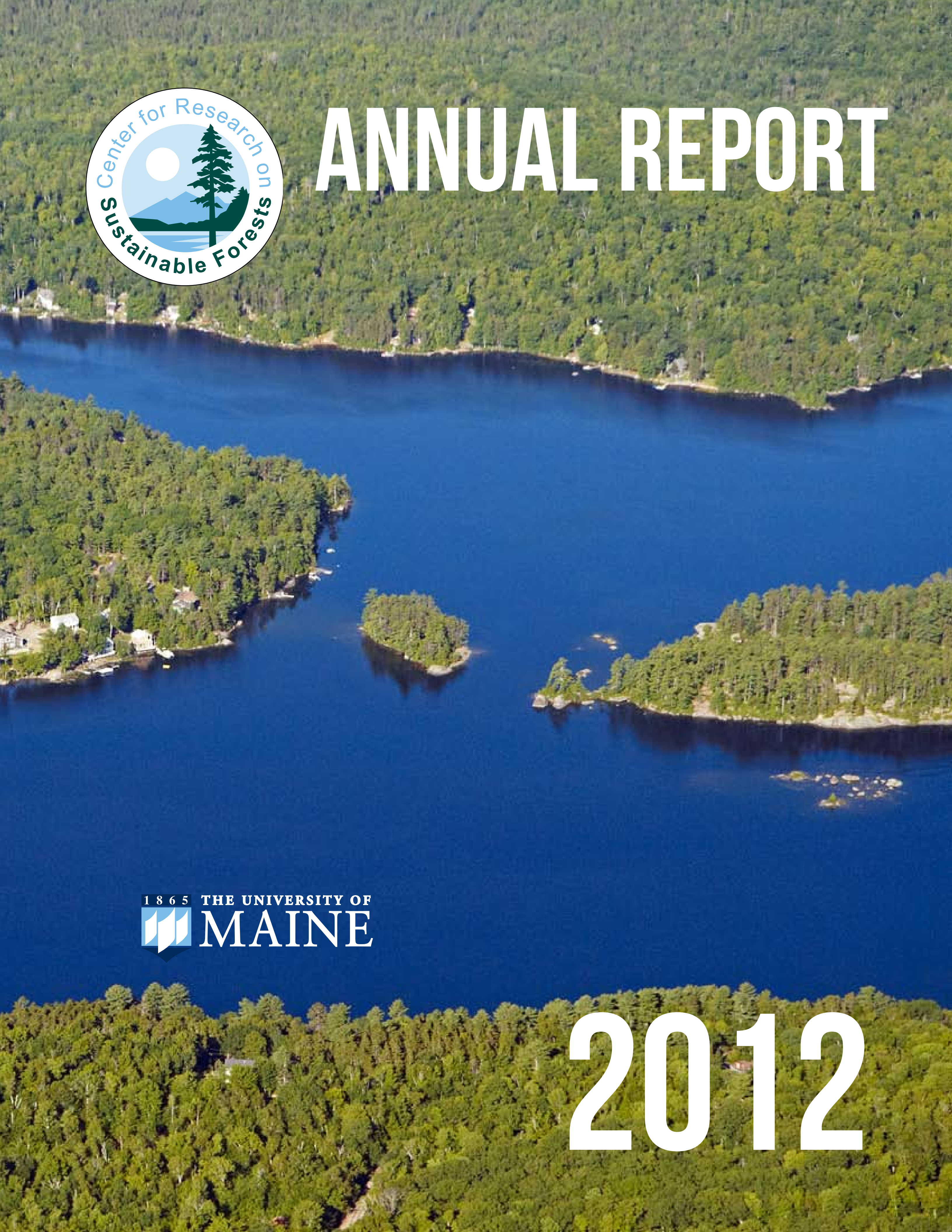
Center for Research on Sustainable Forests

ANNUAL REPORT



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2012

CENTER FOR RESEARCH ON SUSTAINABLE FORESTS

2012 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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Cover photo: *Phillips Lake* by Pam Wells

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Center for Research on Sustainable Forests

$1.5 MILLION IN FUNDING

130 PARTNER ORGANIZATIONS

> 8.2 MILLION ACRES REPRESENTED

47 FACULTY, STAFF, AND STUDENTS ENGAGED

57 PUBLICATIONS & >90 PUBLIC PRESENTATIONS

EXECUTIVE SUMMARY

In 2012, the Center for Research on Sustainable Forests (CRSF) completed its second year under an expanded mission to serve the needs of all forest stakeholders in Maine. Building on its rich tradition of working with industrial partners to conduct research related to commercial forestry in the state, the CRSF now strives to solve the challenges of three distinct segments of Maine's 17 million acres of forest: *Commercial Forests*, *Family Forests*, and *Conservation Lands*. With a renewed focus on relevant, stakeholder-driven research, the CRSF has emerged as a key source of scientific information about all of these forest resources.

In 2012, CRSF raised over $1.5 million of federal, state, and private funding for forest research. These funds supported 29 research projects focused on Maine's commercial forests, family forest landowners, and conservation interests ranging from NGOs to the general public. These research projects resulted in nearly 60 research publications and more than 90 public and scientific presentations. In addition, our 47 faculty, staff, and students spent countless hours working with our stakeholders to understand their research needs, and many more hours delivering research results to them and to scientific and broader public audiences.

The formation of several strategic partnerships has been a key to the success of the CRSF. UMaine's *Sustainability Solutions Initiative* and *Forest Bioproducts Research Initiative*, the U.S. Forest Service *Northern States Research Cooperative*, the National Science Foundation *Center for Advanced Forestry Systems*, and the *Forest for Maine's Future* consortium provide CRSF researchers with linkages to funding, stakeholder groups, outreach programs, and other resources that enrich our work. In addition, CRSF researchers worked with more than 130 other governmental, non-governmental, and private stakeholder organizations this year.

This report recounts the myriad successes that CRSF had in 2012. Please *contact us* for more information if you would like to be part of uncovering the science behind the Maine Woods.

Spencer Meyer

DIRECTOR'S REPORT

Center for Research on Sustainable Forests

This report marks the end of the second year of operation for the Center for Research on Sustainable Forests (CRSF) under the new organizational design that was initiated last year (see the *2011 Annual Report*). Each of the research programs within CRSF has been very productive over the past year. **Dr. Jessica Leahy** and her graduate students have done a wonderful job building the *Family Forests Research Unit*, delivering one of the largest efforts to serve small woodland owners around the state that UMaine has had in many years. Under the leadership of **Dr. Rob Lilieholm**, the *Conservation Lands Program* has done a great job addressing a number of critical issues facing Maine's conservation lands. **Dr. Brian Roth** did an outstanding job during his first year as Associate Director of the Cooperative Forestry Research Unit (*CFRU)*, including organizing several very well attend workshops and coordinating several large field studies.

In addition to pursuing a Ph.D., **Spencer Meyer** has done a very nice job as the Associate Scientist for the Family Forests and Conservation Lands programs, including maintaining the CRSF web page, managing communications, and compiling this annual report. **Dr. Mohammad Bataineh** had a productive first year as a Post-Doctoral Fellow working with the CFRU and USFS Northern Research Station by developing several new research projects and proposals. **Kae Cooney** did a fantastic job this year managing the CRSF and *NSRC*, as well as the CFRU after the departure of the CFRU administrative assistant. **Rosanna Libby** left the CFRU after four years of faithful service. We thank her for her dedication and hard work over the years. We are searching for a replacement that should be in place by the end of summer 2012.

Finally, we all very much appreciate the continued support for the CRSF provided by Dr. **Mike Eckardt**, Vice President for Research.

Robert G. Wagner, CRSF Director

PEOPLE

Leadership & Staff

Robert Wagner
Director

Jessica Leahy
Family Forest Research Unit Leader

Rob Lilieholm
Conservation Lands Program Leader

Spencer Meyer
Associate Scientist for Forest Stewardship

Brian Roth
CFRU Associate Director

Mohammed Bataineh
CFRU Post-Doctoral Research Scientist

Matthew Russell
CFRU Forest Data Manager

Kae Cooney
CRSF Administrative Assistant

Rosanna Libby
CFRU Administrative Assistant

Note: All personnel are from University of Maine, unless otherwise noted.

Cooperating Scientists

Jeffrey Benjamin (CFRU)
Daniel Harrison (CFRU)
Robert Seymour (CFRU)
Aaron Weiskittel (CFRU)

Graduate Students

Patrick Clune (CFRU)
Steven Dunham (CFRU)
Erika Gorczyca (Family Forests)
Patrick Hiesl (CFRU)
Michelle Johnson (SSI, Cons. Lands)
Patrick Lyons (Family Forests)
Emily Meachum (CFRU)
Spencer Meyer (SSI, Cons. Lands)
Andrew Nelson (CFRU)
Sheryn Olson (CFRU)
Joseph Pekol (CFRU)
Michael Quartuch (SSI, Family Forests)
Ben Rice (CFRU)
Baburam Rijal (CFRU)
Matthew Russell (CFRU)
Brittney Townsend (Family Forests)

Project Scientists

Thom Erdle, *Univ. of New Brunswick* (CFRU)
Angela Fuller, *New York Cooperative Fish and Wildlife Research Unit* (CFRU)
Gary Hawley, *Univ. of Vermont* (NSRC)
Chris Hennigar, *Univ. of New Brunswick* (CFRU)
Ted Howard, *Univ. of New Hampshire* (NSRC)
John Kershaw, *Univ. of New Brunswick* (CFRU)
Kasey Legaard (NSRC)
David MacLean, *Univ. of New Brunswick* (CFRU)
Andrew Nelson (NSRC, CFRU)
David Newman (NSRC)
Ralph Nyland, *SUNY College of Environmental Science and Forestry* (NSRC)
Matthew Olson (NSRC, CFRU)
Ben Rice (NSRC, CFRU)
Steven Sader (NSRC)
Robert Seymour (NSRC)
Aaron Weiskittel (NSRC)
Jeremy Wilson (CFRU)
Ronald Zalesny, *U.S. Forest Service* (NSRC)

Undergraduate Students

Dane Sherman (SSI, Cons. Lands)

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 these 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.

On the next page is a partial list of more than 130 organizations without whom we could not do our work. These organizations make our work richer.

Top left by Lisa Schabenberger, others by Spencer Meyer

A.W. Madden Forest Products
Acadia National Park
Alliance of Trail Vehicles of Maine
American Tree Farm System
Appalachian Mountain Club
Association of Consulting Foresters
Baskahegan Corporation
Baxter State Park, Scientific Forest Management Area
BBC Land, LLC
Boulos Property Management
Bowdoin College
Broadturn Farm
Canopy Timberlands Maine, LLC
Casco Bay Estuary Partnership
Chadwick-BaRoss, Inc.
Cianbro
Clayton Lake Woodlands Holding, LLC
Downeast Lakes Land Trust
Downeast Salmon Federation
Ed Bessey and Son
EMC Holdings, LLC
Environmental Funders Network
ERA Dawson
Field Timberlands
Finestkind Tree Farms
The Forest Guild
The Forest Society of Maine
The Forestland Group, LLC
Frenchman Bay Conservancy
Frontier Forest, LLC
GrowSmart Maine
Hancock Lumber
Hansel's Orchard
Harvard Forest
Huber Engineered Woods, LLC
Inland Fisheries and Wildlife
Innovative Natural Resources Solutions, LLC
The Irland Group
Irving Woodlands, LLC
James W. Sewall Co.
John Deere
Jordan Farm
Kasprzak Development
Katahdin Forest Management, LLC
Kennebec Land Trust
Kennebec Woodland Partnership
Land for Maine's Future Program
Land Use Regulation Commission
LandVest
Laughing Stock Farm
Lavalley Lumber Co.
Maine Audubon
Maine Bowhunters Association
Maine Bureau of Parks and Lands
Maine Coast Heritage Trust
Maine Department of Conservation
Maine Department of Inland Fisheries and Wildlife
Maine Farm Bureau
Maine Farmland Trust
Maine Forest Products Council
Maine Forest Service
Maine Landowners and Sportsmen's Relations Advisory Board
Maine Legislature
Maine Natural Areas Program
Maine Pulp and Paper Foundation
Maine Sea Grant
Maine Snowmobile Association
Maine State Planning Office
Maine Trappers Association
Maine Tree Foundation
Manomet Center for Conservation Sciences
Marine Environmental Research Institute
Keller Williams Realty
Michigan State University
Milton CAT
Maine Organic Farmers and Gardeners Association
Mosquito, LLC
National Aeronautics and Space Administration
National Wild Turkey Federation
The Nature Conservancy
New England Outdoor Center
North Maine Woods Inc.
North Woods ME, LLC
Northeast Master Logger Certification Program
NorTrax
Natural Resource Conservation Service
Old Town Fuel & Fiber
The Oliver Stores
Plum Creek Timber Company, Inc.
Ponsse
Portland Trails
Prentiss & Carlisle Company, Inc.
Priority Group
Randall Madden Trucking Inc.
Richard Adams Logging
Robbins Lumber Company
SAPPI Fine Paper
Schoodic Research and Education Center
Sebago Lake Ranch
Sebasticook Land Trust
Seven Islands Land Company
Small Woodland Owners Association of Maine
Snowshoe Timberlands, LLC
Society of American Foresters
South Portland Economic Development
Sportsman's Alliance of Maine
St. John Timber, LLC
Stantec
State of Maine, Office of Information Technology
Sylvan Timberlands, LLC
Timbervest, LLC
Town of Falmouth
Town of Orono
Town of Windham
The Trust for Public Land
University of Maine
University of Maine, Cooperative Extension
University of Massachusetts – Amherst
University of New Brunswick
University of New England
UPM Madison Paper
U.S. Forest Service, Forest Inventory and Analysis
U.S. Forest Service, Northern Research Station
USDA, Natural Resource Conservation Service
USDA, Resource Conservation and Development
Verso Paper
Wagner Forest Management
The Wilderness Society

FINANCIAL REPORT

The income and allocated expenses for the CRSF are shown in Tables 1 and 2, respectively. Income supporting the center came from programs that are administered by, or that support, the general operations of the CRSF ($1,000,344), as well as extramural grants supporting specific research projects ($521,381) that were submitted by CRSF scientists for competitive funding to outside agencies. These extramural grants made up 34% of funding supporting the center and leveraged an additional 52% above the center's general funding (Figure 1). Total funding supporting the CRSF for FY2011-12 was $1.52 million.

About 65% of the funding received by the center went directly to support the research projects described in this report (Figure 2). The remaining 26% supported personnel salaries (26%) and operating expenses (9%) for the center. The proportion of total funding allocated to research projects among the four programs making up the CRSF is shown in Figure 3: *Commercial Forests* (33%), *Family Forests* (25%), *Conservation Lands* (21%), and Forest Productivity & Wood Products through the *Northeastern States Research Cooperative* (21%).

Table 1. FY2011-12 income for Center for Research on Sustainable Forests.

INCOME	
CRSF Sources:	**Amount**
Cooperative Forestry Research Unit (CFRU)	$490,001
U.S. Forest Service, Northeastern States Research Cooperative, Theme 3 (NSRC)	$260,934
Maine Economic Improvement Fund (MEIF)	$141,762
National Science Foundation - Center for Advanced Forestry Systems (CAFS)	$70,000
Maine Agriculture & Forest Experiment Station (MAFES)	$20,553
UMaine Munsungan Fund	$17,094
CRSF Total	**$1,000,344**
Extramural Project Grants:	
National Science Foundation - Sustainability Solutions Initiative (SSI)	$224,253
U.S. Forest Service, Northeastern States Research Cooperative, Theme 1 (NSRC)	$37,500
Small Woodland Owners of Maine (SWOAM)	$73,000
U.S. Forest Service, Northern Research Station, Joint Venture Agreement (USDA-JVA)	$72,535
Colorado State University (CSU)	$50,000
Maine Economic Improvement Fund (MEIF)	$18,229
UMaine, George J. Mitchell Center	$45,864
Extramural Grant Total	**$521,381**
Total Income	**$1,521,725**

$1.5 MILLION FOR FOREST RESEARCH

Income Sources

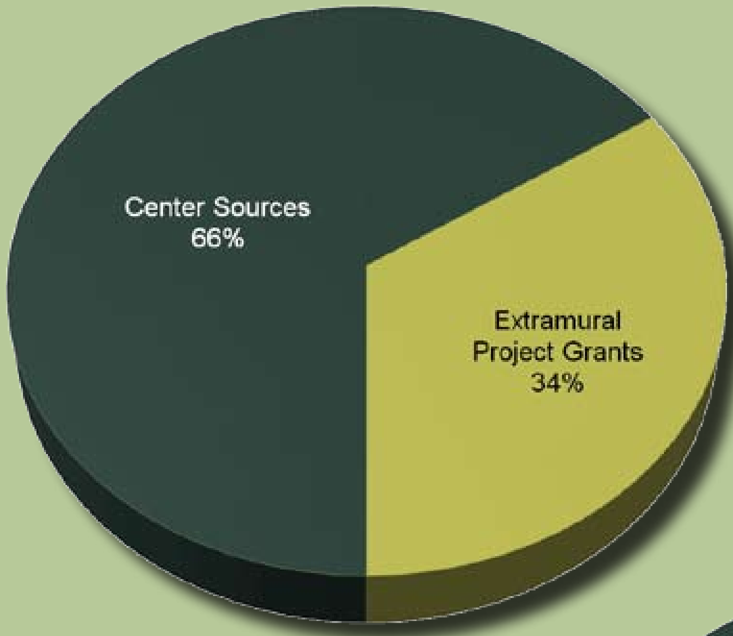


Figure 1. CRSF generated 34% of its income this year from extramural grants.

Overall Expense Allocation

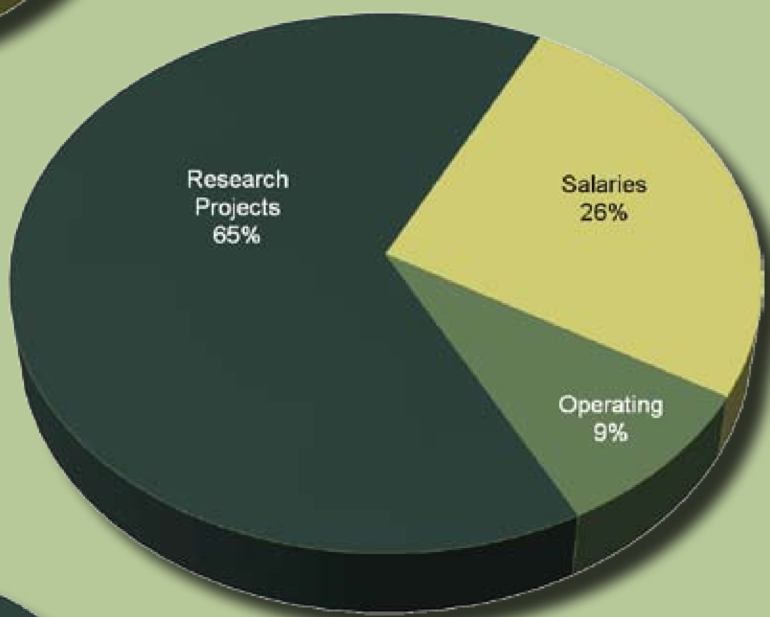


Figure 2. CRSF spends 65% of its revenue directly on research related to sustainable forests.

Research Program Allocation

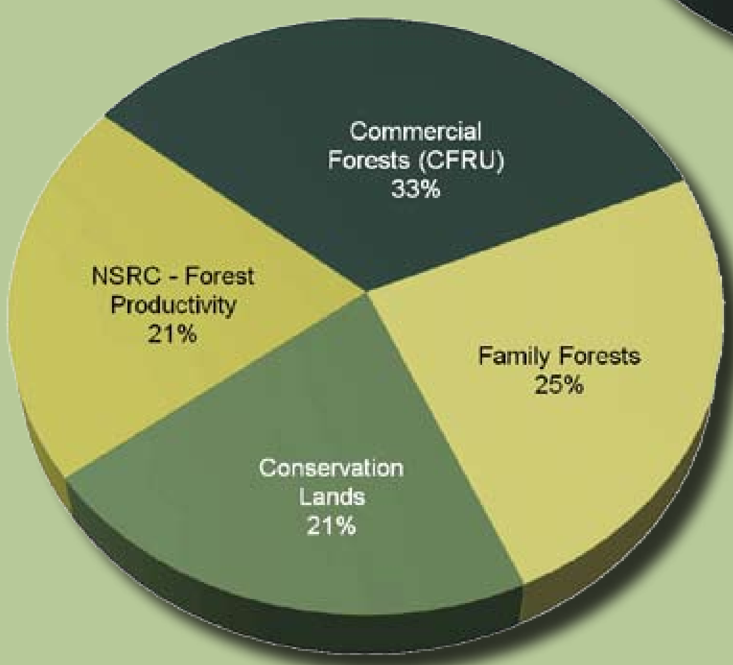


Figure 3. CRSF conducts research on these four key areas of sustainable forest management.

