Maine. October 23, 2009.
- Meyer, S.R. 2009. *Spruce Budworm: What's Past Is Prologue. A CFRU Fall Field Tour and Forum*. Caribou, Maine. October 29, 2009.
- Nelson, A.S. 2010. *Spatial Ecology and Compositional Management of American Beech and Sugar Maple Regeneration in Maine*. Presented At the University of Maine, College of Natural Sciences, Forestry and Agriculture Spring 2010 Graduate Student Awards Seminar. Orono, Maine. February 15.
- Nelson, A.S. and R.G. Wagner. 2010. *Managing Beech Barkdisease With Silviculture in Maine*. Presented to the Northeastern Forest Pest Council. March 17.
- Nelson, A.S. and R.G. Wagner. 2010. *CFRU Beech Control Study: 3rd Year Results*. Presented At the Right-of-Way / Forestry Recertification Meeting. May 19.
- Quartuch, M., and J. Leahy. "Using Mixed Methods to Conduct Stakeholder-driven Research on Maine's Family Forest Owners," for the Small Woodland Owners Association of Maine Annual Meeting, January 2011. Augusta, ME.
- Quartuch, M., and T. Beckley. "Who or What do Small-scale Forest Landowners Consider When Making Forest Management Decisions?: Case evidence From Maine and New Brunswick," for International Symposium on Society and Resource Management, June 2011. Madison, WI.
- Quartuch, M., and T. Beckley. 2011. "Why do You Practice Good Management?: Ethical Motivations for Land Stewardship in Sweden, New Brunswick and Maine," for International Symposium on Society and Resource Management, June 2011. Madison, WI.
- Quigley, R.J. Lillieholm, Ranco, Daigle, Secord, Neptune, Livingston, Lizotte. May 2011. *Mobilizing Diverse Interests to Address Invasive Species Threats: The Case of the Emerald Ash Borer in Maine*. Citizen Science Symposium, University of Maine.
- Quigley, R.J. Lillieholm. March 2011. *Threats from the Emerald Ash Borer in Maine*. Student Symposium of the Forest Pest Council Meeting, University of Maine.
- Ranco, R.J. Lillieholm, Quigley, Secord, Neptune, Daigle, McCloskey, Livingston, Lizotte. March 2011. *Mobilizing Diverse Interests to Address Invasive Species Threats: The Case of the Emerald Ash Borer in Maine*. Maine Water Conference, Augusta Civic Center.
- Rijal, B. and Weiskittel, A. 2010. *Development of Regional Height to Crown Base Models in the Acadian Forest*. 14th Annual Northeastern Mensurationists Organization Meeting. Stockbridge, MA. November 1-2.
- Rijal, B. and Weiskittel, A.R. 2010. *Development of Regional Height to Diameter Allometric Equations for Naturally-Regenerated, Mixed Species, and Multi-Cohort Forests of the Acadian Region*. ECANUSA Conference. University of Moncton. Edmundston, New Brunswick. October 14-16.
- Russell, M.B., S.R. Meyer, and R.G. Wagner. 2010. *Recovering Long Lost Data: Successes of Forest Data Management*.
- Russell, M.B. and Weiskittel, A.R. 2010. *Assessing Model Prediction Uncertainty in Forecasting Long-Term Tree Basal Area and Diameter Increment for the Primary Acadian Tree Species*. ECANUSA Conference. University of Moncton. Edmundston, New Brunswick. October 14-16.