Table 2. FY2011-12 Expenses for Center for Research on Sustainable Forests.

Expenses			
Salaries & Benefits			
Director, Associate Director, Program Leaders, and Scientists			$346,253
Support staff			$48,843
		Salaries & Benefits Total	**$395,096**
Operating Expenses			**$134,385**
		Salaries, Benefits, & Operating Total	**$529,481**
Research Programs	**Funding Source**	**Principle Investigator(s)**	
Cooperative Forestry Research Unit (CFRU) Projects			
Improved Growth & Yield Models	NSF	Wagner & Weiskittel	$70,000
Commericial Thinning Research Network	CFRU	Wagner et al.	$52,407
Early Commercial Thinning	CFRU	Benjamin	$13,557
Modeling Natural Regeneration	CFRU	Weiskittel	$28,685
Spruce Budworm DSS	CFRU	Hennigar	$17,609
CTRN Mortality	CFRU	Pekol	$11,044
Productivity Cost of Logging Equipment	CFRU	Benjamin	$28,050
Austin Pond: Third Wave	CFRU	Wagner	$18,798
Young Hardwood Silviculture Response G&Y Modeling	CFRU	Wagner et al.	$3,850
Sampling Methods and G&Y Models for Partially Harvested Stands	CFRU	Weiskittel & Rice	$25,000
Long-term Monitoring of Snowshoe Hare	CFRU	Harrison	$25,465
Spruce Grouse Habitat in Northern Maine	CFRU	Harrison	$30,800
		CFRU Sub-Total	**$325,265**
Family Forest Research Unit Projects			
Identifying Meaningful Incentives-Public Access/Private Lands	SWOAM	Leahy	$45,000
An Oral History Place Attachment Project	NSRC	Leahy	$12,500
A Long-Term Monitoring Program-Logging Industry Health	NSRC	Leahy	$25,000
Family Forest ForCAST Project	MEIF	Mann	$15,000
Maine Sustainability Science Initiative Yr 3	NSF/SSI	Benjamin	$110,000
Kennebec Woodland Owners Project	USDA	Leahy	$9,385
Small Woodland Owner Research	SWOAM	Leahy	$28,000
		Family Forest Research Unit Sub-Total	**$244,885**
Conservation Lands Program Projects			
Alternative Futures Modeling in Maine	NSF-SSI	Lilieholm et al.	$156,320
Wildebeest Forage Acquisition in Fragmented Landscapes	CSU	Boone et al.	$50,000
Address Invasive Species Threats: Emerald Ash Borer in Maine	NSF-SSI	Ranco et al.	$7,026
		Conservation Lands Program Sub-Total	**$213,346**
NSRC Theme 3 Projects			
Forest Regeneration Differences	NSRC	Howard	$25,000
Evaluating the Interacting Effects of Forest Management Practices	NSRC	Legaard	$35,000
Nonselective Partial Harvesting in Maine's Working Forests	NSRC	Rice	$22,000
Silvicultural Factors Affecting Enviromental Conditions	NSRC	Nelson	$14,350
Effects of Climate Change on Growth, Productivity and Wood Properties	NSRC	Zalesny	$30,000
Managing an Aging Resource	NSRC	Seymour	$27,357
How Silviculture Treatments Effect Carbon Storage	NSRC	Weiskittel	$55,041
		NSRC Program Sub-Total	**$208,748**
		Research Projects Sub-Total	**$992,244**
		Total Expenses	**$1,521,725**

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 strenghten our research programs.

Through partnerships with other universities, such as through the Center for Advanced Forestry Systems (CAFS) and the Northeastern States Research Cooperative (NSRC), 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.

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 U.S. 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. Dr. Bob Wagner and Kae Cooney manage NSRC within CRSF.

During FY2011-12, Theme 3 supported seven research projects across the Northern Forest. UMaine researchers leading NSRC Theme 3 projects for FY2011-12 included: Kasey Legaard, Andrew Nelson, Ben Rice, Bob Seymour, and Aaron Weiskittel. The University of New Hampshire (Ted Howard) and the USFS Northern Research Station (Ron Zalesny) led two other projects.

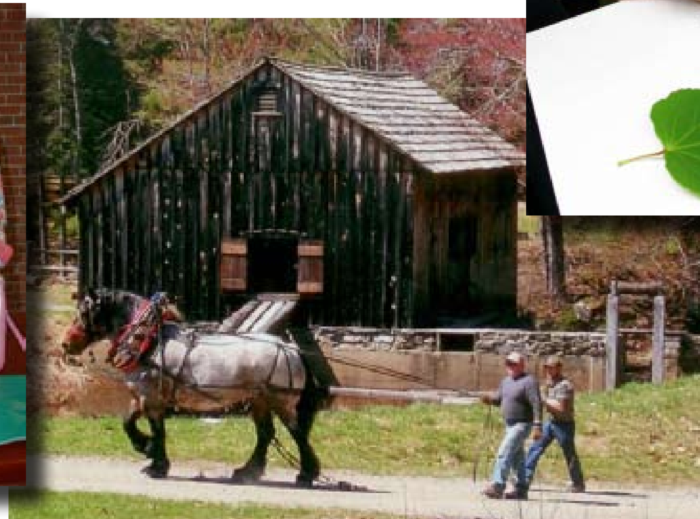
For details about each project, see the complete NSRC section beginning on *page 77*. For details about how NSRC is funded within CRSF, see the CRSF Financial Report on *page 8*.

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. During this past year, article topics ranged from mobile apps for nature aficionados, to the fashionable side of papermaking. Did you know SAPPI supplies materials for Gucci? More than 4,000 readers subscribe to our articles and newsletters.

Additionally, Spencer Meyer led a successful $15,000 grant proposal to the Maine Outdoor Heritage Fund to organize a statewide consortium of organizations that conduct forest-related outreach work. Stay tuned for news about the Maine Woods Outreach Network...



Photos by Joe Rankin

FOREST BIOPRODUCTS RESEARCH INSTITUTE

Over the past several years, CRSF and CFRU have worked closely with Dr. Hemant Pendse, the Director of the Forest Bioproducts Research Institute (FBRI), and other 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. Through the office of the Vice President for Research, the Maine Economic Improvement Fund (MEIF) supports the salaries of Drs. Wiestkittel and Halog.

Spencer Meyer

A bulldozer makes its way up a massive pile of wood chips destined for biomass.

CENTER FOR ADVANCED FORESTRY SYSTEMS

Drs. Bob Wagner and Aaron Weiskittel completed the third 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). Led by North Carolina State University, CAFS is a consortium of leading university forest research programs (see list of universities to the right) and forest industry members across the U.S. 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 research addresses 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.

CAFS provides $70,000 per year (Table 2) to the University of Maine and CFRU members to advance growth and yield models for natural forest stands in the Northeast. This funding supports Matt Russell (a Ph.D. student) and Patrick Clune (a M.S. student). Matt recently completed his Ph.D. dissertation entitled, “Modeling Individual Tree and Snag Dynamics in the Mixed-species Acadian Forest.” We congratulate Matt on his completion and wish him the best in his new position as a post-doctoral fellow with the University of Minnesota. Patrick is completing his last year analyzing the 10-year results from the CFRU Commercial Thinning Research Network. Funding provided by CAFS is shown in the *Financial Report* on *page 8*.

PARTNER UNIVERSITIES

In June 2012, the Center hosted the CAFS Annual Meeting in Bangor, ME. Over 65 scientists, graduate students, and forest industry representatives met to review and approve all CAFS projects nationwide. The meeting included a tour of UMaine and U.S. Forest Service research on the Penobscot Experimental Forest.

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 Forest Research Unit* and *Conservation Lands Program*, CRSF maintains an active partnership 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 scientific disciplines to tackle 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.

Joint CRSF-SSI Projects for 2012

FAMILY FOREST RESEARCH UNIT

- Coupled Social-Ecological Systems Modeling of Family Forests (*page 36*)
- Listening Beyond the Choir: Finding the Voice of Limited-Resource Landowners in Maine (*page 57*)
- Improving our Understanding of Kennebec County Woodland Owner Interests, Needs, and Stewardship (*page 49*)

CONSERVATION LANDS PROGRAM

- Alternative Futures Modeling for the Lower Penobscot and Lower Androscoggin River Watersheds in Maine (*page 62*)
- Mobilizing Diverse Interests to Address Invasive Species Threats: The Case of the Emerald Ash Borer in Maine (*page 67*)

New CRSF-SSI Initiative

Based on the work of the Alternative Futures SSI/CRSF team, Spencer Meyer led a proposal to develop the *Maine Futures Community Mapper*, a web-based tool for conservationists, planners, and others to visualize multiple scenarios of land use decisions. The proposal was submitted to an internal SSI competition, during which it was selected to go forward to the Elmina B. Sewall Foundation, where it was awarded funding. Work on the project is underway.

Pam Wells

The Penobscot Narrows Bridge and the Verso paper mill in Bucksport.

Map by Center for Community GIS

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 second Acadian Internship in Regional Conservation and Stewardship took place in July and August of 2012. This innovative program, led by Rob Lilieholm (CRSF), Jim Levitt (Harvard Forest), and Yvonne Davis (SERC Institute), 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. Dr. Rob Lilieholm of the University of Maine's School of Forest Resources coordinated an intensive week of coursework in conservation theory, tools, and methods. A diverse set of nearly 25 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 2012 class of 16 students included a mix of graduates and undergraduates majoring in natural resource-related programs at American institutions ranging from Yale University to St. Lawrence College and the University of New Hampshire. Also included were nine overseas interns from Europe, South America, Africa, and the Middle East. intern sponsors for the four-week field component included the Maine Coast Heritage Trust, Frenchman Bay Conservancy, Marine Environmental Research Institute, Maine Sea Grant, Downeast Lakes Land Trust, and the Downeast Salmon Federation. One 2011 intern from Belize returned this year to assist with the course, and an environmental science major from Princeton served as a course assistant for the entire 6-week period.

The Acadian Internship Program is sponsored by the University of Maine, the Quebec-Labrador Foundation, and the Schoodic Education and Research Center located in Acadia National Park.


Karena Mahung

Sixteen students from five continents participated in the 2nd Acadian Internship in Regional Conservation and Stewardship.

32 MEMBERS WITH

8.2 MILLION ACRES

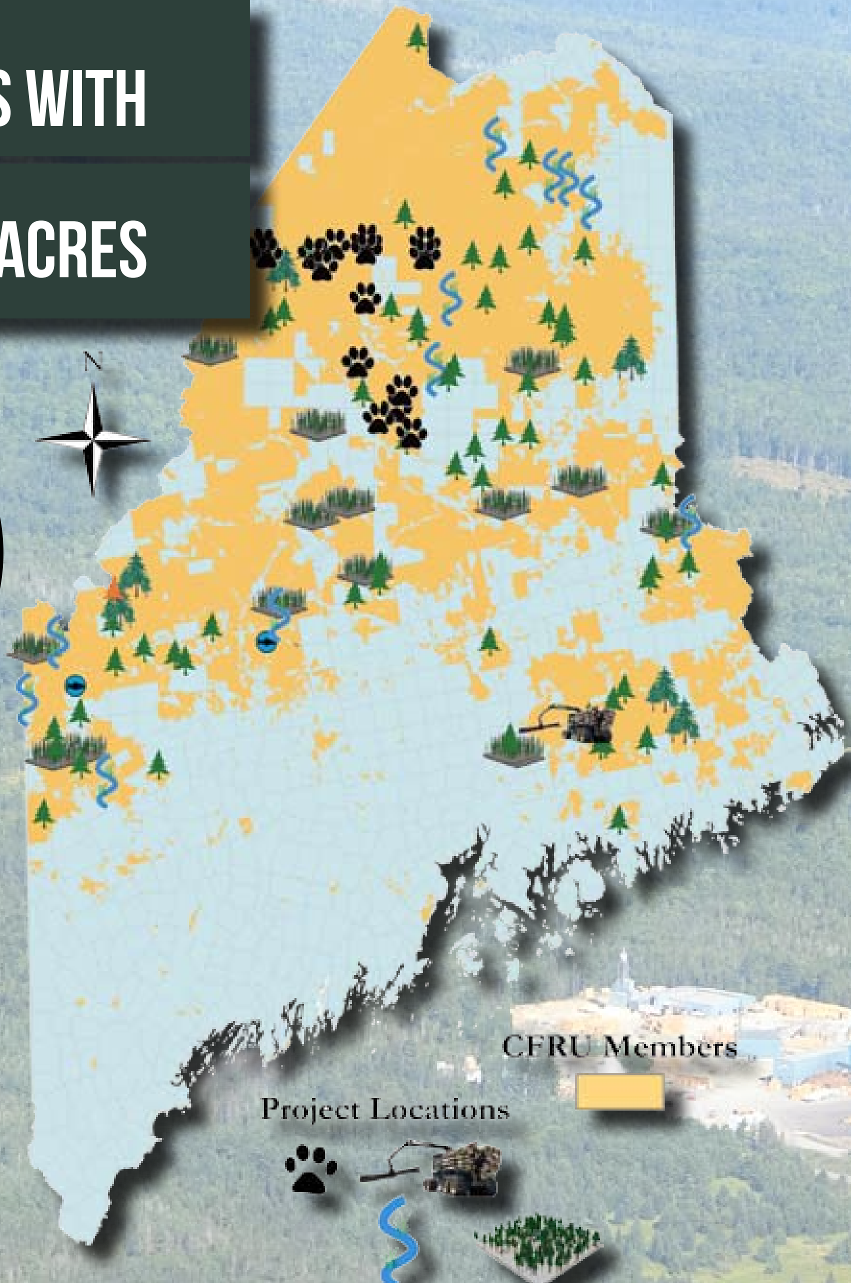


Figure 4. This map illustrates the lands owned by the members of the Cooperative Forestry Research Unit. This map is not exact but is meant to show the overall coverage of the CFRU.

CFRU Members

Appalachian Mountain Club
Baskahegan Company
Baxter State Park, SFMA
BBC Land, LLC
Canopy Timberlands Maine, LLC
Clayton Lake Woodlands Holdings, LLC
EMC Holdings, LLC
Field Timberlands
Finestkind Tree Farms
The Forest Society of Maine
The Forestland Group, LLC
Frontier Forest, LLC
Huber Engineered Woods, LLC
Irving Woodlands, LLC
Katahdin Forest Management, LLC
LandVest
Maine Bureau of Parks and Lands
Mosquito, LLC
The Nature Conservancy
North Woods ME Timberlands, LLC
Old Town Fuel and Fiber
Plum Creek Timber Company, Inc.
Prentiss & Carlisle Company, Inc.
Robbins Lumber Company
Sappi Fine Paper
Seven Islands Land Company
Snowshoe Timberlands, LLC
St. John Timber, LLC
Sylvan Timberlands, LLC
Timbervest, LLC
UPM Madison Paper
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 together to improve our understanding about Maine's forests and how best to use them for all of society's values. With 32 member organizations and their more than 8.2 million acres as a living laboratory (Figure 4), 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 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 improvement, improvements to growth and yield models, spruce budworm impacts using a decision support system, and monitoring of snowshoe hare and Canada lynx populations. More information about these and other projects can be found in the *2011-12 CFRU Annual Report* and on the *CFRU website*.

Spencer Meyer

Spencer Meyer

Commercial Thinning Research Network

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

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 PCT are used to examine responses due to CT timing and relative amount of removal, while those without PCT are used to examine responses due to CT method and relative amount of removal. The network now consists of three experimentally controlled studies, on 15 study sites across the state.

Results from the network are being used to improve growth and yield models for Maine's forests. Several of the following projects have been made possible because the CFRU continues to manage the long-term CTRN experiments.

Funding

- CFRU: $52,407
- Center for Advanced Forestry Systems: $35,000 (includes some support for the two following projects)

Brian Roth

Avery & Sons cable skidder on a CTRN study site on the Penobscot Experimental Forest on December 16th, 2011.

Spencer Meyer

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

Aaron Weiskittel, Matthew Russell,
Robert Wagner, and Robert Seymour

Abstract

This is the third year of a joint project between CFRU and CAFS aimed at making refinements to the Northeast variant of an existing forest growth and yield model: the Forest Vegetation Simulator (FVS) which was developed by the USFS.

A Ph.D. dissertation completed by Mathew Russell this year validated existing and developed component equations that comprise a widely used individual-tree growth and yield model in the northeastern U.S. and Canadian Maritime provinces (Figure 5). An assessment of deadwood stocking was conducted and models were developed to improve our understandings of standing deadwood dynamics as they relate to silvicultural treatment, species, and stand conditions in these forests.

Three key submodels of the Northeastern variant of the Forest Vegetation Simulator (FVS-NE) were benchmarked and calibrated using remeasurement data obtained from a national forest inventory. Advances in methodologies for fitting individual-tree increment equations in mixed-species stands were made by including species as a random element of the regional equations. Using nonlinear mixed-effects models that employ tree species as a random effect, predictions of DBH and height increment showed improvements over currently-used models in FVS-NE and reduced the complications of portraying growth dynamics in mixed-species stands with multi-cohort stand structures. Futher work was done to assess the role of deadwood in the regional carbon cycle.

Funding

- CFRU: $28,685
- USFS Agenda 2020: $81,933
- NSRC: $84,194
- CAFS: $35,000

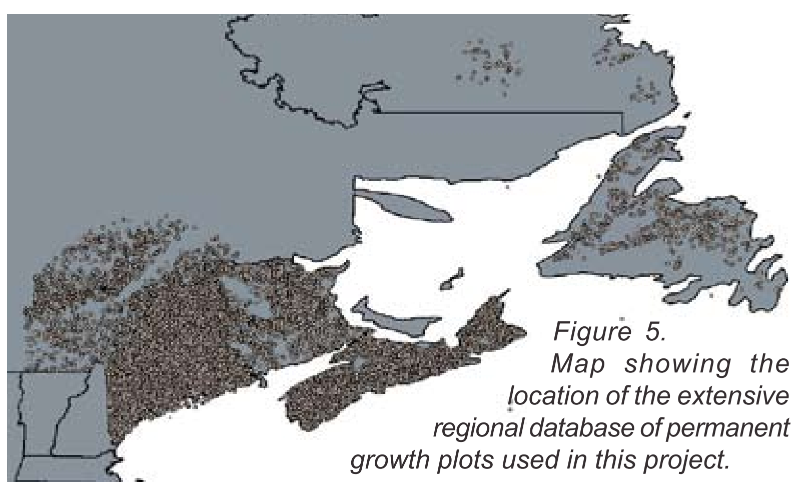
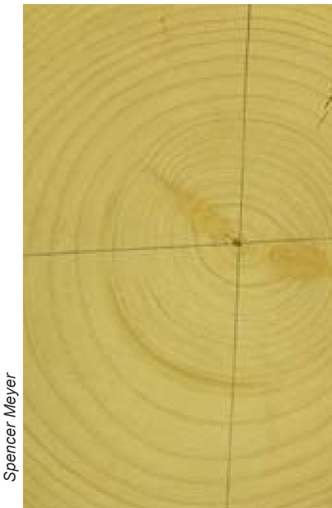


Figure 5. Map showing the location of the extensive regional database of permanent growth plots used in this project.

GROWTH AND DEVELOPMENT OF MAINE SPRUCE-FIR FORESTS FOLLOWING COMMERCIAL THINNING



Spencer Meyer

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

Abstract

This joint CFRU-CAFS project is being conducted by M.S. student, Patrick Clune who is using the Commercial Thinning Research Network (see above) to address three core questions:

1. What is the range of expected response to precommercial (PCT) and commercial thinning (CT) across the state;
2. How does the intensity of the treatment influence response; and
3. What is the optimal time for treatment?

A better understanding of the effect of PCT and CT treatments is needed to help improve regional growth and yield models by representing them as growth model thinning modifiers.

In 2001, 12 permanent research installations were established in Maine. The installations had both a no-PCT and PCT design with different levels and timing of CT. The primary treatments being examined were thinning method (low, crown, dominant), intensity (33%, 50% of relative density), and timing (0, 5, and 10 years). A combination of treatments was applied at each installation with a 3 x 2 factorial design that included a control. Both pre- and post-assessments were conducted as well as annual inventories since 2001. This experiment has provided extensive observations across a range of site conditions.

The specific objectives of this project are to:

1. Compare the influence of relative density reduction and method on residual growth & yield following commercial thinning of 50-70 year old natural spruce-fir stands (No-PCT);
2. Compare the influence of relative density reduction and timing of entry on residual stand growth following commercial thinning of previously pre-commercially thinned fir-spruce stands (PCT);
3. Compare the effect of different thinning treatments on diameter distribution for both the No-PCT and PCT stands;
4. Compare the effect of different thinning treatments on individual tree growth; and
5. Assess regional growth equations to predict post thinning growth, and construct growth modifiers for commercial thinning.

Progress to date includes cleaning of a large database and preliminary analysis of stand-level responses. A tree-level analysis has been initiated and the thesis is scheduled for completion in fall 2012.

Funding

• CAFS: $35,000

Spencer Meyer

RESPONSE OF TREE REGENERATION TO COMMERCIAL THINNING IN SPRUCE-FIR STANDS

Matthew Olson, Spencer Meyer,
Robert Wagner, and Robert Seymour

Abstract

Traditional silvicultural thinning is implemented to boost growth and final yield of crop trees with no specific intention of triggering a regeneration response. However, there is some reason to anticipate that thinning will initiate some tree regeneration. The goal of this project is to increase our understanding about the influence of commercial thinning on the development of viable regeneration in Maine spruce-fir stands. This project piggybacks on the Commercial Thinning Research Network and evaluates regeneration patterns ten years following thinning to various levels, with and without a previous pre-commercial thinning treatment (PCT). Preliminary findings indicate that there is an abundance of regeneration in both PCT and non-PCT forest stands ten years following commercial thinning.

Brian Roth

Matt Olson examines vegetation at a sample grid point on the Penobscot Experimental Forest CTRN location.

Funding

- CFRU: $11,044
- Northern States Research Cooperative: $ 10,040

Development of Regional Stem Taper and Volume Equations: Hardwood Species

Aaron Weiskittel and Rongxia Li

Spencer Meyer

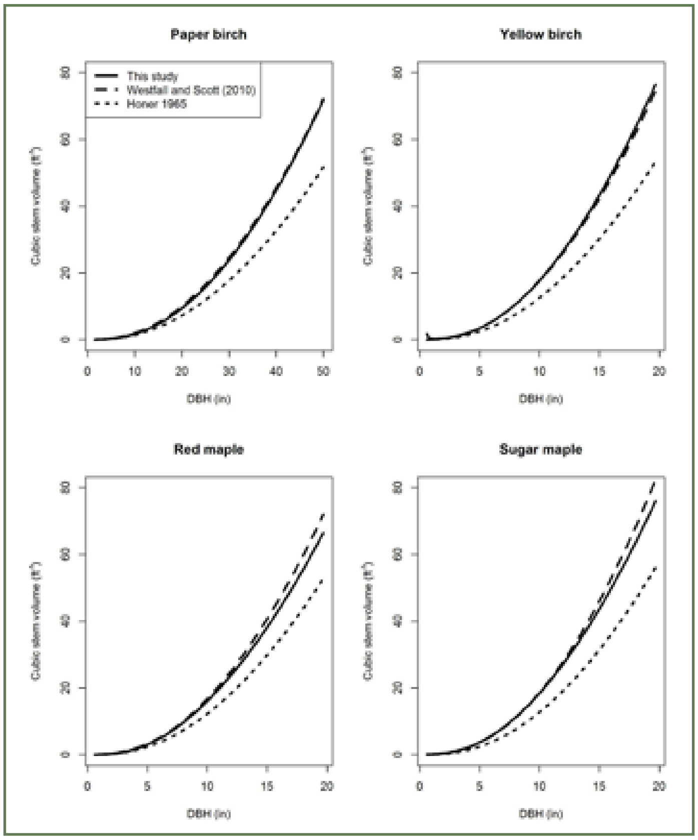


Figure 6. Estimated total stem volume (ft³) for paper birch, yellow birch, red maple, and sugar maple using the taper equations in this study as well as Westfall and Scott (2010) and the volume equations of Honer (1965) across a range of DBH classes (in).

Abstract

Taper equations are an important component of modeling tree growth and yield. The tree form and stem volume of hardwoods are significantly more difficult to model than those of softwoods since a larger proportion of their total biomass is in branches rather than a main bole and this varies by region. The primary goal of this analysis was to compare and evaluate previously developed taper equations for the major hardwood species in the Northeast Region with the objective of determining whether these taper equations could be directly applied to the hardwood species in the Acadian Region (Figure 6).

Funding

- CFRU: $17,608

Spencer Meyer

INFLUENCE OF COMMERCIAL THINNING ON STAND- AND TREE-LEVEL MORTALITY PATTERNS OF BALSAM FIR AND RED SPRUCE

Joseph Pekol, Aaron Weiskittel, and Robert Wagner

Abstract

Individual trees within a stand compete for limited resources such as light, nutrients, and growing space. Over time, some trees die and others dominate depending on a variety of factors. Foresters apply silvicultural practices such as pre-commercial (PCT) and commercial thinning (CT) in an effort to 'harvest' this mortality before it occurs and increase the growth of the remaining crop trees. This study examined mortality patterns following thinning in an effort to better understand how best to apply the method and timing of thinning to reduce mortality. Results indicate that when applying a commercial thinning treatment to dense, mature spruce-fir stands, mortality rates will be higher if dominant and/or co-dominant trees are removed.

Funding

- CFRU: $3,846
- School of Forest Resources: $25,000

Brian Roth

Balsam fir mortality following commercial thinning due to stem breakage around heart rot.

Response of Early-Successional Stands to Different Intensities of Silviculture and Species Composition

Andrew Nelson and Robert Wagner

Spencer Meyer

Abstract

In Maine, roughly 2.3 million acres (13%) of forestlands are dominated by early-successional hardwood species and 4.2 million acres (24%) are dominated by saplings. Trees species diversity can often be high in these young stands which are typically mixed-wood composition (conifer and hardwood), yet the response of these young stands to silvicultural intensity is poorly understood. The overall goal of this study is to document the response of early-successional stands to different intensities of silviculture and species composition objectives. In 2003-04, a factorial experiment was established in a mixed-wood regenerating clearcut on the Penobscot Experimental Forest that included three species compositional objectives (Hardwood, Mixed-wood,Conifer) and three silvicultural intensities (Low, Medium, and High), plus an untreated control. Results from this investigation suggest that the silvicultural prescriptions have been effective in shifting or maintaining their target species composition (hardwood, conifer, or mixed-wood).

Funding

- CFRU: $13,557
- Henry W. Saunders Chair: $18,487

Andrew Nelson

Intensively managed white spruce saplings in the experiment.

Spencer Meyer

Early Commercial Thinning Harvest Systems:
A Silvicultural and Operational Assessment

Jeff Benjamin, Emily Meacham, Robert Seymour, and Jeremy Wilson

Abstract

Many of Maine's regenerating clearcuts from the budworm era are dominated by dense spruce and fir saplings. Some of these stands were pre-commercially thinned; others, however, have grown beyond the stage where brush-saw treatment is feasible. Such stands are overstocked and would benefit from thinning, but they are decades away from being operable with traditional harvesting systems. The objectives of this study are to determine the effectiveness of early commercial thinning treatments using cut-to-length (CTL) and whole-tree (WT) harvest methods. In 2011 a study was initiated which involved three sectors of the forest industry (landowners, contractors, and equipment dealers and manufacturers) to develop silviculturally effective, operational solutions for implementing early commercial thinning treatment.

Funding

- CFRU: $27,558
- The Forest Guild: $17,000

Jeff Benjamin

A shiny new processer prepares to show what it can do in dense spruce-fir.

SPRUCE BUDWORM DECISION SUPPORT AND STRATEGIES TO REDUCE OUTBREAK IMPACTS IN MAINE

Max McCormack

Chris Hennigar, David MacLean, and Thom Erdle

Abstract

Both theory and past experience suggest that another eastern spruce budworm (SBW) outbreak is due across the Northern Forest region. Management of this threat by Maine landowners can be improved by (a) quantifying the potential magnitude of consequences of the next SBW outbreak on wood supplies, land values, and management plans; (b) implementing appropriate harvesting and silviculture in advance of that outbreak to mitigate consequences when it occurs; and (c) having in place a sound decision support system to allocate harvest and protection activities once the outbreak begins. This project calibrated a Spruce Budworm Decision Support System (SBW DSS), originally developed for New Brunswick, throughout the managed forests of Maine. Using this Maine-calibrated SBW DSS, maps of stand merchantable volume impact by various hypothetical outbreak severities were generated (Figure 7). Additionally a non-spatial wood supply model for Maine was developed to quantify potential benefits of alternative silviculture portfolios for a wide range of outbreak start dates and severities.

Funding

- CFRU: $25,000
- Atlantic Innovation Fund: $5,000

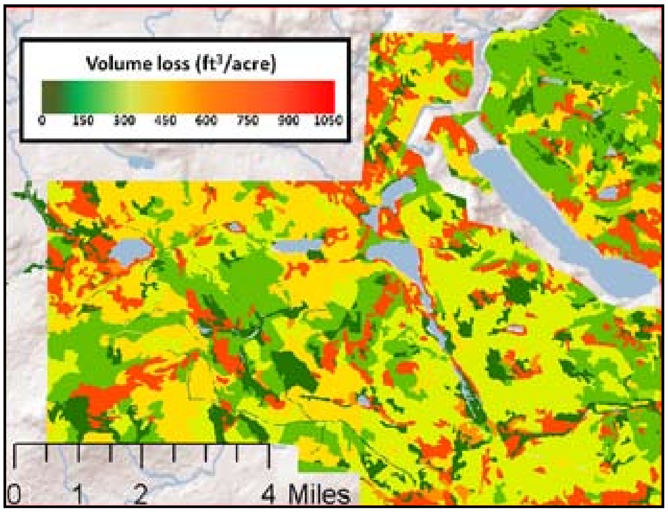


Figure 7. Projected spruce-fir merchantable volume reduction 20 years post severe outbreak (initiation in 2010) for a portion of the Maine Bureau of Public Lands' forest.

Adam Komar

EFFECTS OF NONSELECTIVE PARTIAL HARVESTING IN MAINE'S WORKING FORESTS

Ben Rice, Aaron Weiskittel,
Jeremy Wilson, and Robert Wagner

Abstract

Over the past 20 years forest management in Maine has shifted to a heavy reliance on partial harvesting practices. Partial harvesting includes selective methods, such as shelterwood, group selection, and single-tree selection, and also nonselective methods that remove timber within and adjacent to trails, typically leaving a matrix of unharvested areas between trails. Forest inventory is vital to all aspects of forest management and it is unclear which inventory methods perform best under the heterogeneous conditions created by these practices. We compared efficiency and stand level inventory estimates using horizontal point, fixed area, and horizontal line sampling measurement methods in 16 partially harvested stands across northern and central Maine. Some stand-level values were sensitive to the measurement method (e.g., volume, quadratic mean diameter and small stem density and basal area), while others were less sensitive (e.g., overall basal area and stem density; Figure 8). Efficiency varied among measurement methods at lower basal areas and with the exception of the fixed-area method, was similar at higher basal areas. Our results illustrate the tradeoffs between precision and time involved in several measurement methods under a range of heterogeneous stand conditions.

Funding

- CFRU: $23,904
- NSRC: $43,054

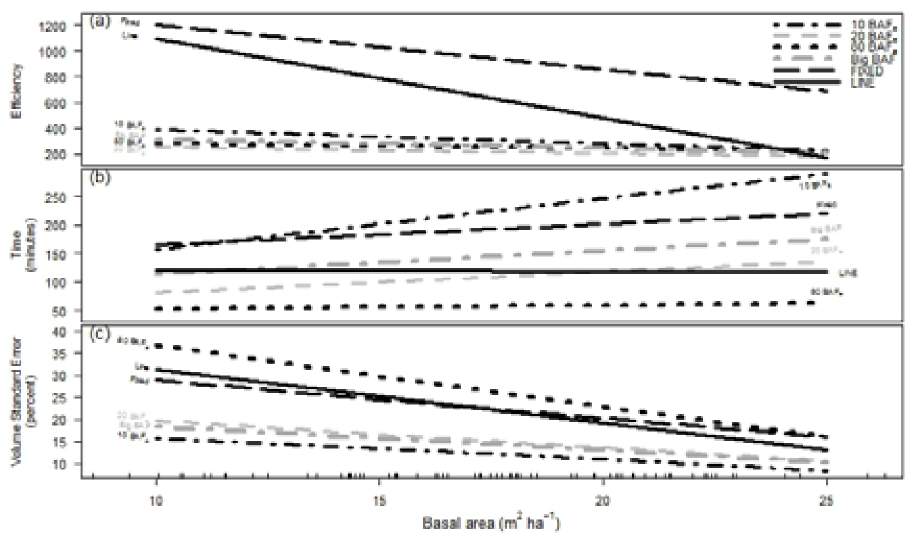


Figure 8. Regression lines showing the interaction of method and basal area with (a) efficiency, (b) stand measurement time and (c) volume standard error. The horizontal lines at the bottom of the x-axis represent observed values.

MODELING NATURAL REGENERATION INGROWTH IN THE ACADIAN FOREST

Spencer Meyer

Aaron Weiskittel, Rongxia Li, and John Kershaw

Abstract

Modeling tree ingrowth is of great importance for forest growth simulations, particularly long-term projections, since it represents one of four key components of forest development: survivor growth, ingrowth, mortality, and harvest. The goal of this project was to develop the best modeling approach for estimating annualized ingrowth occurrence and frequency for stands in the Acadian Region. In addition, models for ingrowth species composition were also developed.

Data used in this study came from an extensive regional database of fixed-area permanent plots compiled from a variety of data sources such as: U.S. Forest Service (USFS) Forest Inventory and Analysis (FIA), the USFS Penobscot Experimental Forest, and permanent sample plot (PSP) data from several Canadian provinces including Québec, Nova Scotia, and New Brunswick. In summary, this work represents a significant improvement in modeling tree recruitment in the Acadian region.

Funding

- CFRU: $18,797

Spencer Meyer

Natural regeneration is prolific in Maine. Here balsam fir seedlings grow in a gap on an old nurse log.

Manomet Archives

Relative Densities, Patch Occupancy, and Population Performance of Spruce Grouse in Managed and Unmanaged Forests in Northern Maine

Daniel Harrison and Stephen Dunham

Abstract

Spruce grouse are dependent on conifer dominated forests and are abundant across Canada and Alaska. However, the southern border of their range intersects only the northern edge of the contiguous United States where a recent assessment by the International Association of Fish and Wildlife Agencies concluded that populations are rare or declining. There is also concern that their habitat, mid-late successional coniferous forests and wetlands, are being harvested at accelerating rates in Maine. The goals of this project are to increase our understanding of the effects of commercial forest management in northern Maine on patterns of habitat occupancy, habitat use, and reproductive success of spruce grouse.

Funding

- CFRU: $30,672
- McIntire-Stennis: $2,000

Stephen Dunham

A spruce grouse fitted with a radio collar for tracking.

RELATIONSHIP AMONG COMMERCIAL FOREST HARVESTING, SNOWSHOES HARES, AND CANADA LYNX IN MAINE

Daniel Harrison, Sheryn Olson, David Mallet,
Jennifer Vashon, and Angela Fuller

CFRU Archives

Abstract

Snowshoe hares are a keystone species affecting plant succession, nutrient cycling, and populations of numerous predators and co-existing prey species in northern forest ecosystems. Maintaining an adequate supply of high-quality hare habitat is central to recovery and management efforts for populations of Canada lynx, which are officially designated as threatened in the lower 48 U.S. states and in New Brunswick, Canada. This project documents the relationships among commercial forest harvesting, snowshoe hares, and Canada Lynx in Maine.

Specific objectives for this project are:

1. To monitor benchmark conifer clearcut stands to assess their long-term trajectories in hare densities as related to their age since cutting, site quality, and structural conditions;
2. To understand seasonal shifts in habitat use of snowshoe hares and lynx as they relate to different harvesting treatments and the extent that lynx depend on snowshoe hares during the winter and summer seasons; and
3. To better understand the role of changing hare densities on lynx during periods of relative abundance and scarcity.

Funding

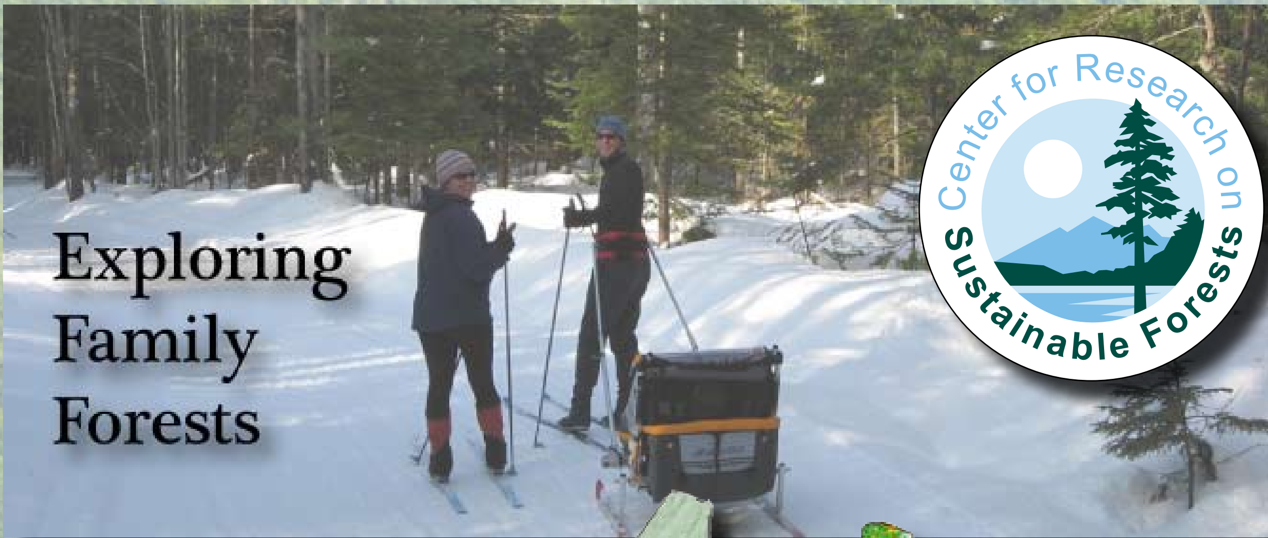
- CFRU: $31,893
- U.S. Fish and Wildlife Service: $28,000
- McIntire-Stennis: $26,000

Dan Harrison

Graduate Research Assistant, David Mallet, fixing a GPS transmitter to a captured adult lynx.