- Russell, M.B. Presentation to the Maine Cooperative Forestry Research Unit At Lessons From the Past—Research for the Future: A Workshop for CFRU Members, Orono, Maine. May 20.
- Russell, M.B. and Weiskittel, A.R. 2010. Development of Maximum and Stand-Grown Crown Width Equations for the Primary Species in the Acadian Region. FIA and Southern Mensurationists Joint Symposium. Knoxville, TN. October 5-7.
- Seymour, R.S. 2010. Two-Aged Silviculture of Spruce-Fir-White Pine Mixtures. Presentation to the Maine Cooperative Forestry Research Unit At Lessons From the Past – Research for the Future: A Workshop for CFRU Members, Orono, Maine. May 20.
- Seymour, R.S. 2010. The CFRU Commercial Thinning Network. Presented to the Maine Industrial Forestry Forum, Forest Resources Association. Brewer, ME. May 13.
- Seymour, R.S. and L.S. Kenefic. 2011. Sixty Years of Experience Managing Conifers: Can We Really Favor Red Spruce? 8th Biennial North American Forest Ecology Workshop, Roanoke, Virginia. June 21, 2011.
- Shank, E., J. Leahy, and A. Shultz. "An Analysis of Maine Forest Service WoodsWISE Forest Stewardship Management Plan Evaluations," for the Small Woodland Owners Association of Maine Annual Meeting, January 2011. Augusta, ME.
- Shank, E., P. Lyons, and J. Leahy. "Family Ties: Exploring Intergenerational Estate Transfer Among Maine's Family Forest Owners," for the New England Society of American Foresters Annual Winter Meeting, March 2011. Fairlee, VT.
- Shank, E., P. Lyons, P., and J. Leahy. "The Existence and Creation of Intergenerational Estate Transfer Plans Among Family Forest Owners in Maine" for the University of Maine Center for Undergraduate Research, Annual Undergraduate Research & Academic Showcase, March 2011. Orono, ME.
- Sharik, T.L. and R.J. Lillieholm. June 2011. Undergraduate Enrollment Trends in Natural Resources in the United States: An Update. Integrated Conservation and Sustainable Living. International Symposium on Society and Resource Management, Madison, WI.
- Simons, E. 2010. Quantifying Biodiversity: Seeing the Big Picture. Presentation to the Maine Cooperative Forestry Research Unit At Lessons From the Past – Research for the Future: A Workshop for CFRU Members, Orono, Maine. May 20.
- Simons, E., D. Harrison, A. Whitman, and J. Wilson. 2010. Present and Future Status of Biodiversity in Maine's Commercial Forests As Indicated by a Suite of Condition Indicators. Presented At the Department of Wildlife Ecology Spring Seminar Series, University of Maine, Orono. March 29.
- Simons-Legaard, E.M., D.J. Harrison, K. Legaard, and S. Sader. 2010. The Effectiveness of Zoning to Protect Deer Wintering Areas During the Period 1975-2007: Does Compromising Forest Productivity to Protect Deer Habitat Achieve Desired Ecological Objectives? Invited Presentation At Advisory Committee Meeting, Maine Cooperative Forestry Research Unit, University of Maine, Orono, January 26.
- Simons, E.M., W.B. Krohn, and D.J. Harrison. 2010. Influences of Past and Future Forest Management on the Spatiotemporal Dynamics of Habitat Supply for Canada Lynx and American Marten. Presentation to the Maine Cooperative Fish and Wildlife Research Unit, Cooperators' Meeting, University of Maine, Orono. May 11.
- Tessema, R.J. Lillieholm, Blahna, Kruger. June 2011. Community-Resource Linkages on Alaska's National Forests. Integrated Conservation and Sustainable Living. International Symposium on Society and Resource Management, Madison, WI.
- Wagner, R.G. Budworms, Humans, Hares & Lynx: Interactions in the Forest and the Unforeseen Consequences. Dirigo Pines Retirement Community, Orono, Maine. June 2010.
- Wagner, R.G. Increasing Biomass Production in Maine Forests? Invited Presentation to the Maine Nature Conservancy Board, Greenville, Maine. June 2010.
- Wagner, R.G. Maine's Commercial Thinning Research Network Study Proposal. National Science Foundation Industry & University Cooperative Research Program (I/UCRC), Center For Advanced Forestry Systems (CAFS). Indianapolis, Indiana. April 2010.
- Wagner, R.G., J. Benjamin, and A. Weiskittel. Increasing Biomass Production in Maine Forests? Invited Presentation and Recorded Podcast At the National Council for Air & Stream Improvement (NCASI) Northern Regional Meeting. Holiday Inn By the Bay Hotel & Convention Center, Portland, Maine. May 12-13, 2010.
- Waskiewicz, J.D., R. Seymour, A. Weiskittel. 2011. Structure, Composition, and Growth Rate in Northern Red Oak – Eastern White Pine-Dominated Mixed Stands At the Massabesic Experimental Forest, Southern Maine. North American Forest Ecology Workshop (NAFEW), Roanoke, VA, June.
- Waskiewicz, J.D., L. Kenefic, R. Seymour, A. Weiskittel. 2010. Effects of Neighborhood-Scale Competition and Composition on Individual Tree

Growth in Oak-Pine Mixed Stands in Maine. Oral Presentation At Eastern Canada / USA (ECANUSA) Forest Science Conference, Edmundston, NB, October 15.