The Lincoln Paper and Tissue mill in Lincoln (Pam Wells)

Exploring Family Forests



Spencer Meyer

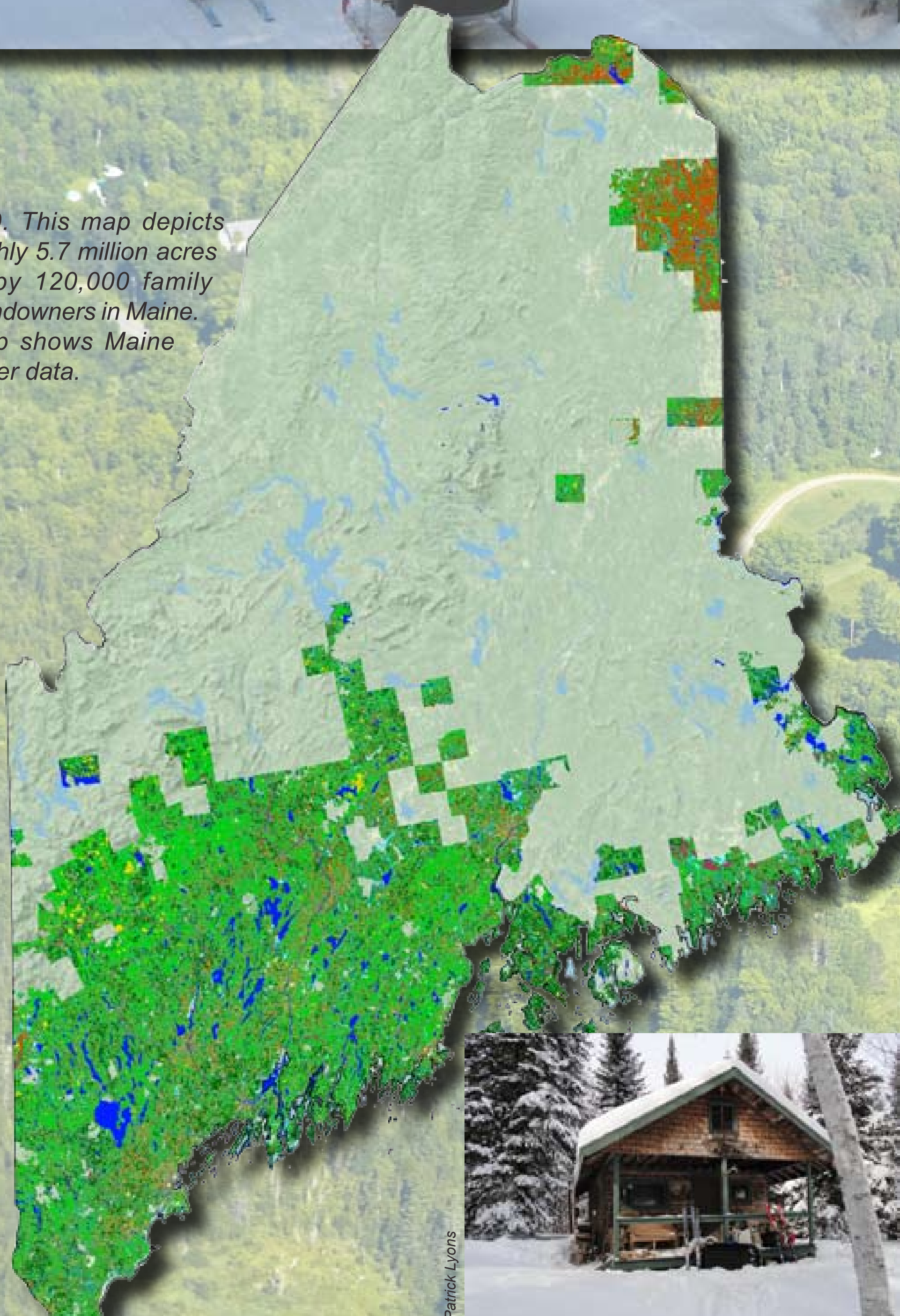


Figure 9. This map depicts the roughly 5.7 million acres owned by 120,000 family forest landowners in Maine. The map shows Maine land cover data.

Patrick Lyons

FAMILY FOREST RESEARCH UNIT

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 approximately 5.7 million acres of forest land in Maine (Figure 9). These landowners, who own between 1-1,000 acres each, have largely been under-served 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. These stakeholders include the Small Woodland Owners Association of Maine (SWOAM), USDA Family Forest Research Center, UMaine Cooperative Extension, American Tree Farm System (ATFS), Maine Forest Service (MFS), Natural Resources Conservation Service (NRCS), USDA State and Private Forestry, American Consulting Foresters (ACF), Professional Logging Contractors of Maine, and forest management firms offering services to family forest owners. 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 challenges, and opportunities facing Maine's small woodland owners;
3. Modeling dynamic and complex interactions between landowner decisions and forests, including projecting future conditions in a 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 include raising $244,885 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 "There's No Place Like Home: Role of Place Attachment" study is actively being used by the Kennebec Woodland Partnership (KWP) to design websites, publications, and programs that better engage landowners and support a "Culture of Conservation." This project has benefitted from a close working relationship with the KWP as evidenced from co-constructing the survey, analyzing data together, and giving regular updates at quarterly meetings.

As the Family Forest program looks toward next year, the goals include focusing research and outreach on important family forest issues, such as succession planning; increasing the number of stakeholders and partnerships, especially in southern Maine; and co-hosting the 2012 International Union of Forest Research Organizations Small Scale Forestry Symposium.

COUPLED SOCIAL-ECOLOGICAL SYSTEMS MODELING OF FAMILY FORESTS


Spencer Meyer

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

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 this project was the development of a prototype agent-based model that was designed specifically 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) consists of 12 Python modules that provide for agent profile generation, agent decision making, tying the U.S. Forest Service Forest Vegetation Simulator (FVS) into the model, agent communication, and general population dynamics. Each of these components are designed to be relatively 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 wide

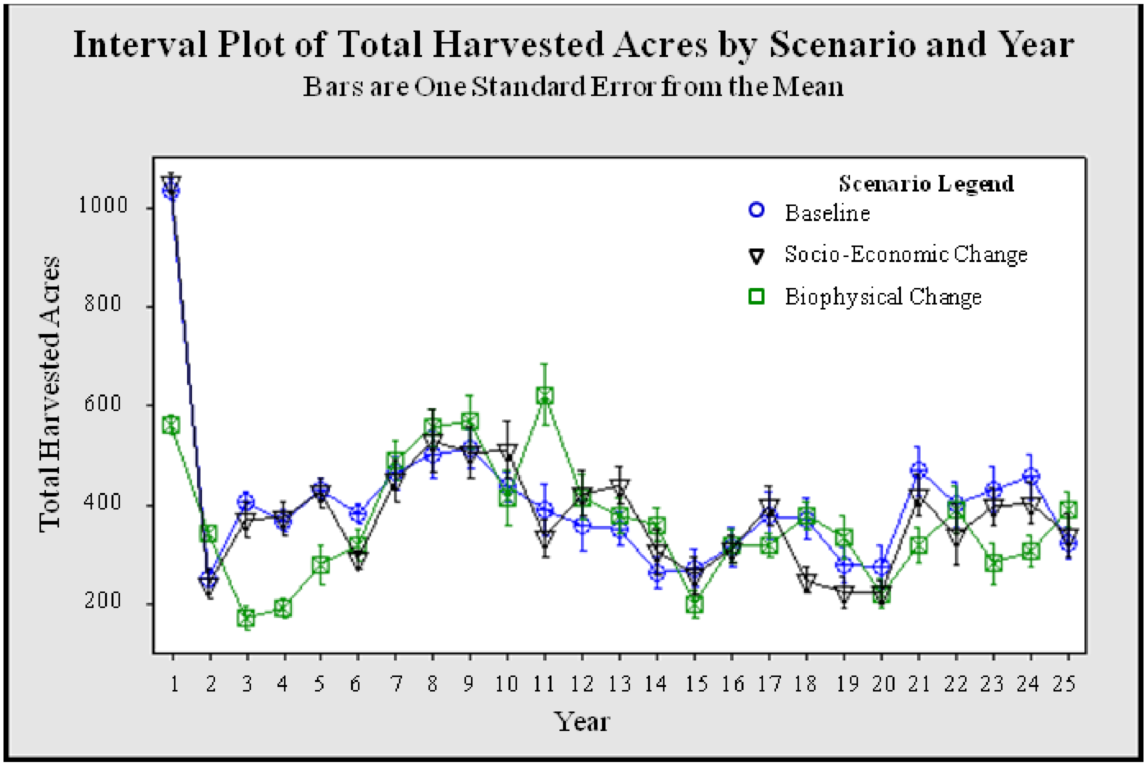


Figure 10. A 95% confidence interval plot for the mean of the 10 runs within each scenario of total harvested (combined light and heavy) acres by year. Here the shapes represent the mean, and the perpendicular lines the interval of one standard error.

variety of other agent-based models. We focused specifically on the use of FVS in the last twelve months. FVS is a well-accepted model in forest resources, so it adds stakeholder credibility in the new ABM, and we could find FVS experts to assist in model creation. FVS also modeled at the appropriate scale as landowners tend to manage at the tree, stand, or parcel scale. Regional variants within FVS allow for "portability" across the United States.

Overall, this 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 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.

The model shows promising results at modeling predicted timber harvest levels on family forests, and shows sensitivity to various changes in biophysical and social settings. An insect outbreak with increased tree mortality and an increase in property taxes both resulted in changes in land-

Table 3. Harvesting and goal score ANOVA output. The means, standard deviations (between parentheses), sample size and interactions of goal score changes and acres harvested are presented here by scenario and action. Significant difference in means is represented by bold.

ANOVA: Scenario by Action on Fiscal Goal Score				**Interaction Effect**	
Scenario:	**Heavy Harvest**	**Light Harvest**	**No Harvest**	**F**	***p***
Baseline	-11,623,710 (7,398,318) N=240	-6,458,109 (10,513,934) N=212	-377,276 (7,904,496) N=1,229	213.08	0.000
Socio-Economic	-12,985,883 (8,321,021) N=240	-7,072,157 (13,760,942) N=211	-756,019 (8,462,467) N=1,231	194.67	0.000
Biophysical	-14,304,978 (8,265,848) N=240	-10,822,391 (17,840,793) N=198	-605,034 (8,013,855) N=1,236	257.83	0.000
One-way ANOVA: Scenario on Total Harvested Acres, by Heavy, Light and Combined				**Interaction Effect**	
Total Acres:	**Baseline**	**Socio-Economic**	**Biophysical**	**F**	***p***
Heavy Harvested	303.9 (181.0) N=250	301.5 (187.0) N=250	288.0 (130.3) N=250	0.65	0.522
Light Harvested	**101.85** (95.21) N=250	91.45 (85.21) N=250	**77.28** (81.19), N=250	4.98	0.007
Combined Harvested	**405.8** (186.9) N=250	392.9 (201.5) N=250	**365.3** (163.8) N=250	3.14	0.044

Table 4. Participants' mean[1] survey response and standard deviations by successive engagement activity.

Question/Statement	**First (n=13) mean**	**Second (n=7) mean**	**Third (n=7) mean**
There is too much uncertainly in agent-based models.	3.08 (0.64)	3.00 (0.89)	3.00 (1.30)
I trust the scientific quality of agent-based models.	3.55 (1.04)	3.17 (0.75)	3.20 (0.84)
I trust the skills of the modelers to create an agent-based model.	3.38 (0.96)	3.57 (0.79)	3.80 (0.84)
Agent-based models rely on too many assumptions.	3.55 (1.29)	3.29 (0.95)	3.29 (0.84)
I trust the reliability of agent-based model results.	3.00 (0.74)	3.14 (0.69)	3.00 (0.71)
How satisfied are you with how we incorporated your feedback from the last meeting?	-	3.57 (0.98)	4.00 (0.71)

[1] Mean based upon a 5-point Likert scale of 1=strongly disagree/very unsatisfied to 5=strongly agree/very satisfied.

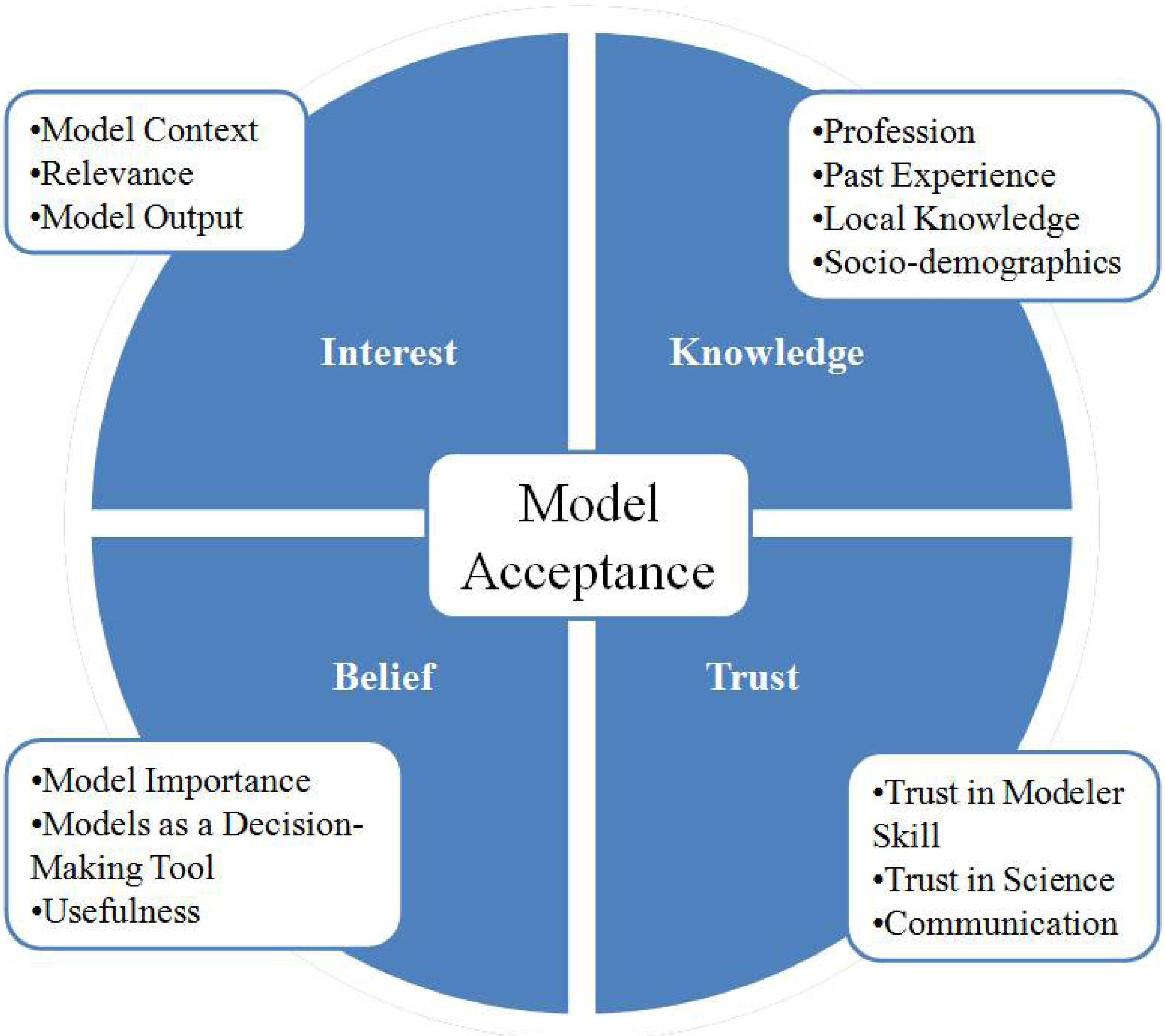


Figure 11. Examples of stakeholder acceptance factors by interests, background and trust. Adapted from Olsson & Andersson, 2007.

owner behavior (Figure 10). Significant differences between the baseline, mortality scenario, and tax increase scenario existed (Table 3).

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. Our mixed-methods research revealed four stakeholder model acceptance factors: interest, knowledge, trust, and beliefs. Furthermore, we found social learning activities increased stakeholder knowledge, improved attitudes and beliefs, and, ultimately, led to an improved model. This part of the benefits researchers seeking to have their modeling efforts used to improve the sustainability of family forests, as well as benefits forest policy makers through feedback loops to improve social learning through modeling efforts (Table 4, Figure 11).

Funding

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

KNOWLEDGE TO ACTION:

INVESTIGATING IMPLICIT KNOWLEDGE PRODUCTION MODELS HELD AMONG FOREST SCIENCE RESEARCHERS

Jessica Leahy, Patrick Lyons,Laura Lindenfeld, and Linda Silka

Spencer Meyer

Background

Some members of the academic community argue that research has become ossified and reliant upon traditional knowledge transfer systems, resulting in the paradox of an academic system that has largely failed to contribute to sustainable resource use (Lubchenco 1998). Recognizing the problem, certain researchers and practitioners have pushed for a paradigm shift in knowledge generation and application, calling for interdisciplinary, inclusive approaches (Cash et al. 2003). Sustainability science and participatory research, two fields that exemplify this shift, share the tenets of stakeholder participation and knowledge co-production, approaches that value and incorporate local stakeholder knowledge while confronting issues of power inequality and equity inherent in traditional academic systems (Cash et al. 2003; van Kerkhoff and Lebel 2006).

Within forest resources, participatory research approaches have predominately been applied in the developing world, incorporating indigenous knowledge and partnerships to address sustainability issues (Arnold and Fernanez-Gimenez 2007). Sustainability science methodologies and participatory research practices have been employed with success on U.S. public lands (Arnold and Fernanez-Gimenez 2007; Ballard and Huntsinger 2006; Everett 2001; Lemos and Morehouse 2005), but currently represent only a small fraction of research practices. The variety of approaches makes it important to understand what circumstances and incentives influence researchers to work with stakeholders versus using traditional methods.

Objectives

To understand how and why forest science research incorporates participatory research, and investigate researchers' implicit knowledge production models, we completed an assessment of research practices and conducted semi-structured interviews with forest science researchers. This enabled us to evaluate researchers' approaches to knowledge production with a focus on views of stakeholder engagement in research. The primary objectives of this research were to:

1. Explore implicit models of and assumptions about stakeholders, including who stakeholders are, what researchers assume about

their skills, the nature of their relationships, and temporal assumptions about stakeholder engagement;
2. Find similarities and differences that emerge with regard to variances in research themes and stakeholder assumptions;
3. Create suggestions with regard to enlarging and refining stakeholder engagement models within forest science research.

This research aims to understand how sustainability science and participatory research processes can operate successfully in forest science research. This research can help researchers adapt stakeholder approaches to their ethos and identify means of addressing pressing issues facing the ecological, economic, social systems of forests.

Approach

We conducted semi-structured interviews with cooperating researchers of the University of Maine's Center for Research on Sustainable Forests (CRSF) to understand assumptions held about stakeholder engagement and forest science researchers' practices. Potential participants were contacted through email, and interview time and date were confirmed with an explanation of the study and informed consent notification. Eighteen cooperating CRSF researchers agreed to participate, with interviews lasting between 20 to 90 minutes. Participants were asked direct questions about their work with stakeholders, such as: who do you consider to be the primary stakeholders targeted in your research and outreach; how do you define a stakeholder; how do you typically work with your stakeholders; can you think of other individuals, groups, or communities who would benefit from your research; and if so, what are the reasons you do not work with them?

Interviews were transcribed verbatim and organized around single questions. NVivo 7 software was utilized to identify and organize data using open coding to preserve the rich, descriptive quality of the participants' language and explore the emergent nature of the inquiry (Corbin and Strauss 2008). Data was recorded using the constant comparative method, and categories were evaluated using axial coding to trim theoretical constructions for more precise distinctions (Corbin and Strauss 2008). To ensure confidentiality, interview recordings and transcripts were kept secure and listened to only by University of Maine researcher assistants.

Results

Our first objective explored various implicit models and assumptions researchers held about stakeholders, including who stakeholders are, assumptions about their skills and the nature of their relationships, and temporal assumptions about engagement. Forest science's use of traditional, linear knowledge transfer systems has recently shifted to include stakeholder driven, participatory research methods. Our analysis revealed that forest scientists hold diverse perceptions of stakeholders and exhibit a range of assumptions about who they are, how and when they should be involved in the research process, and what they can contribute (Figure 12).