Weiskittel A. and R. Li. 2010. *Modeling Stem Form: Is It Time for a New Volume Equation?. Presentation to the Maine Cooperative Forestry Research Unit At Lessons From the Past—Research for the Future: A Workshop for CFRU Members, Orono, Maine. May 20.*

Weiskittel, A. 2010. *Avoiding the Growth and Yield “black Box” Syndrome. Presentation to the Maine Cooperative Forestry Research Unit At Lessons From the Past—Research for the Future: A Workshop for CFRU Members, Orono, Maine. May 20.*

Whitman, A. 2010. *Climate Change Or Global Weirding?. Presentation to the Maine Cooperative Forestry Research Unit At Lessons From the Past – Research for the Future: A Workshop for CFRU Members, Orono, Maine. May 20.*

Willand, M. *Maine Agricultural Trade Show, January 2011, Augusta, ME. “Woodland Owner Attitudes Toward Public Use of Private Land in Maine: What It Means for Landowner Relations.”*

Willand, M. *Landowner Relations Conference, December 2010, Augusta, ME. “Finding Common Ground: Examining Meaningful Incentives for Small Woodland Owners in Maine.”*

Willand, M. *Sportsman/Forest Landowners Alliance, May 12th, 2011 “Finding Common Ground: Exploring Meaningful Incentives for Family Forest Owners to Encourage Public Access to Private Lands in Maine.”*

Wilson, J.S. 2009. *Spruce Budworm Decision Support: Application and Pitfalls. Presented At the Cooperative Forestry Research Unit Fall Field Tour and Forum. Caribou, Maine. October 29.*

Wilson, J.S. 2009. *Decision Support for Future Spruce Budworm Outbreaks in Maine. Presented At the Northeast Forest Health Field Workshop. Winter Harbor, Maine. June 2-4.*

Wilson, J.S., E.M. Simons, K.R. Legaard, S.A. Sader, and J. Leahy. *Spatial Forest Planning to Meet Multiple Natural Resource Goals. Eastern CANUSA Forest Science Conference. Edmundston, New Brunswick. October 15, 2010.*

Wilson, J.S., E. Simons, K. Legaard, S. Sader, J. Leahy, and A. Weiskittel. 2011. *Landscape Inertia, the Impact of Past Practices on Future Forest Scenarios in Northern Maine. SFR Noontime Seminar. Orono, ME. 4/8/2011.*

Conference Proceedings

Benjamin, J.G., D.J. Mansius, and K. Albert. 2010. *Developing Woody Biomass Retention Guidelines in Maine. 2010 Council on Forest Engineering. Auburn, Alabama. June 6-9.*

Burke, A.M., I.J. Fernandez, A. Weiskittel, and R. Wagner. 2009. *Modeling Balsam Fir Nutrient Uptake to Address Sustainability Concerns in an Age of Bioenergy Opportunity. Carbon in Northern Forests Meeting. Traverse City, MI. June 9–12.*

Jansujwicz, J.S., A.J.K. Calhoun, and R.J. Lillieholm. 2010. *Cooperation and Natural Resource Management: Community-Based Vernal Pool Conservation Planning in Maine, USA. Abstract in Proceedings of the 24th Annual Meeting of the Society for Conservation Biology, Edmonton, Alberta, Canada.*

Jansujwicz, J.S., A.J.K. Calhoun, and R.J. Lillieholm. 2010. *Cooperation and Natural Resource Management: Community-Based Vernal Pool Conservation Planning in Maine, USA. Abstract in the Proceedings of the 16th International Symposium on Society and Resource Management, Corpus Christi, TX.*

Kenefic, L., J.S. Wilson, J. Brissette, R. Nyland, and R.J. Lillieholm. 2010. *Silvicultural Rehabilitation of Cutover Mixedwood Stands. Annual Meeting of the New England Chapter of the Society of American Foresters, Durham, NH.*

Li, R. and Weiskittel, A.R. 2010. *Modeling the Occurrence, Frequency, and Composition of Ingrowth in the Acadian Region. FIA and Southern Mensurationists Joint Symposium. Knoxville, TN. October 5-7.*

Li, R., Weiskittel, A.R., Dick, A., Kershaw, J.A. 2010. *Evaluating Stem Taper and Bark Thickness Equations for the Major Conifer Species in the Acadian Region of North America. ECANUSA Conference. Universite De Moncton. Edmundston, New Brunswick. October 14-16.*

Lillieholm, R.J., D. Foster, L.C. Irland, and M. Hunter. 2010. *Wildlands and Woodlands: A Vision for the New England Landscape. Maine Land Conservation Conference, Topsham, ME.*

Lillieholm, R.J., M.E. Tessema, D.J. Blahna, and L.E. Kruger. 2010. *Using Secondary Data to Estimate Community-Resource Linkages in Utah’s Grand Staircase-Escalante National Monument. Pages 424-435 in Proceedings of the Grand Staircase-Escalante National Monument Science Symposium, Southern Utah University. 545 Pages.*

- Looze, B. and S.A. Sader. *Analysis of Fragmentation and Large-Diameter Forest in Maine*. New England Society of American Foresters Winter Meeting, Lake Morey, Fairlee, Vermont 03/30/2011
- Mallet, D.G., D.J. Harrison, and A.K. Fuller. 2010. *Variable Fix Success of GPS Collars Across Habitats Used by Canada Lynx: Influences of Habitat Structure, Topography, and Satellite Configuration*. 66th Annual Northeast Fish and Wildlife Conference. Newton, Massachusetts. April 27.
- McCloskey, J.T., R.J. Lillieholm, R. Boone, R. Reid, D. Nkedianye, S. Sader, M. Said, and J. Worden. (In Press). *A Participatory Approach for Modeling Alternative Future Land Use Scenarios Around Nairobi National Park Using Bayesian Belief Networks*. *Ecology and the Environment*.
- Nelson, A.S., R.G. Wagner, and M.R. Saunders. 2010. *Hybrid Poplar Production and Survival on Forested Sites in Maine*. ECANUSA Conference. Universite De Moncton. Edmundston, New Brunswick. October 14-16.
- Nelson, A.S. and R.G. Wagner. 2010. *Spatial Patterns of American Beech and Sugar Maple Regeneration in Beechdominated Understories in Maine*. ECANUSA Conference. Universite De Moncton. Edmundston, New Brunswick. October 14-16.
- Olson, M.G. and R.G. Wagner. 2010. *40-Year Compositional Dynamics of a Long-Term Silviculture Experiment in Northern Maine: The Austin Pond Study*. ECANUSA Conference, October 14-16, Universite De Moncton, Edmundston, NB, Canada.
- Quartuch, M., and J. Leahy. 2011. "The Future of Maine's Changing Family Forests: Preliminary Analysis of Tipping Points in Landowner Attitudes and Behaviors," for the International Symposium on Society and Resource Management, June 2011. Madison, WI.
- Rijal, B. and Weiskittel, A.R. 2010. *Development of Regional Height to Diameter Allometric Equations for Naturally Regenerated, Mixed Species, and Multi-Cohort Forests of the Acadian Region*. ECANUSA Conference. Universite De Moncton. Edmundston, New Brunswick. October 14-16.
- Rijal, B. and Weiskittel, A. 2010. *Development of Regional Height to Crown Base Models in the Acadian Forest*. 14th Annual Northeastern Mensurationists Organization Meeting. Stockbridge, MA. November 1-2.
- Russell, M.B. and Weiskittel, A.R. 2010. *Development of Maximum and Stand-Grown Crown Width Equations for the Primary Species in the Acadian Region*. FIA and Southern Mensurationists Joint Symposium. Knoxville, TN. October 5-7.
- Russell, M.B. and Weiskittel, A.R. 2010. *Assessing Model Prediction Uncertainty in Forecasting Long-Term Tree Basal Area and Diameter Increment for the Primary Acadian Tree Species*. ECANUSA Conference. Universite De Moncton. Edmundston, New Brunswick. October 14-16.
- Sharik, T.L., and R.J. Lillieholm. 2011. *Undergraduate Enrollment Trends in Natural Resources in the United States: An Update*. Abstract in the Proceedings of the 17th International Symposium on Society and Resource Management, Madison, WI.
- Smith, T. and S.A. Sader. *Evaluation of Partial Harvesting on Multiple Ownerships in Maine*. New England Society of American Foresters Winter Meeting, Lake Morey, Fairlee, Vermont 03/30/2011
- Tessema, M.E., R.J. Lillieholm, D.J. Blahna, and L.E. Kruger. 2011. *Measuring Community-Forest Resource Use, Dependency, and Vulnerability in Southcentral and Southeast Alaska*. Abstract in the Proceedings of the 17th International Symposium on Society and Resource Management, Madison, WI.
- Wilson, J.S., K. Legaard, E. Simons, S. Sader, and J. Leahy. 2010. *Developing Geospatial Tools to Forecast Management Outcomes Across a Diverse Landscape of Ownership Types and Stakeholder Interests*. ECANUSA Conference. Universite De Moncton. Edmundston, New Brunswick. October 14-16.