Our second objective studied similarities and differences that emerged with regard to variances in research themes and stakeholder assumptions, revealing pervasive conditions that influence researchers' approaches to methodology and engagement. These models centered on funding influences, communication approaches, institutional support and culture, and the applied nature of forest resources. Previous studies (van Kerkhoff and Lebel 2006) of knowledge transfer systems identified external factors beyond objective science that influence research, such as the impact of publishing mandates on career advancement (Shanley and Laird 2002), lack of support or compensation for materials produced in participatory research (Kainer et al. 2009), and diminished innovation and superficial outputs

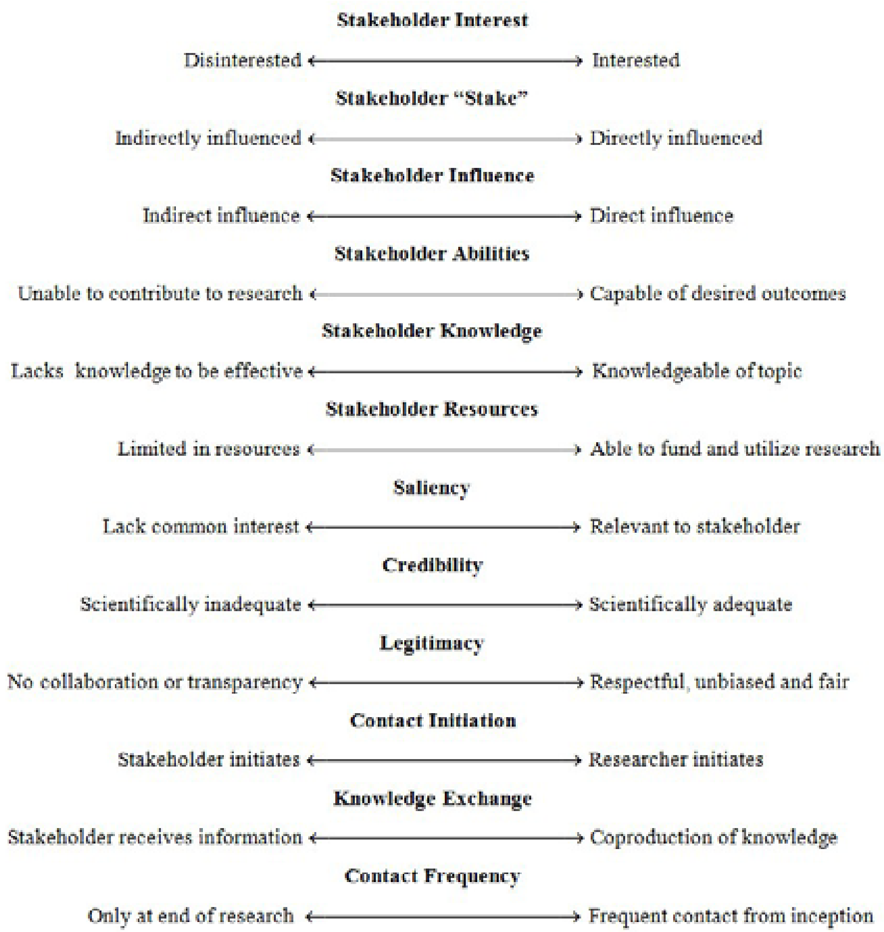


Figure 12. Forest science researchers' stakeholder engagement models and assumptions.

of research (Shanley and Lopez 2009). Not all emergent themes condemned traditional models, as distinct situations were identified where these were relevant. These findings support previous studies' assertions that certain types of scientific research benefit little from stakeholder engagement and these approaches can be onerously demanding on time and resources (Arnold and Fernanez-Gimenez 2008; Kainer et al. 2009; Shanley and Lopez 2009).

Our final objective was to produce suggestions to enlarge and refine stakeholder engagement models within forest science research. Sustainability science and participatory research methods are being adopted in community health and governance policy and research in the natural resources arena. U.S. forest science has begun to adopt these paradigms and methodologies through community forestry and the study of non-timber forest products (NTFP). Though sustainability science and participatory research approaches have only been implemented in a limited fashion by forest science researchers, these studies have proven effective in addressing complex problems. Long-term forest management is often wrought with power struggles, equity debates, and decision making using imprecise information (Allen and Gould Jr. 1986). As a consequence there is an increasing need to incorporate stakeholder knowledge while adopting interdisciplinary, inclusive methodologies.

Our analysis backs previous findings of researcher penchant for working within systems that support financially endowed, institutionally sanctioned research and stakeholders. These findings support the argument that knowledge is not exclusively created through objective scientific pursuit, but is biased by individual, scientific, financial and organizational deliberations (van Kerkhoff and Lebel 2006), while giving credence to claims made in Shanley and Lopez (2009) that this system can result in the depredation of science, inhibiting the communication of research findings and fostering conformity, stagnation, lack of innovation, and superficial outputs. Our findings indicate that if forest science researchers and their institutions wish to engage in stakeholder-oriented, participatory research, there needs to be a significant paradigm shift. By encouraging these methodologies institutes and organizations can provide researchers with the means to address the complex problems inherent in forest resources.

Impacts

If forest science researchers desire to adopt sustainability science and participatory research approaches, they first need to address the issue of communicating and cooperating with communities and citizens. This requires trust, as researchers need to show they can produce salient results by using credible research methods unique to each issue while proving their legitimacy by accounting for the distinctive and contrasting needs and interests of all stakeholders. Researchers thus become invested in and accountable for the outcome of their research, further strengthen stakeholder confidence that these researchers and institutes are in fact looking out for their best interests (van Kerkhoff and Lebel 2006; Randall 1974).

By conducting qualitative research on forest resource scientists and their stakeholder perceptions, our study has identified numerous models and assumptions that researchers operate under in regards to engaging stakeholders. We found a great awareness for the need to cooperate with stakeholders and to incorporate their knowledge and abilities into the research process, as well as lamentations over structural, institutional, and resource limitations inhibiting the adoption of sustainability science and participatory research practices. Because stakeholder cooperation and knowledge is so important in addressing the complex problems facing forest resources, it is critical to understand how these approaches can be implemented.The results of this study give insight to not only how forest science researchers work with stakeholders, but also how individuals and institutions can better incorporate these methodologies into their research ethos.

Funding

- Maine Economic Improvement Fund
- Maine Agriculture and Forestry Experiment Station, McIntyre-Stennis

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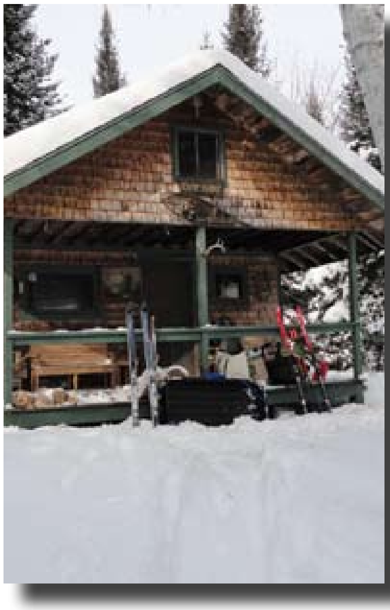
There's No Place Like Home:
The Role of Place Attachment in Understanding Family Forest Landowner Behavior


Patrick Lyons

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

Background

Family forest landowners will have a significant influence on the forests of the United States over the next thirty years (Butler and Leatherberry 2004). Trends indicate this group of landowners is increasing in numbers and is a leading cause of forest fragmentation (Stein et al. 2005). Concurrently, these landowners are aging and unprecedented numbers of acres are expected to exchange hands over the coming decades (Butler and Leatherberry 2004). To address these issues, natural resource professionals have begun to seek a better understanding of landowner attitudes and behaviors. In response, researchers have employed a variety of statistical analysis techniques to identify distinct segments of family forest landowners, frequently characterized by their forest ownership values and attitudes. This information can be used to form strategies of outreach and communication that accommodate landowner heterogeneity (Finley and Kittredge 2006; Butler et al. 2007).

Measuring the difference in ownership values and goals (e.g. timber income, wildlife habitat, recreation) is one way to consider the variability in landowners and their potential conservation behaviors. A different and important perspective is to estimate the various ways and degree to which landowners relate to their land, or are "attached" to it. Place and place attachment are concepts that represent a separate paradigm employed heavily by human dimensions researchers to explore how values and attitudes towards the environment influence human behavior (Jorgensen and Stedman 2001; Vaske and Kobrin 2001; Davenport and Anderson 2005). Over the past decade the concept of place attachment has focused on how wilderness areas, open spaces, and recreational experiences influence identity, dependence, and satisfaction for individuals and communities.

Objectives

This study posits place attachment can advance research on family forests by adopting proven conceptual frameworks for operationalizing place and create a more robust understanding of how attitudes and values of landowners influence behavior.

By adopting the conceptual place attachment framework utilized by Stedman (2002), this study explores the impacts of place attachment and landowner concern on forest landowners' behavior and the resulting implications for policy and outreach applications (Figure 13). The objectives of this study are to:

1. Identify place meanings and evaluative beliefs held by Maine family forest landowners and how those perceptions influence place attachment and landowner concern.
2. Explore the relationship between place attachment, landowner concern, and segments of family forest landowners.
3. Determine the relationship between behavioral intentions, place attachment and landowner concern.

This study has the potential to provide a new perspective to the traditional analysis of family forest landowners, advancing human dimensions theory of family forests while identifying alternative values and objectives to target in outreach and conservation efforts.

Approach

Survey Design

For our study, a mailed survey was administered using the four-wave Tailored Design Method recommended by Dillman (2009). Property tax records for landowners in Maine came from the Center for Research on Sustainable Forests (CRSF) Family Forest Program database. The survey was administered by mail to 1,000 randomly selected family forest landowners in Maine holding 10 to 1000 acres. The survey had a response rate of 54.9 percent (n=878), with 122 surveys returned as undeliverable and 46 surveys dropped from analysis due to missing values.

Scale Development

In addition to collecting demographic information about respondents, their management objectives, concern regarding their land, information-seeking behavior, and three place concepts were measured: place meanings, evaluative beliefs, and place attachment. The model used was adapted from Stedman (2002) and variables used to measure the concepts were developed using previous research (Vaske and Kobrin, 2001; Stedman 2002; Davenport

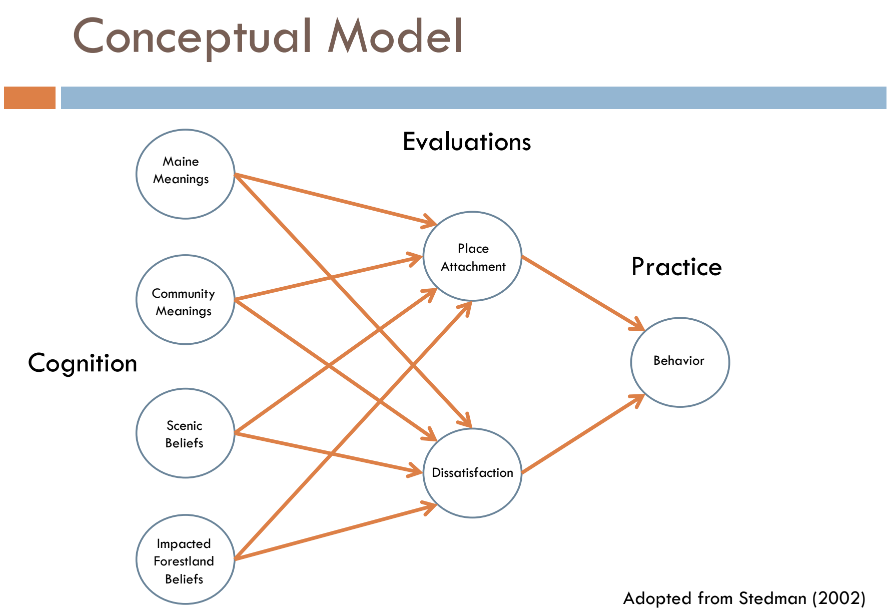


Figure 13. The scheduling framework models the decision process for family forest owners.

Table 5. Least squares regression measuring influence of place meanings and evaluative beliefs on place attachment and landowner concern. (p-value = 0.05)

	Attachment			Landowner Concern		
	Beta (Std.)	t	Significance	Beta (Std.)	t	Significance
Constant	5.862	2.09	0.037*	28.251	4.465	0.001*
Maine Meanings	0.276	6.695	0.001*	0.09	1.604	0.109
Community Meanings	0.407	9.986	0.001*	0.04	0.717	0.474
Impacted Forestland Beliefs	-0.012	-0.344	0.731	0.136	2.837	0.005*
Scenic Beliefs	0.181	4.553	0.001*	0.079	1.45	0.148
ANOVA	**SS**	**df**	**MS**	**F**	**Significance**	**Adjusted R^2**
Attachment						
Regression	17853	4	4463	101	0.001*	0.48
Residual	18962	431	43			
Total	36816	435				
Landowner Concern						
Regression	4246	4	1061	4.74	0.001*	0.033
Residual	96488	431	223			
Total	100734	435				

et al. 2010) and the U.S. Forest Service National Woodland Owner Survey (NWOS) (Butler and Leatherberry 2004).

Results

Cognitions of Place

Based on Stedman (2002), our study hypothesized that place attachment and landowner concern would be significantly influenced by place meanings and evaluative beliefs. Place meanings, evaluative beliefs, place attachment and landowner concern scales were each summated into single values based on factor analysis loading. Ordinary least squared regression found that, for our study, place meanings and evaluative beliefs predicted both place attachment ($F=101.448$, $p < 0.001$) and landowner concern ($F=4.742$, $p < 0.001$) (Table 5). Three of the four cognitive measures showed significant relationships for place attachment, with a strong goodness of fit for the model ($R^2=0.480$). Only one of the four cognitive measures for landowner concern, Impacted Forestland Beliefs, showed a significant influence (Beta=2.837, p=.005) and had a relatively weak goodness of fit for the model ($R^2=0.033$).

Landowner Segments

Cluster analysis was run using the twelve standard NWOS questions addressing family forest ownership objectives to identify landowners segments. This form of analysis was used as it yields statistically significant and distinct segments of family forest landowners, accommodating the heterogeneous nature of their values and attitudes (Finley and Kittredge 2006). The k-means clustering assigned the survey participants to their respective segments based on responses to the ownership objectives, measuring level of importance on a 5-point Likert scale. In exploring the appropriate number

Table 6. Landowner segmentation and its relationship to place attachment and landowner concern.

	Salt of the Earth (N=191)	Heirs of the Woods (N=133)	Fortress of Solitude (N=69)	Uninvolved (N=38)
Ownership Objectives				
Enjoy the beauty or scenery	4.66[b]	4.52[b]	4.72[b]	1.47[a]
Protect nature and biodiversity	4.22[b]	4.20[b]	4.07[b]	1.83[a]
Land investment	4.14[c]	3.61[bc]	3.44[b]	2.13[a]
Part of home or vacation home	4.57[b]	4.50[b]	4.64[b]	1.50[a]
Part of farm or ranch	3.53[c]	3.36[b]	1.74[a]	2.04[a]
Privacy	4.48[b]	4.42[b]	4.59[b]	1.55[a]
Pass land on to heirs	4.31[c]	4.26[c]	3.08[b]	1.97[a]
Non-timber forest products	3.53[c]	2.79[b]	1.74[a]	2.04[a]
Firewood	4.31[c]	2.97[b]	1.97[a]	1.81[a]
Timber products	4.31[c]	2.46[b]	1.87[a]	2.21[ab]
Place Scales	**Salt of the Earth**	**Heirs of the Woods**	**Fortress of Solitude**	**Uninvolved**
Attachment[1]	52.6[b]	51.2[b]	49.0[ab]	46.5[a]
Landowner Concern [2]	56.0[b]	53.7[b]	47.2[a]	54.1[b]

Note: Items measured on a Likert scale, 1=very unimportant, and 5=very important
[1]mean score out of possible 60
[2]mean score out of possible 100

of landowner segments, two-, three-, four-, and five-cluster solutions were analyzed, eventually arriving at a four-cluster solution based on ease and effectiveness of interpretation. Using this four cluster solution, ANOVA, Pearson's chi-square and independent sample t-tests were used to explore how these segments differed in their ownership objectives, place attachment and landowner concern data (Table 6).

Predicting Stewardship Behavior

Using logistic regression, the relationship between place attachment, landowner concern and various landowner behaviors was measured. Landowner behavior questions covered topics pertaining to information-seeking behavior, land acquisitions, and forest management. The analysis revealed that increasing landowner concern predicted the greater likelihood of past and anticipated information-seeking behavior, as well as the increased probability of giving heirs land, buying more land, having a management plan, intentions to create a management plan and planning to enroll land in a cost-share program. Our model predicted higher place attachment increased likelihood of landowners having a will and decreased their likelihood to sell their land.

Impacts

Our study revealed that two landowner segments, Heirs of the Woods and Salt of the Earth, together comprised over 75 percent of Maine family forest landowners and that these two groups had the highest levels of place attachment. Additionally, Heirs of the Woods and Salt of the Earth landowners placed high importance on passing land on to their heirs. With this knowledge, we can begin to speculate on the implication of family legacy among family forest landowners. Two-thirds of family forest landowners are over the age of 55, and the number of owners 65 years in age or older increased by 34 percent from 1993 to 2003 (Butler and Leatherberry 2004). This advanced age of landowners indicates that over the next two decades a large percentage of family forest land will exchange hands. Previous studies on family forests have shown family legacy to be increasing in importance among ownership objectives (Butler and Leatherberry 2004; Butler and Ma 2011). Moreover, Majumdar et al. (2009) identified a significant difference in the motivations and management practices between inheritor and non-inheritor family forest landowners, finding inheritors were significantly more likely to engage in active forest management through the production of both timber and NTFPs when compared to non-inheritors.

Thus, the findings of our study and previous studies indicate: (1) 75 percent of family forest landowners in Maine have strong place attachment, indicating they are more likely to have a will and less likely to sell their land; (2) passing land on to heirs is a highly valued objective of Maine family forest landowners and is increasing in importance throughout the northern United States (Butler and Ma 2011); and (3) inheritors of land are more likely to engage in active forest management (Majumdar et al. 2009). These results indicate there could be a significant value derived from state policies and programs that promote and bolster intergenerational transfer of family forests, with the aim of keeping land in the hands of people with proven stewardship and management values. This could better ensure the state's timber supply, as well as continue the tradition of public access to private lands, preserve ecosystem services, and help deter forest fragmentation and parcelization.

Funding

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- Maine Agriculture and Forestry Experiment Station, McIntyre - Stennis

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CRSF Archives

IMPROVING OUR UNDERSTANDING OF KENNEBEC COUNTY WOODLAND OWNER INTERESTS, NEEDS, AND STEWARDSHIP

Michael Quartuch, John Daigle, Jessica Leahy, and Kathleen Bell

Introduction

Forest ecosystems are responsible for producing fiber, clean air and water, sequestering carbon from the atmosphere, maintaining biodiversity, wildlife habitat, soil and nutrient stability, and offer a wide array of recreational and aesthetic opportunities (Stein et al. 2005; Beckley 1999). Throughout the world, however, human activities and land use decisions are resulting in the loss of wildlife, biodiversity, and natural resources including fisheries and forests (Chapin et al. 2009; Ostrom 2009). Furthermore, many of the ecosystem services and amenity values discussed above are disrupted when forest lands are split into smaller lots or converted for residential development (White et al. 2010; Stein et al. 2007). Residential development, for example, permanently alters the landscape and can have unintended consequences on natural resources, wildlife, forest management, and overall quality of life. Sustainable forest management is one approach to assuring that social, ecological, and economic attributes are conserved over time. Therefore, it is vital that forest managers and forest landowners become aware of this stewardship approach to optimize benefits of maintaining large intact forests for themselves as well as society at large.

Family Forest Landowners: U.S. and Maine

Family forests comprise one of the largest land tenure categories in the U.S. and the number of family forest landowners increases each year. Over 264 million acres of forest land in the United States rests upon the shoulders of over 10.4 million individuals and families (Butler 2008). These individuals and families supply approximately 50 percent of the nation's timber harvest (Powell et al. 1993) and provide various recreational, aesthetic, and economic opportunities. Research suggests however, that as the number of forest landowners increases, both the average parcel size and the number of written forest management plans, decrease (Kendra and Hull 2005; Kittredge 2004; Rickenbach and Kittredge 2009; Sampson and DeCoster 1997; Mehmood and Zhang 2001; Butler 2008; Butler and Ma 2011; Sampson and DeCoster 2000). Furthermore, researchers have found that

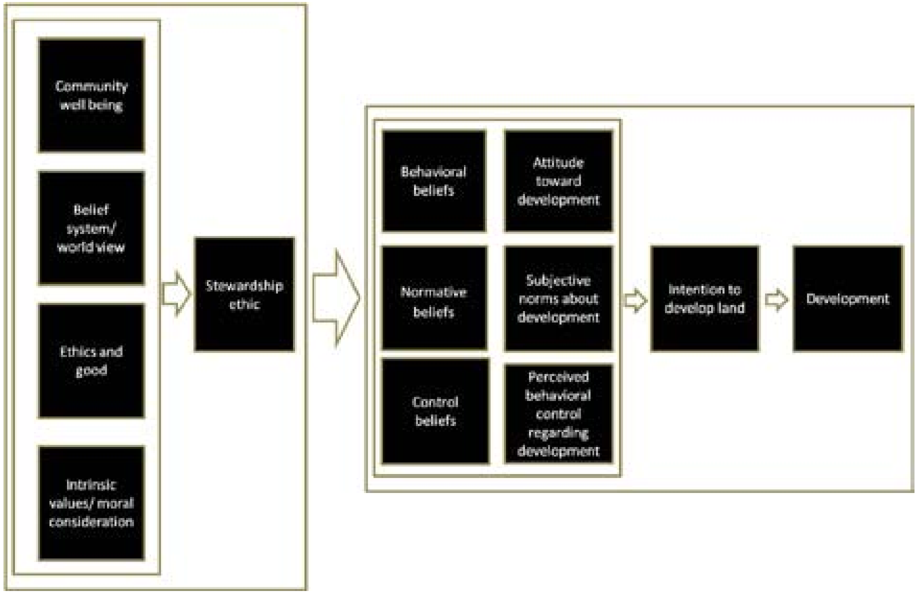

Figure 14. This conceptual model indicates the flow of landowners attitudes and beliefs into behaviors related to conservation, management, and development.

increasing population densities and urban expansion often result in declining rates of commercial timber harvesting and active forest management (Munn et al. 2002; Wear et al. 1999; Kline et al. 2004). Many Northern states are experiencing such trends and Maine is no exception. Nearly one-third of the total forest land (about 5.7 million acres) in the state of Maine is owned by over 200,000 family forest landowners (McWilliams et al. 2005; Maine Department of Conservation 2009). These individuals and families own their land for a variety of reasons and are located predominantly in the central and southern regions of the state (Maine Department of Conservation 2010). However, increasing parcelization and forest land conversion in central and southern Maine threaten these forests. Approximately 210,000 acres of forest land along various sections of the Lower Kennebec River, for example, are projected to experience substantial increases in residential housing density by 2030 (Stein et al. 2005). In order to sustain intact forest parcels, it is increasingly important to understand why such trends for parcelization of forests are occurring and it is equally important to begin to identify potential solutions to these issues.