Posters

- Clune, P., Wagner, R., Weiskittel, A., Seymour, R.S., and Meyer, S. 2010. *Commercial Thinning Research Network: New Site Additions and Plans for Future Analysis of Commercial Thinning Responses in Maine Spruce-Fir Stands*. ECANUSA Conference. University of Moncton. Edmundston, New Brunswick. October 14-16.
- Dhungel, S., A. Halog, and J. Benjamin. 2010. *Carbon Footprint of Biomass Harvesting: An Empirical Study from Maine*. 4th Canadian Forum on the Life Cycle Management of Products and Services, Holiday Inn Montreal-Midtown. Montreal, Quebec. May 4-5.
- Lillieholm, R.J. May 2011. *Analysis of Alternative Futures of the Maine Landscape Using Stakeholder-Derived Models*. American Association of Geographers Annual Meeting, Seattle, WA. (Johnson Presenting, With Cronan, Meyer, Tremblay and McCloskey.)
- Lillieholm, R.J. May 2011. *Mobilizing Diverse Interests to Address Invasive Species Threats: The Case of the Emerald Ash Borer in Maine*. Citizen Science Symposium: Connecting Communities With the

- Natural World. Orono. (Quigley Presenting, With Ranco, Secord, Neptune, Daigle, McCloskey, Livingston and Lizotte).*
- Lilieholm, R.J. May 2011. *Population Persistence in Complex Landscapes: Vernal Pools As a Model System. 2010. Citizen Science Symposium: Connecting Communities With the Natural World, Orono. (Jansujwicz Presenting, With Hunter, Ryan, Cline, Bell, Levesque, Morgan, Popescu, Calhoun and Loftin).*
- Lilieholm, R.J. February 2011. *Mobilizing Diverse Interests to Address Invasive Species Threats: The Case of the Emerald Ash Borer in Maine. 2nd Annual Maine Invasive Species Network Meeting, Orono. (Quigley Presenting, With Ranco, Secord, Neptune, Daigle, McCloskey, Livingston and Lizotte).*
- Lilieholm, R.J. December 2010. *Mobilizing Diverse Interests to Address Invasive Species Threats: The Case of the Emerald Ash Borer in Maine. World Sustainable Development Teach-in Day, University of Maine, Orono (Quigley Presenting, With Ranco, Secord, Neptune, Daigle, McCloskey, Livingston and Lizotte).*
- Lilieholm, R.J. November 2010. *Mobilizing Diverse Interests to Address Invasive Species Threats: The Case of the Emerald Ash Borer in Maine. 2010 Maine State EPSCoR Conference, University of Maine, Orono (with Quigley, Ranco, Secord, Neptune, Daigle, McCloskey, Livingston and Lizotte).*
- Lilieholm, R.J. November 2010. *Comparison of Undergraduate Enrollment Trends in Forestry-Related Programs Between the USA and China. 2010 Maine State EPSCoR Conference, University of Maine, Orono. (Lilieholm Presenting, With Sharik, Neuvonen, Wang and Chen).*
- Lilieholm, R.J. November 2010. *Engaging High School Students in Science-Based Study Abroad Programs: Leatherback Sea Turtle Research and Conservation At the Pacuare National Reserve, Costa Rica. 2010 Maine State EPSCoR Conference, University of Maine, Orono. (With Jennifer Lilieholm and Morris).*
- Lilieholm, R.J. November 2010. *Population Persistence in Complex Landscapes: Vernal Pools As a Model System. 2010 Maine State EPSCoR Conference, University of Maine, Orono. (With Jansujwicz, Hunter, Ryan, Cline, Bell, Levesque, Morgan, Popescu, Calhoun and Loftin).*
- Lilieholm, R.J. November 2010. *Analysis of Alternative Futures of the Maine Landscape Using Spatial Models of Coupled Social and Ecological Systems. 2010 Maine State EPSCoR Conference, University of Maine, Orono. (With Cronan, Judd, Wilson, Gallandt, Hornsby, McCloskey, Tremblay, Johnson, Meyer, Mallory and Glidden)*
- Lilieholm, R.J. November 2010. *Alternative Futures Modeling in Kenya's National Parks and Reserves. 2010 Maine State EPSCoR Conference, University of Maine, Orono. (With McCloskey, Boone, Reid, Worden and Ogutu).*
- Meyer, S.R., R.J. Lilieholm, C.S. Cronan, M.L. Johnson, J.T. McCloskey, J.W. Wilson, E.G. Gallandt, J. Tremblay, T. Glidden, R. Judd, S. Hornsby, and E. Mallory. 2011. *Using Bayesian Belief Networks to Model Future Land Use in Maine. Poster Presentation to Maine EPSCoR Conference. Orono, ME. April 15, 2011.*
- Meyer, S.R., R.J. Lilieholm, C.S. Cronan, M.L. Johnson, and J.T. McCloskey. 2011. *Using Bayesian Belief Networks to Model Future Land Uses in Maine. Poster Presentation At United States-International Association of Landscape Ecology Symposium. Portland, OR. April 3-7, 2011.*
- Meyer, S.R., M.L. Johnson, R.J. Lilieholm, and C.S. Cronan. 2010. *Spatial and Temporal Distribution of Conserved Lands in Maine and the Northeast. Tied for 1st Place in Poster Session At Maine GIS Educators Conference. Augusta, ME. November 19, 2010.*
- Pekol, J. Weiskittel, A.R., Wagner, R.G., and Seymour, R.S. 2010. *Individual- and Stand-Level Mortality in Red Spruce/balsam Fir Stands Receiving Precommercial and Commercial Thinning. Poster Presentation At ECANUSA Conference. University of Moncton, Edmundston, New Brunswick. October 14-16.*
- Rice B. and R.G. Wagner. 2010. *Effects of Nonselective Partial Harvesting in Maine's Working Forests. ECANUSA Conference, October 14-16, Universite De Moncton, Edmundston, NB, Canada.*
- Roxby, Gabriel. 2011. *Evaluating the Sustainability of Whole Tree Harvesting Graduate Research Conference April 25-26. University of New Hampshire. Poster Presentation.*
- Scott, S.A., W.B. Krohn, and D.J. Harrison. 2010. *Influence of Declining Snowshoe Hare Densities on Canada Lynx Occurrence in Northern Maine. Poster Presentation At the Maine Cooperative Fish and Wildlife Research Unit Cooperator's Meeting University of Maine, Orono. May 11.*
- Simons, E., W. Krohn, and D. Harrison. 2010. *Predicting Responses of Forest Landscape Changes on Wildlife Umbrella Species: Future Projections Results for Canada Lynx and American Marten. Poster Presentation At the Maine Cooperative Fish and Wildlife Research Unit Cooperator's Meeting University of Maine, Orono. May 11.*
- Willand, M. *National Association of Recreation Resource Planners, May 2011, Breckenridge, CO "Finding Common Ground: Exploring Meaningful*

Incentives for Family Forest Owners to Encourage Public Recreation Access to Private Lands in Maine."

Willand, M. *Maine Agricultural Trade Show, January 2011, Augusta, ME* "Exploring Incentives for Public Recreation Access in a Dominantly Privately Owned Landscape: Differing Perspectives Between Landowners, Interest Groups and Government."