Previous Research

Efforts to understand landowner behavior have focused on gauging general landowner attitudes and motivations through socio-demographic characteristics, objectives, management preferences, reasons for owning land, and other landowner attributes (e.g. acreage, residential status, how land was acquired, etc.) (Kluender and Walkingstick 2000; Majumdar et al. 2009; Finley and Kittredge 2006; Kendra and Hull 2005). These studies have helped resource professionals and academics better understand how and why this target group engages (or does not engage) in certain land use practices such as parcelization. Importantly, social science research of landowner behavior has found that planned objectives and management practices, for example, do not necessarily translate into actual behavior. Therefore, in order to identify how Kennebec County woodland owners are using their land and to identify more effective and practical approaches to engaging with landowners, our research builds upon existing knowledge by asking questions about: active forest management, land stewardship, landscape change (caused by development), reasons for owning land, and what issue(s) they face as landowners. Furthermore, we expand upon previous research by examining landowner's sense of responsibility via land stewardship and stewardship ethics. As this research is on-going, preliminary results will be provided below followed by a brief section outlining anticipated results with regard to using landowner stewardship ethics-value orientations to predict whether or not they will develop their parcel(s).

Stewardship

The term stewardship refers to an ethical or moral obligation to care for something on behalf of someone (or something) else and shares similarities with other land management approaches such as sustainable management and conservation (Worrell and Appleby 2000). The primary difference between stewardship and other types of management is an explicit, life-centered focus versus a more people-centered approach, for example and an emphasis on having to both incorporate and answer to, a broader set of "stakeholders" (e.g. society, plants/animals, future generations of humans, etc.) (Worrell and Appleby 2000). By understanding landowner stewardship and stewardship ethics resource professionals and policy makers will be able to better engage with landowners and target specific landowner needs based on a more comprehensive, value-orientation, rather than management objectives and reasons for owning land, alone.

Objectives

1. To determine how Kennebec County woodland owners are using/managing their forest land and what information is important to them
2. To identify appropriate and effective methods to inform and assist woodland owners in using/managing their land
3. To examine the multi-dimensional nature of stewardship ethics held by family forest landowners

Approach

Using the CRSF family forest landowner property tax 2009 and 2010 database, our sample included records from all towns within Kennebec County, with the exception of Randolph and Oakland. We created a master list of all non-commercial property owners with 10 - 1,000 acres of total land and from these data, 903 landowners were randomly selected and included in our sample. A mailed questionnaire titled, Kennebec County Woodland Owner Survey, was created and comprised of 9 sections with a total of 38 questions. The nine primary sections in the survey assessed various interests ranging from forestry programs and green certification to timber harvesting and stewardship. The majority of questions were either binary (yes/no), or contained statements where participants would indicate their level of agreement/disagreement, preference, or likelihood, along a 5-point Likert scale. Survey administration followed Dillman's Tailored Design method (Dillman et al. 2009). Over the course of a five week period potential respondents receive four different contacts which serve to increase the response rate and decrease bias. A total of 393 deliverable surveys were returned while 39 were "returned to sender" or were unable to be delivered. The overall response rate was 45 percent. Non-response bias was examined by comparing early versus late respondents for both demographic and landowner characteristics (e.g. age, employment situation, gender, amount of woodland owned) (Armstrong and Overton 1977). No significant differences were found

Results

Socio-demographic and landowner attributes

The majority (66.5 percent) of woodland owners in Kennebec County own between 1-50 acres of forest land, have owned their parcel(s) for over 27 years (average), live on their woodland (74.9 percent), and are between the ages of 51-75 years old (68.3 percent). Over 80 percent of survey respondents are male (19.4 percent female) and approximately 88 percent are either "retired" or are "working full time." When making decisions about how to use or manage woodland, almost 73 percent of respondents are making decisions with input from another (joint) owner while 23.7 percent of respondents are the sole owners of their woodland.

Land use and management

Findings from the National Woodland Owner Survey suggest that family forest landowners own land to enjoy beauty or scenery, because it is part of the farm or homestead, for privacy, to pass on to heirs, and to protect nature and biologic diversity (Butler and Leatherberry 2004). Similarly, the top three reasons why Kennebec County woodland owners own forest land are: "Part of my primary home" (62.3 percent), "To enjoy beauty or scenery" (60.3 percent), and "For privacy" (60.9 percent). Only 15.5 percent of participants own land "For production of saw logs, pulpwood, biomass, or other timber products" (Table 7). Over half (51.2 percent) of participants have conducted a commercial timber harvest on their woodland and 74.6 percent of these individuals were "somewhat" to "very satisfied" with the outcome. When asked if they would consider conducting another commercial harvest in the future, nearly 60 percent indicated that they would. While these results may be encouraging to individuals, organizations, companies, and government agencies interested in future timber harvesting, it is also important to note that approximately 16 percent were either "somewhat" to "very unsatisfied" with the commercial harvest. The majority of Kennebec County woodland owners have never used a forestry assistance program and most (73.4 percent) do not currently have a written forest management plan. However, about 36 percent of respondents would consider using an assistance program and almost 67 percent would consider using a management plan or are unsure. When asked what would encourage woodland owners to acquire a written management plan, 51.7 percent identified getting "a property tax reduction," 37.2 percent suggested finding "ways to improve wildlife," and 31.4 percent indicated getting "professional advice about how to improve my land."

Learning about land and trusted resources

When asked how they prefer to learn about their land, participants identified "Publications, books, or pamphlets" (31.4 percent), "Newsletters" (27.8 percent), and the "Internet/Web" (18.3 percent) as the three most preferred methods; while the three least preferred methods include, "Television" (19.7 percent), "Conferences, workshops or video conferences" (29.0 percent), and "Radio programs" (30.7 percent) (Table 8). With regard to whom they prefer to obtain information from, respondents indicated "Maine Forest Service" (67.6 percent), "Forester or other natural resource professional" (67.3 percent), and "Cooperative Extension professional" (45.5 percent). The three least preferred sources were "Neighbors" (49.3 percent), "Logging contractor" (43.2 percent), and "Family members" (39.6 percent).

Stewardship

Findings indicate an overall stewardship ethic in congruence with individual/familial needs and the needs of what Leopold (1949) referred to as, the biotic community (e.g. the land, plants, animals). Interestingly, few respondents indicated a responsibility to their neighbors, their community, or the broader society yet many participants (91.3 percent) "agree" or "strongly agree" that the public has a responsibility to them and their land when using it (Table 9). These findings suggest that most landowners are less influenced by social phenomena than they are biophysical and/or individual needs. Our results also corroborate previous research efforts regarding landowner stewardship. Egan and Jones (1993) found that landowners with a "high" degree of stewardship expressed concerns about other "non-commodity" values including soil and water, amongst other things.

Table 7. Level of importance for each land ownership reason. Source: Survey Question 9, Section 1.

Reason for Owning Woodland	N	Very Important				Very Unimportant
Part of my primary home	313	62.3%	11.2%	7.3%	5.4%	13.7%
For privacy	307	60.9%	18.2%	12.4%	1.6%	6.8%
To enjoy beauty or scenery	317	60.3%	18.3%	15.5%	3.5%	2.5%
To protect nature and biologic diversity	308	45.5%	22.1%	21.1%	7.5%	3.4%
For hunting or fishing	314	42.0%	13.7%	15.9%	7.3%	21.0%
For wildlife or fish habitat enhancement	308	39.9%	23.4%	21.4%	7.1%	8.1%
For production of firewood for my use	321	38.6%	19.6%	18.4%	10.0%	13.4%
To pass land on to my children or their heirs	310	37.4%	19.0%	21.6%	7.1%	14.8%
For recreation other than hunting or fishing	301	33.2%	20.3%	23.3%	9.6%	13.6%
For land investment	303	29.0%	21.1%	25.1%	10.6%	14.2%
Part of my farm or ranch	273	26.4%	11.4%	13.6%	8.4%	40.3%
For production of saw logs, pulpwood, biomass, or other timber products	303	15.5%	14.2%	25.1%	16.5%	28.7%
Part of my vacation home or camp	256	14.5%	7.0%	13.3%	9.8%	55.5%
For cultivation/collection of non-timber forest products (berries, maple syrup, balsam fir tips)	295	12.9%	10.2%	23.7%	18.6%	34.6%

Anticipated results: stewardship and development

In August, 2012 analysis on the stewardship ethics portion of the study will begin. First, we plan to examine the validity and reliability of our four dimensional stewardship construct by using confirmatory factor analysis and Cronbach's alpha to test for internal consistency. If statistically significant factors are identified each will serve as independent variables used to predict whether they are influencing landowners to develop (or not develop) their parcel(s) (Figure 14). Second, these data will be used to identify segments or clusters of landowners based on individual responses to each of the stewardship ethics questions. This will result in the identification (or not) of statistically significant subgroups of landowner stewardship ethics value-orientations. Next, we will use these results to conduct regression analysis in order to examine whether socio-demographic characteristics, reasons for

Table 8. Way(s) in which woodland owners prefer/do not prefer to learn about their land. Source: Survey Question 13, Section 4.

Preferred Method to Learn About Woodland	N	Most Preferred				Least Preferred	Not Sure
Publications, books, or pamphlets	296	31.4%	29.7%	23.0%	1.4%	8.8%	5.7%
Newsletters	299	27.8%	25.1%	26.8%	3.7%	11.7%	5.0%
Internet/Web	290	18.3%	20.7%	27.9%	4.1%	21.8%	7.9%
Visiting or field trips to woodlands	289	17.3%	18.7%	24.2%	8.3%	21.8%	9.7%
Magazines	294	17.0%	22.4%	32.7%	5.4%	16.0%	6.5%
Newspapers	289	13.5%	14.5%	38.1%	6.9%	20.4%	6.6%
Movie for home viewing	290	12.8%	19.3%	31.0%	9.3%	20.7%	6.9%
Television	290	11.0%	16.9%	36.9%	6.9%	19.7%	8.6%
Conferences, workshops or video conferences	286	7.0%	17.1%	30.8%	8.0%	29.0%	8.0%
Radio programs	287	3.8%	10.8%	32.8%	10.8%	30.7%	11.1%

Table 9. Level of agreement/disagreement with having a responsibility to various entities. Source: Question 27, section 7.

Responsibility to the following when using woodland	N	Strongly Agree				Strongly Disagree	Not Sure
My needs	319	79.0%	11.6%	6.0%	0.3%	0.6%	2.5%
Animals	324	49.4%	30.2%	13.6%	1.9%	2.8%	2.2%
The land (e.g. soil, water resources)	313	48.2%	27.5%	16.9%	2.2%	2.6%	2.6%
Future generations	316	44.0%	28.2%	19.6%	1.9%	3.5%	2.8%
Family members	321	38.9%	29.9%	19.0%	2.8%	6.9%	2.5%
Plants	312	36.2%	29.2%	22.8%	4.5%	4.5%	2.9%
Neighbors	308	12.3%	27.3%	32.8%	7.5%	17.5%	2.6%
Society	305	9.5%	20.0%	35.4%	11.5%	19.3%	4.3%
Community members	308	6.5%	18.2%	38.0%	12.7%	21.1%	3.6%

owning land, and other landowner attributes (e.g. acreage) influence any of the stewardship ethics-value orientation clusters.

Impacts

The findings presented in this report offer both practical solutions for natural resource organizations and agencies as well as implications for policy makers. First, agencies or organizations interested in encouraging active woodland management may want to target landowners that are undecided or "not sure" about whether they would obtain a written forest management plan, participate in forestry assistance programs, become green certified, or conduct future commercial harvests. With regard to written forest management plans for example, respondents indicated that being able to improve wildlife habitat or simply getting professional advice to improve land might sway them to obtain a plan. Equally important to landowners is who is delivering the message as well as the mode of delivery. Findings suggest that landowners prefer learning about their land from natural resource and forestry professionals and through various publications, newsletters, and the internet. Therefore, one way to encourage active forest management would entail delivering information about woodland improvement or wildlife habitat from a trusted source (e.g. Maine Forest Service) using local newsletters, pamphlets, or electronic media. The notion of wildlife habitat improvement was further supported when asked about stewardship. Participants identified a heightened sense of responsibility to the biotic community or, plants, animals, and the land itself. Resource professionals interested in engaging with woodland owners can use this information to target outreach and education efforts that entail increased one-on-one interaction with landowners and an increased emphasis on promoting wildlife/wildlife habitat. Policy makers may want to consider using these data to create (or amend) policies that better align with landowner interests/needs. For example, landowners identified concerns over property taxes as one of the top three issues they are facing and "To get a property tax reduction" ranked first when asked what would encourage landowners to obtain a written forest management plan. Based on our results, landowners are genuinely concerned about the state of the forest including plants, animals, the land itself, and water/soil protection. Future forest management policies may want to include direct compensation or other non-monetary rewards/incentives that tap into this facet of landowner stewardship ethics.

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Brewer Lake: Even close to population centers,,homes with substantial acreage of forest are common.

Pam Wells

Spencer Meyer

Listening Beyond the Choir:

Finding the Voice of Limited-Resource Landowners in Maine

Brittney Townsend and Jessica Leahy

Background

One often hears anecdotes of the "Land Rich, Cash Poor" - stories of landowners harvesting timber too soon to pay for medical bills or to replace a broken vehicle, or rumors of landowners selling because they could no longer afford their property taxes on their fixed incomes. Yet, there has been little scientific research performed on limited-resource landowners in Maine (Flora and Flora, 2008). This study seeks to change this and offer potential solutions for how we might study, engage, and assist limited-resource landowners with their forest stewardship. Traditional research methods, which include landowner surveys, may not be effective for studying limited-resource landowners for reasons such as low literacy levels, rural transportation issues, time constraints, as well as a lack of internet service. As a result, our understanding of the stewardship values, challenges and opportunities faced by this unique demographic may be incomplete or in the least skewed. This study will take a qualitative, analytical approach employing semi-structured, in-person interviews to shed light on issues faced by these individuals. Researchers and professionals throughout Maine will gain new insight into the needs, preferences, and challenges of limited-resource landowners.

Objectives

The overall goal of this project is to better understand limited-resource landowners within the state of Maine so that they may be better served by future research and outreach efforts. The objectives are to:

1. Use qualitative interviews to identify stewardship values, challenges, and opportunities of limited-resource forest landowners.

2. Summarize findings for future use in subsequent research and outreach campaigns targeting this unique demographic group.

Maine provides an excellent setting for this research as it boasts the highest percentage of private landowners in the United States (Acheson, 2006), but also suffers from a relatively low per capita income level when compared to the rest of New England and the United States as a whole (Maine Development Foundation, 2011).

Approach

The research will use a qualitative approach, relying on semi-structured interviews with up to 20 landowners, and is most appropriate as exploratory research that delves into human-forest connections and the influence of socioeconomic status on aspects of forest stewardship. These methods avoids potential illiteracy issues encountered with mail surveys. Our criteria for inclusion in the study will be that the landowner must have an annual household income less than 200% above the federal poverty income guidelines, as well as own a minimum of 10 forested acres. Using a 2009 database of forest landowners in Maine developed by CRSF, landowners fitting our landownership and socioeconomic participant criteria were identified and their phone numbers retrieved from free and publicly available online records. Interviews will be recorded and transcribed verbatim. University of Maine human subjects review board approval will be in place before initiating contact with participants. Every attempt will be made to ensure participant confidentiality. Qualitative research provides findings that are based on themes, patterns and relationships (Dey, 1999). Data analysis of the interview transcripts will be an iterative process focusing on identifying relevant themes, patterns and relationships concerning limited-resource landowners. After coding all of the transcripts, an initial concept map will be developed. Themes will be refined using questions, single word phrase analysis, and negative case analysis. Next, data gaps will be identified and concept maps will be finalized. Finally a report summarizing the results and findings of the study will be created for use in subsequent research and outreach campaigns targeting this unique demographic group.

Results

Interviews are currently ongoing, but preliminary findings show a great deal of diversity within this demographic as well as widely varying outreach preferences. So far, the Tree Growth Tax Law has proven integral in allowing many landowners to retain ownership of their forest lands. It is anticipated that this trend will continue throughout the duration of the study.

Impacts

This study will identify the unique set of needs, preferences and challenges of limited-resource forest land owners in Maine as well as offer potential solutions for how we might more effectively study, engage and assist limited-resource landowners with their forest stewardship in the future. The stereotypical family forest landowner is an older, white male with a college education and keen interest in learning about and managing his small woodlot (McCaskill et. al, 2008). However, this stereotype may be an artifact of research methods and outreach strategies currently employed by researchers, educators and other professionals. This study hopes to change this stereotype and hopefully alter the way in which future forest stewardship outreach materials and programs are administered. Perhaps with the added insight provided by this exploratory study, future research may be more effectively tailored to this unique demographic group and better provide for their specific set of needs.

Funding

- The University of Maine, School of Forest Resources, Maine Agricultural and Forestry Experiment Station

- National Science Foundation, Maine EPSCoR award EPS-0904155 (SSI)
- Small Woodland Owners Association of Maine

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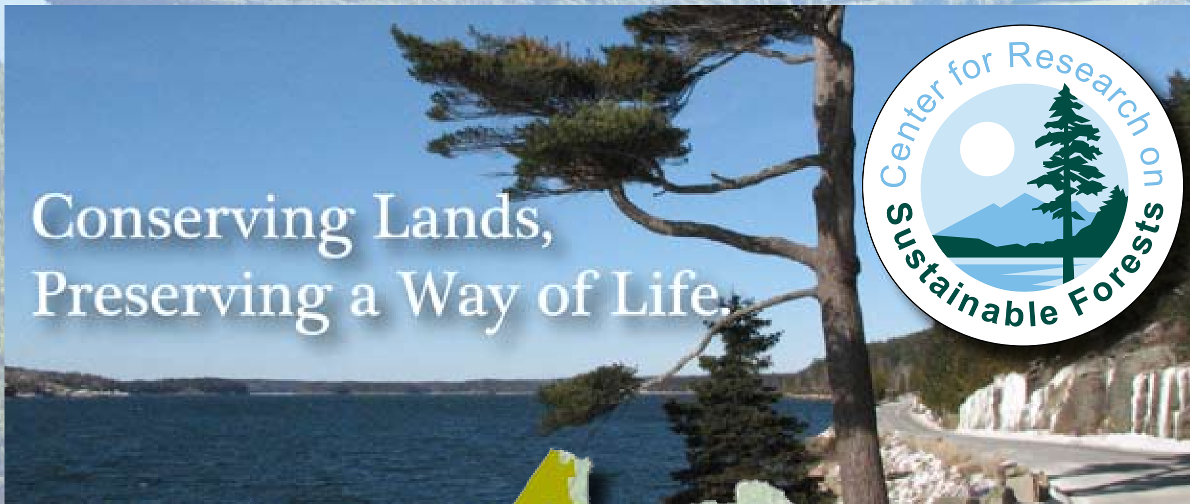
Conserving Lands, Preserving a Way of Life



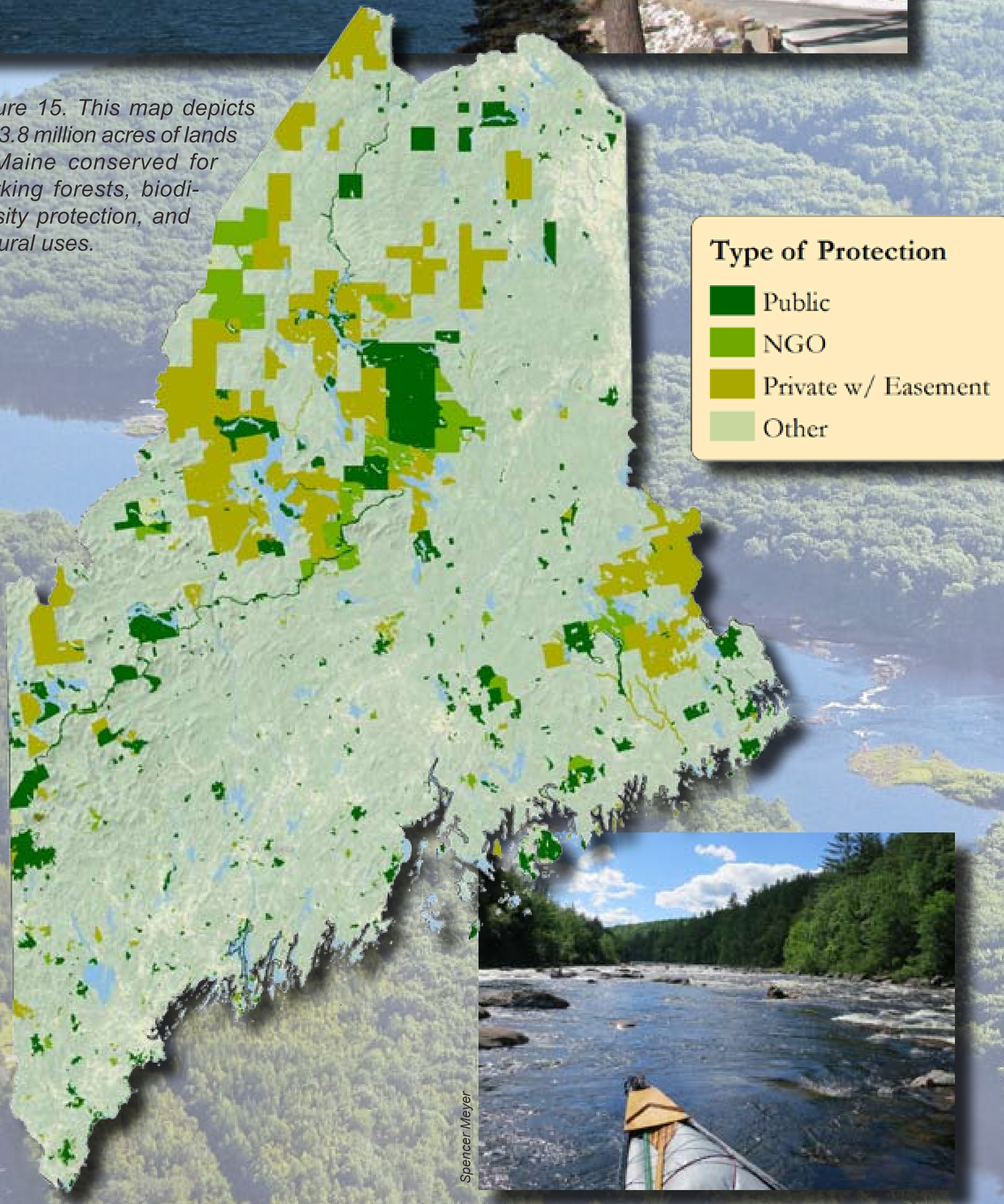


Figure 15. This map depicts the 3.8 million acres of lands in Maine conserved for working forests, biodiversity protection, and cultural uses.

Spencer Meyer

CONSERVATION LANDS PROGRAM

Maine has led the nation in the development and application of innovative land conservation tools, especially when it comes to private lands and the protection of working forests. As of today, Maine has conserved roughly 3.8 million acres of land for parks, working forests, biodiversity protection, and other natural resources.

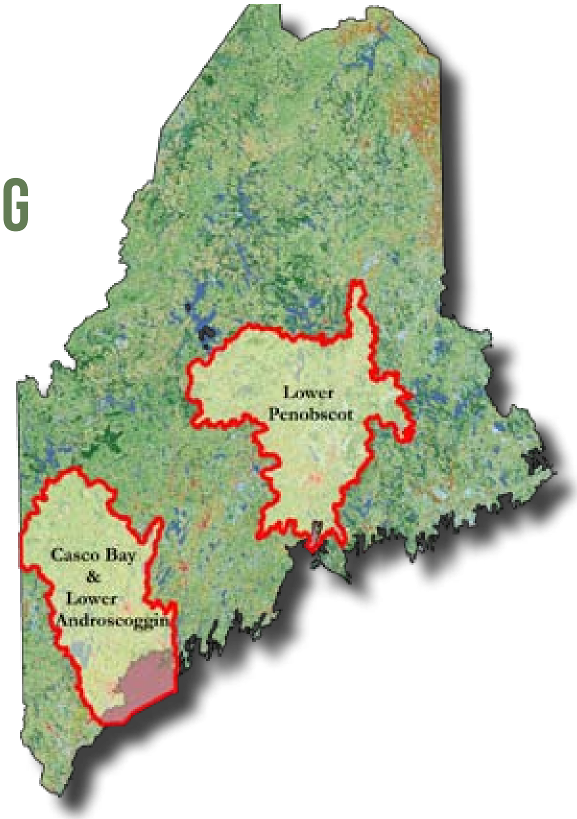
The landscape mosaic of developed and undeveloped lands in the northeastern U.S. has progressively changed at various spatial scales in response to land use and development pressures, socioeconomic influences, expansion of transportation networks, and non-uniform state and local regulatory frameworks. 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 (Figure 15). 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.

CRSF's research program on Conservation Lands and Public Values 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 is designed to:

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;
3. Account for the dominant processes and criteria driving conservation activities across the different states of the Northeast; and
4. Develop tools that help a wide range of stakeholders understand land use change and explore alternative future development paths.

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 MODELING FOR THE LOWER PENOBSCOT AND LOWER ANDROSCOGGIN RIVER WATERSHEDS IN MAINE



Rob Lilieholm, Christopher Cronan, David Owen, Jeremy Wilson, Eric Gallandt, Michelle Johnson, Spencer Meyer, Thomas Parr, Dane Sherman, Kayla Pelletier, and Jill Tremblay

Objectives

The U.S. Forest Service projects that by 2030, both the Lower Penobscot and Lower Androscoggin River watersheds in Maine (Figure 16) will experience significant increases in urbanization and losses of private forestland. The Lower Androscoggin is among the 15 watersheds nationwide at greatest risk of development. The University of Maine's Sustainability Solutions Initiative (SSI), in cooperation with CRSF, has identified these watersheds as prime study areas to develop a new, stakeholder-driven land use planning tool using alternative futures analyses. The overall goal of the project is to spatially assess the suitability of four critical land uses across these two watersheds:

1. Economic development;
2. Forestry;
3. Conservation; and
4. Agriculture

In assessing these suitabilities, compatibilities and potential conflicts can then be identified under a range of stakeholder-defined futures scenarios. This research goes beyond typical conservation planning by evaluating an array of possible futures across multiple land uses. These results will help communities and conservation organizations better prioritize their protection efforts, while allowing policy makers and planners to consider alternate policy strategies.

Approach

Since 2010, the research team has led focus groups on each of our four land uses with more than 70 stakeholders. Stakeholders included policy makers, conservationists, farmers, foresters, business leaders, and scientists. Through these focus groups, we identified key factors affecting the suitability of each of our four land uses, and then co-developed models for land use suitability within each watershed.

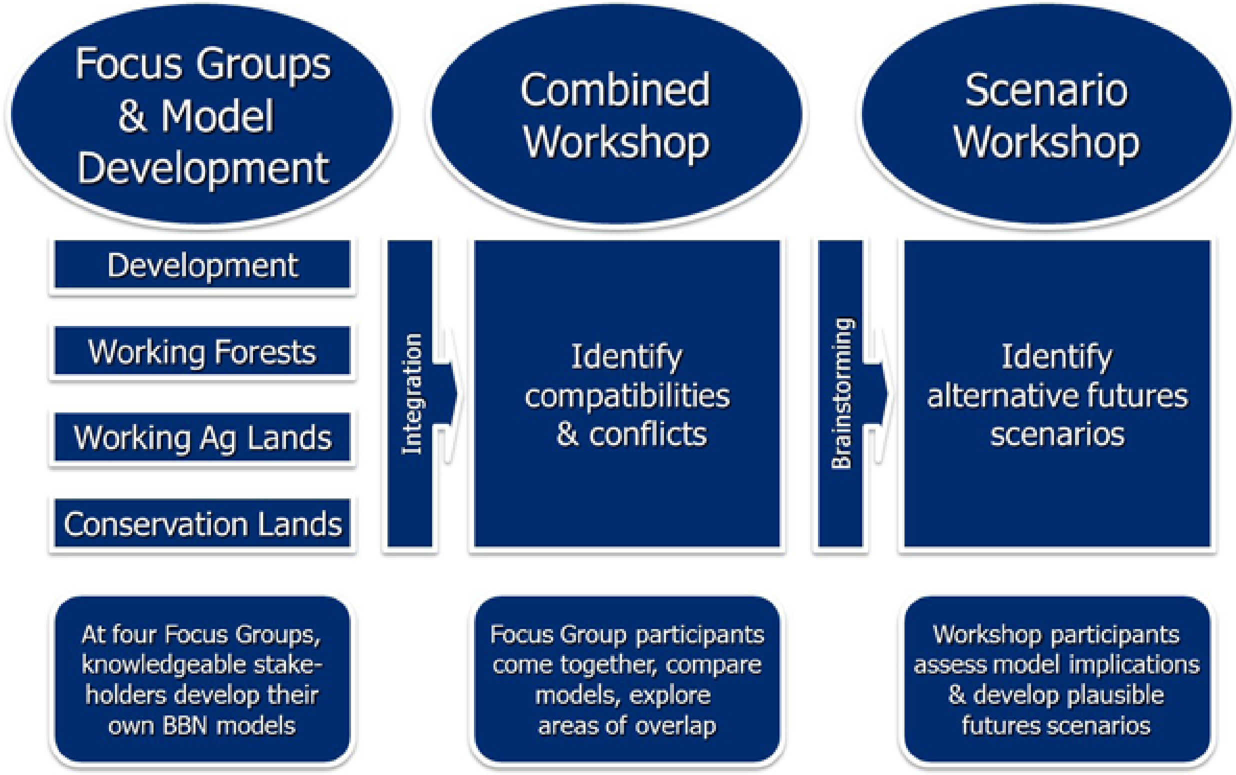


Figure 16. Schematic showing the steps (left to right) in our stakeholder engagement process.

Using a technique called Bayesian belief networks (BBN), expert opinions gleaned through the focus groups were combined with existing geospatial information from a variety of state agencies, conservation organizations, and other sources. Using the relative ratings for each factor, as determined by our stakeholders and influence diagrams, we then produced land use suitability maps for the study areas. For example, in the conservation influence diagram (Figure 17), the various factors of suitability for ecosystem protection come together to identify ecosystem services, biodiversity, and recreation as three

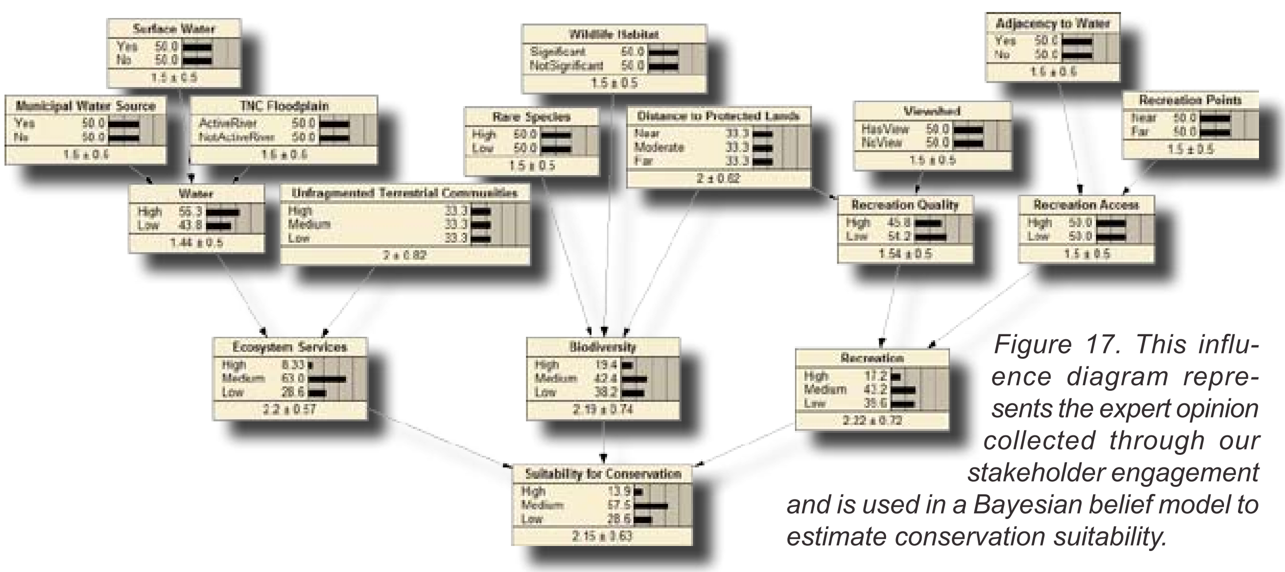


Figure 17. This influence diagram represents the expert opinion collected through our stakeholder engagement and is used in a Bayesian belief model to estimate conservation suitability.

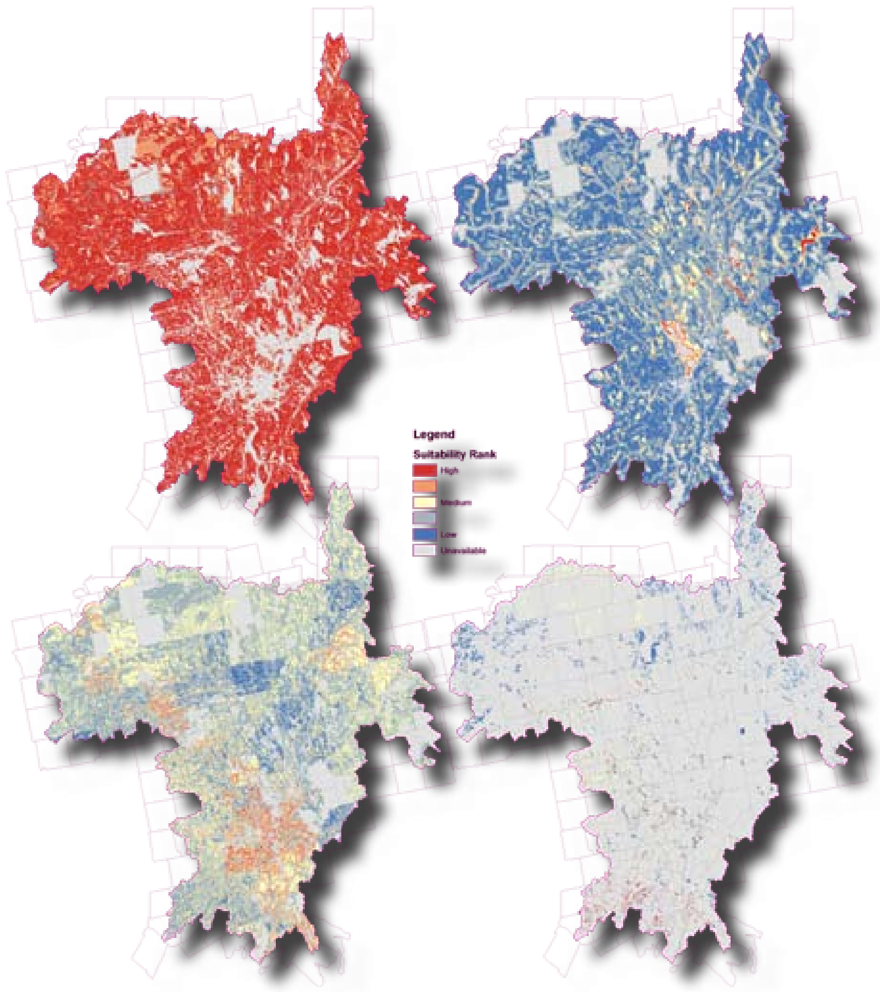


Figure 18. Land suitability for forestry, conservation, agriculture, and development (clockwise, from top left) derived from our stakeholder focus groups.

pillars of conservation. Each land use has its own influence diagram, which results in each of the suitability maps shown above (Figure 18).

Next, a combined workshop allowed focus group stakeholders from each of the four land uses to come together to envision conflicts and opportunities for competing and complementary land uses. We are currently developing a set of futures scenarios through ideas generated with our stakeholder partners. These futures scenarios range from varying levels of development, to changes in agricultural practices due to global energy markets, to "what-ifs" about how conservation and forestry can co-manage landscapes for a variety of products and ecosystem services.

Results

Based on our four land use suitability models, we have begun to explore the potential for future conflict and compatibilities in the 2.5-million-acre Lower Penobscot River Watershed. For example, Figure 19 shows areas highly suitable for conservation (green), as well as the overlap between areas suited for both conservation and development (red). These areas of overlap between two non-compatible land uses show areas of potential future conflict, and are of concern to both conservation and development stakeholders. We have produced similar maps for other conflicts, including overlaps between areas highly suitable for development and forestry.

In Figure 20, we show lands highly suitable for both forestry and conservation in dark green (the balance of highly suitable conservation lands are shown in light green). Here, depending upon conservation objectives, these dark green areas represent locations where these two interests may share a common goal in protecting land from development. Indeed, working forest management and ecosystem conservation are often complementary. Conservation non-profit organizations in Maine hold more than 1.5 million acres of conservation easements, most of which are on working forestlands in the state. Organizations such as The Nature Conservancy and the Appalachian Mountain Club have partnered with large forest products companies to protect some of the most significant ecosystems across the state, while maintaining a steady stream of

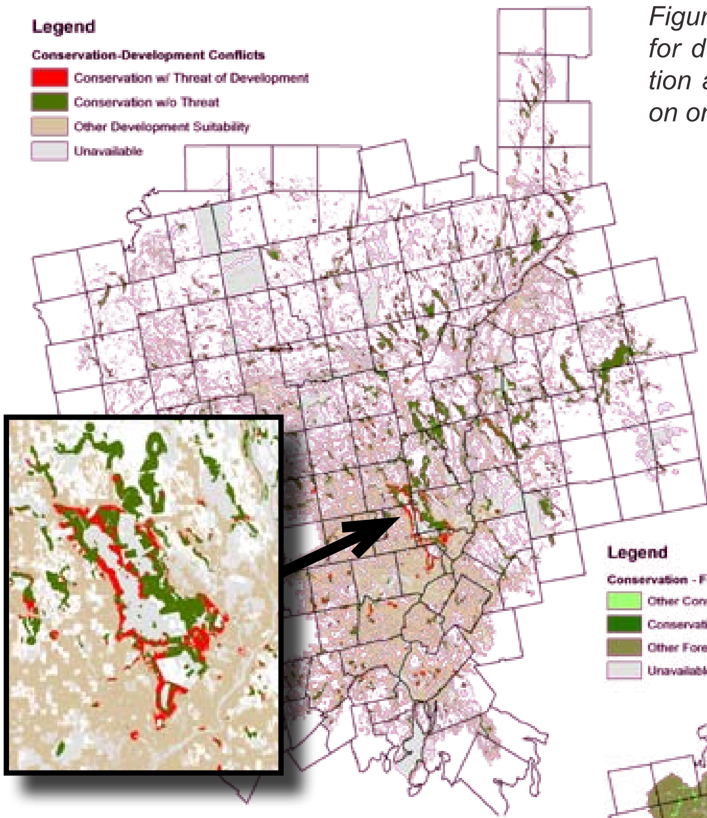


Figure 19. Potential conflicts between areas suitable for development and those suitable for conservation are apparent when the two maps are overlain on one another.

Figure 20. Areas of compatibility between working forest and ecosystem protection are shown below in dark green.

forest products, ecosystem services, and jobs for Maine citizens. By identifying areas of overlap between such complementary uses, our research is intended to foster future partnerships. Moreover, based on our focus group interactions, development interests are also eager to identify these areas, largely because areas of competing interests oftentimes pose additional and/or unforeseen challenges in realizing development proposals.