Wilson, J.S., E.M. Simons, K.R. Legaard, S.A. Sader, and J. Leahy. *Spatial Forest Planning for Meeting Multiple Natural Resource Goals. Poster Presented At Maine EPSCoR State Conference. University of Maine, Orono, Maine. November 8, 2010.*

Other

Leahy, J. 2011. *Interviewed by Frank Ferrel from Maine Public Broadcasting Network about family forests. Arranged and accompanied filming of trucking operations and hand crew harvesting.*

Liliehalm, R.J., R. Boone, R. Reid, J. Worden, M. Said, J.T. McCloskey S. Sader, D. Nkedianye, D. Kaelo, and J. Stabach. 2011. *Alternative Futures for Kenya's National Parks and Wildlife Reserves. Harvard University, Kennedy School of Government, Conservation Innovation Series Entitled "Pioneers of Landscape-Scale Conservation"* (December). (<http://www.innovations.harvard.edu/xchat-Transcript.html?chid=356>)

Liliehalm, R.J. 2010. *Wildlands and Woodlands Report Summary. UMaine Webcast.*

Liliehalm, R.J. 2010. *Maine's Conservation Legacy. UMaine Webcast.*

Liliehalm, R.J., D. Ranco, J. Daigle, T. Secord, and J. Neptune. 2010. *Sustaining Maine's Brown Ash Resource. UMaine Sustainability Solutions Initiative.* (<http://www.umaine.edu/brownash/>)

Liliehalm, R.J. 2010. *Invited Review of "Twentieth-Century New England Land Conservation: A Heritage of Civic Engagement," Edited by Charles H.W. Foster. The Quarterly Review of Biology 85(4):497-498.*

Liliehalm, R.J. June 2011. *Alternative Futures for Kenya's Wildlife Reserves. Narrated Slide Show on the UMaine Webpage.*

Liliehalm, R.J. December 2010. *Pioneers in Large Landscape Conservation: Lions and Tigers and Bears. Webinar, Harvard's Kennedy School of Government (with Levitt, Tabor and Nyhus).*

Lyons, P. and Leahy, J. 2010. "Center for Research on Sustainable Forests: Family Forest Initiative." *Flyer. Hall of Flags Event. This is a joint College of Natural Sciences, Forestry, and Agriculture and*

University of Maine Cooperative Extension event with the goal of increasing the awareness of the value of college and extension programs by State of Maine leaders.

Lyons, P., I. Foertsch, and J. Leahy. 2011. "Family Forest Research Unit: Center for Research on Sustainable Forests." *Oral presentation and Discussion, for Maine Chapter of the Association of Consulting Foresters' Monthly Meeting, Waterville, ME.*

Lyons, P. and M. Quartuch. 2010. *Representatives to the Forest Working Group. The Forest Working Group is composed of representatives from the Maine Forest Service, USDA Forest Service (State and Private Forestry), Natural Resources Conservation Service, the Threshold to Maine Resource Conservation & Development, UMaine Cooperative Extension, and UMaine Center for Research on Sustainable Forests.*

Lyons, P. and J. Leahy. 2011. "The Impact of Family Forests on Maine's Economy." *Poster presentation and discussion. Hall of Flags Event. This is a joint College of Natural Sciences, Forestry, and Agriculture and University of Maine Cooperative Extension event with the goal of increasing the awareness of the value of college and extension programs by State of Maine leaders.*

Meyer, S.R., M.L. Johnson, and M. Quartuch. *Co-organizers of the University of Maine Cooperative Extension and Sustainability Solutions Initiative World Sustainable Development Teach-In Day Workshop titled, "Research-Extension Partnerships in Sustainability Science: Bridging Research-Based Knowledge with Client-Based Needs," December 2010, Orono, ME.*

Quartuch, M. *Emerging Engagement Scholar and participated in a two-day workshop prior to attending the National Outreach Scholarship Conference in October 2010 in Raleigh, NC.*

Willand, M. *Wildfire Maine, 5/25/11 "Tom Doaks of SWOAM Talks About Landowner Issues." [Http://www.wildfiremaine.tv/blog/post/tom-Doak-2](http://www.wildfiremaine.tv/blog/post/tom-Doak-2)*

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