Finally, Figure 21 depicts lands highly suitable for development that are not highly suitable for the other three land uses (i.e., forestry, conservation, and agriculture). These lands, located near existing population centers and infrastructure, represent opportunities for future development that do not compromise areas important for competing and oftentimes incompatible land uses. Once again, based on our focus groups, identifying these lands is of interest to a wide range of stakeholders. For example, in many Maine communities, residential and second-home development is incrementally threatening intact forestlands and important wildlife habitats. Such dispersed development oftentimes adds to municipal budgets as new development demands new services while existing infrastructure such as roads, schools, sewers and water systems are underutilized. Identifying lands suitable for development that leverages existing community assets, as shown in Figure 21, has the potential to mitigate losses to traditional land uses while keeping municipal tax rates low.

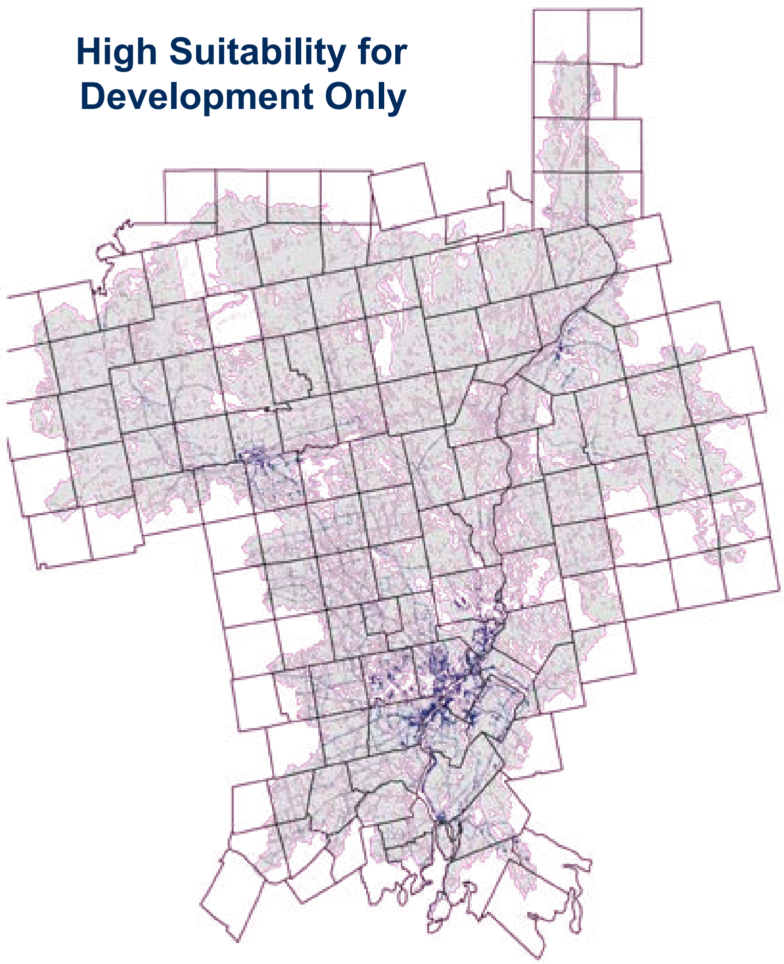


Figure 21. Identifying lands that are highly suitable for development (blue) but not for other land uses helps planners and policy makers identify areas for future economic development.

Impacts

Sustainable development policies seek to identify and promote economic activity, vibrant communities, and environmental quality. In Maine, protecting these assets is an important economic development strategy. Understanding landscape change drivers through interdisciplinary research therefore is critical to sustaining human and natural systems. Equally important is the process of engaging stakeholders in the research process, and understanding how scientific knowledge can be transformed into meaningful solutions.

Alternative futures modeling is an effective way to foster improved understanding of past and existing land use, and of the intricate and dynamic connections between human and natural systems. In Maine, the approach is particularly relevant given the close economic and social ties between the state's landscape and its people. Ensuring the health of these systems is not only important to quality-of-life, but also the sustained viability of the tourism and forest products sectors.

Our work engages stakeholders across a broad range of interests including conservation, government, business, and real estate development. This breadth allows us to better understand the factors likely to drive future challenges and opportunities affecting Maine's landscape. Our stakeholder-derived models of land suitability provide the public with quantitative, spatially explicit depictions that not only inform key stakeholders of current land use and suitability, but also allow various interests to design and evaluate the effects of alternative assumptions regarding population growth and development pressures on current and future landscapes. Most importantly, our modeling seeks to facilitate the identification of locations where compatibilities and conflicts in projected land use are likely to exist across time in response to differing assumptions embodied in future land use scenarios.

Funding

- National Science Foundation, Maine EPSCoR award EPS-0904155 (SSI)
- Elmira B. Sewall Foundation
- Northern States Research Cooperative, Theme Three

Martin Neptune, Maine Indian Basketmakers Alliance

Mobilizing Diverse Interests to Address Invasive Species Threats:

The Case of the Emerald Ash Borer in Maine

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

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

Addressing complex resource management challenges such as EAB requires structured dialogue between scientists, resource users, and interested publics informed about human-environment systems – a process 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 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 the threat of EAB.

Through a series of stakeholder workshops, we have laid the groundwork for a research plan identifying four areas of collaborative research:

1. Mapping ash resources;
2. Developing policy guidance;
3. Stakeholder engagement; and
4. Seed collection.

In tandem with determining these objectives, 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 foster the creation of policy so that an invasive threat such as EAB 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.

We consider this collaborative research plan to be a living document that will be further defined with other structured interactions with key stakeholders over the coming years. To address the development of policy guidance, we have analyzed management information from state and federal agencies and other relevant parties in areas where EAB has already emerged. We are using this information to facilitate the development of 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. This work, along with site-specific ecological studies of ash growth and silvicultural characteristics, has recently been expanded through a $180,000 grant from the U.S. Forest Service

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 EAB as 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 U.S. 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 basket-makers from Michigan, where the EAB has already devastated much of the ash resource.

Part of our process has included experiential learning opportunities for Native American youth from the Penobscot Nation-Indian Island school in how to identify and gather ash seed. Over the last year, we developed the Maine EAB Trap Tree Network (TTN) in cooperation with the U.S. 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 as well, along with meetings and workshops to spur dialogue and collaboration between stakeholders. Finally, we have completed a white paper on EAB emergency response plans in areas already affected by EAB. This paper is serving to guide the State of Maine as it develops its own response plan.

Erin Quigley

UMaine graduate student Molly Lizotte peals an ash log to look for signs of emerald ash borer.

Anticipated Impacts

The outcomes of this project include:

1. The creation of a guidance document to help the state and tribes develop cooperative emergency response plans for the arrival of EAB;
2. Continued focus group interviews on stakeholder engagement questions;
3. BBN focus groups and field-based ecological research to help identify the location of ash resources in Maine;
4. Continued stakeholder engagement in the development of research needs and questions;
5. A stakeholder meeting on research coordination with an emphasis on public education and outreach; and
6. The documentation, with key stakeholders, of best practices for invasive species policy.

Through this approach, our intent is to demonstrate how diverse groups can work together to develop invasive species emergency response plans that address key forest health challenges while including a diverse array of stakeholders.

Funding

- National Science Foundation, Maine EPSCoR award EPS-0904155 (SSI)
- U.S. Forest Service, CARP Funding

PROTECTING NATURAL RESOURCES AT THE COMMUNITY SCALE:

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


Spencer Meyer

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

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 5th year. Research on pool-breeding amphibians is driven by the needs of regulators and planners identified through stakeholder meetings. We use mail surveys and focus group data in five of the VPMP towns to inform our work, with three model towns chosen from our VPMP municipalities. We are combining findings from our work 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 in "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 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 employ regression analysis, GIS, network analysis, and social science survey and focus group methods to examine the influence of demographic, socio-economic, and biophysical characteristics on decisions by municipalities to participate in relevant programs and/or adopt specific types of regulation. Of particular interest are how changes in social and ecological landscape attributes affect patterns in municipal participation and adoption. Lastly, we 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

We have 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). We are also 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 required due to amphibians' biphasic life cycles (i.e., aquatic eggs and larvae, and terrestrial adult stages), as well as annual movements among different habitat types for breeding, foraging, and hibernating.

Our team is also 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 model towns, including Topsham, 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 – all committed to revitalizing underused tools and helping to develop new solutions for linking conservation with opportunities for growth and development. Using participant observation, interviews, and focus groups, we investigated the use of VPMP as a new model of engagement for more effectively linking scientific knowledge, stakeholder decision-making, and on-the-ground outcomes. We found that VPMP mobilized support for collaborative community-based management, enhanced awareness and understanding of vernal pools and regulations at the local level, built stronger stakeholder relationships, and improved participatory local planning through a process of collaborative learning. However, we also found that communication with municipal officials and private landowners was a significant barrier for the effective functioning of VPMP as a participatory model to engage a wider network of stakeholders in proactive conservation planning. We suggest an expanded citizen science model that puts communication with municipal officials and private landowners on par with recruitment, training, and data collection by citizen scientists.

We are also 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. Using mixed-methods, we constructed a frame-based private landowner typology to identify landowner response patterns to vernal pool conservation in Maine. Interviews and focus groups identified a range of responses in two categories of frames, one describing positive views of vernal pools and the other negative views. A mail survey identified three groups of private landowners (Positive, Neutral, and Negative) with similar socio-demographic and property variables but different aesthetic preferences, economic concerns, and views on property rights and conservation. Our results suggest that frame-based typologies are useful for enhancing communications with different landowner groups and in identifying trusted information sources and communication preferences. Our approach represents a critical first-step toward understanding and integrating a range of landowner perspectives into conservation practice, and enhancing private landowner cooperation in proactive planning.

Impacts

Vernal pools, many of which are 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 challenges between Maine's diverse landscapes, as well as promote sound science to support both healthy ecosystems and strong economies.

Funding

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

Dawn Morgan

Rob Lilieholm

WILDEBEEST FORAGE ACQUISITION IN FRAGMENTED LANDSCAPES UNDER VARIABLE CLIMATES

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

Objectives

Kenya's Athi-Kaputiei Plains (AKP) cover over 2,590 km^2 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 (Figure 22) (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

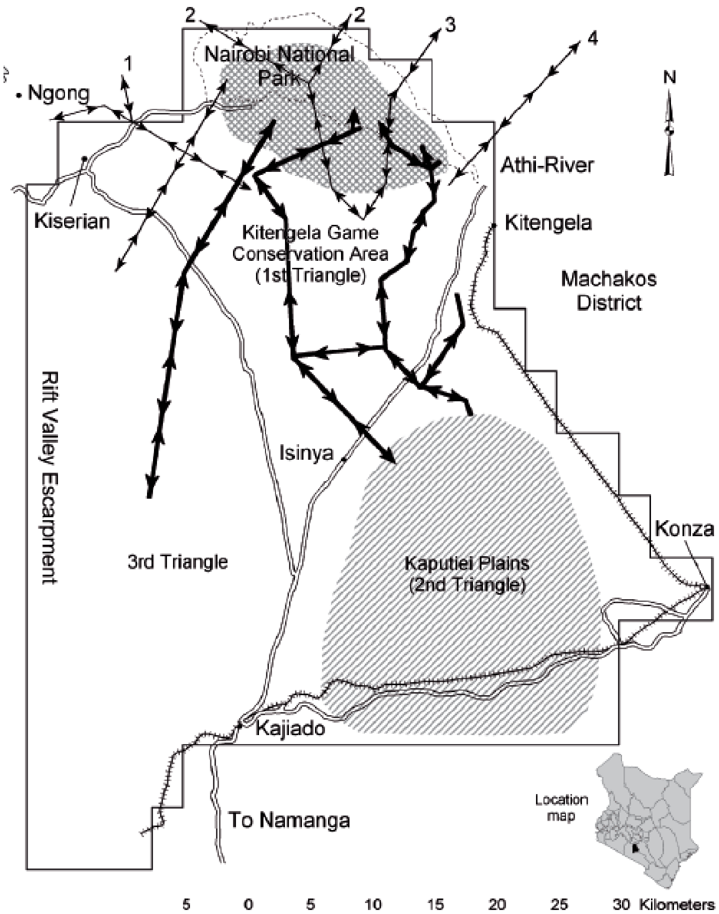


Figure 22.Historic (thin solid lines and arrows, numbered) and current (bold solid lines and arrows) wildlife and livestock grazing routes. Migratory species like wildebeest form a critical link in the ecosystem's food chain.

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 addresses our hypotheses through three major components:

1. The movements of wildebeest must be tracked;
2. Fragmentation in the study areas must be mapped and future fragmentation projected;
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 variables in order to model alternative future landscapes to enhance the sustainability of human and natural systems. 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.

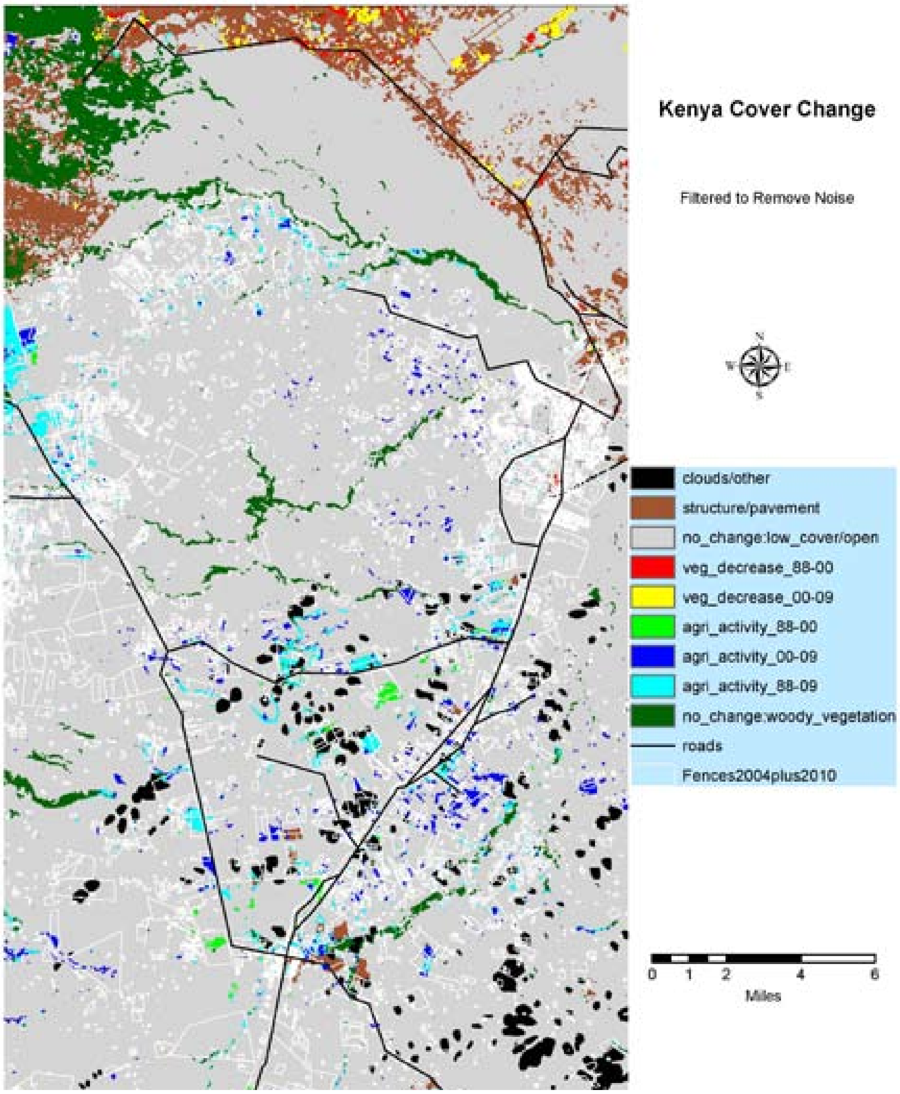
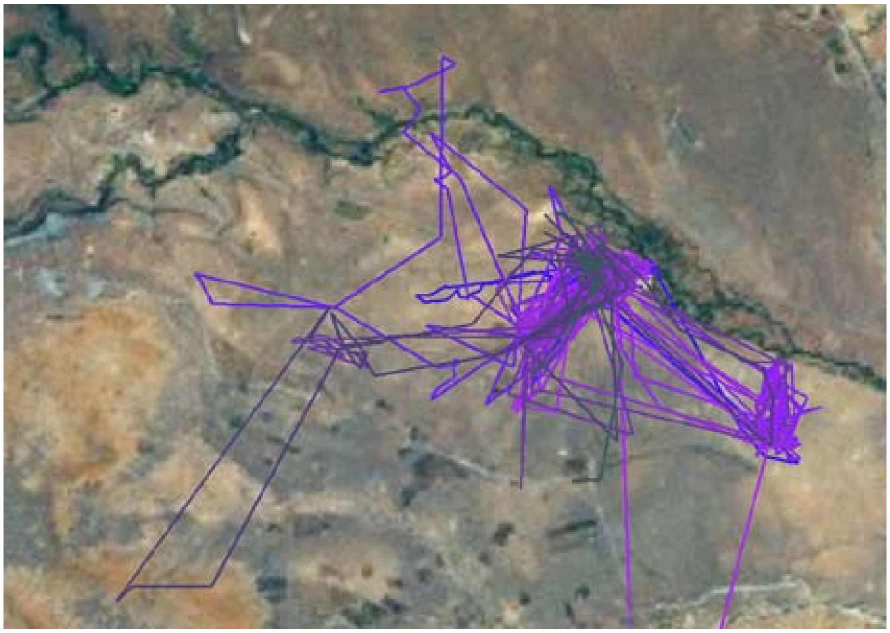


Figure 23. Landscape change in and around Nairobi National Park, 1988-2009.

Results

Urban development has grown substantially since 1984. Consequently, historic northern migration routes for wildebeest (Figure 23) 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" – Kitengela, 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 of wildebeest movement are still pending (Figure 24), 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



Gnu Landscape, NREL, Colorado State

Figure 24. GPS trackers are used to track wildebeest movements. One such track is shown here over satellite imagery. (Gnu Landscape, NREL, Colorado State)

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. 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 U.S. 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
- Planet Action
- The University of Maine

NORTHEASTERN STATES RESEARCH COOPERATIVE

A Research Program for the Northern Forest

Each year, recipients of funding from any of the four Northern States Research Cooperative (NSRC) themes are asked to submit brief reports. These informal progress reports serve to update the program administrators, as well as the general research community. The reports that follow are for projects funded by NSRC Theme 3, led and administered in the Center for Research on Sustainable Forests at the University of Maine. Reports are in order from the oldest ongoing projects to the newest.

2008 NSRC PROJECTS

RESTORING AMERICAN CHESTNUT AND ASSOCIATED PRODUCTS TO THE NORTHERN FOREST

Paul G. Schaberg, U.S. Forest Service
Gary J. Hawley, University of Vermont

Abstract

American chestnut (Castanea dentate (Marsh) Burkh) was once a prized forest products species throughout the eastern United States. It was the "Swiss Army Knife" of tree species – it "did it all". It was fast growing, unusually large, and produced easily worked, straight-grained wood that was highly rot resistant and useful in a wide range of products. American chestnut was also important to the tannin industry and its yearly mast of nuts was a nutritional mainstay for humans, livestock and wildlife, as well as a source of income for many in the southern Appalachians. About 100 years ago a fungal blight was introduced to the U.S. that rapidly removed American chestnut as an overstory tree. Multiple efforts of restoration of this species have been attempted, yet the one with the most immediate promise of effective restoration involves the hybridization of American chestnut with the highly blight resistant Chinese chestnut (Castenea mollissima Blume) followed by repeated backcrosses of resistant offspring with American chestnut. So far, backcross breeding has primarily included American chestnut trees from the heart of the species' former range. Yet, for restoration in the north, the breeding program also needs to identify and include germplasm that provides for growth and survival in colder environments. Indeed, recent research by our laboratory has shown that American chestnuts (both pure native plants and backcrossed stock) are vulnerable to shoot freezing injury and experience winter dieback in the field. Here we propose research to evaluate two methods for bolstering the cold tolerance of American chestnut trees: 1) through the identification of seed sources exhibiting greater cold hardiness, and 2) through studying the influence of overstory silvicultural treatments on the growth, carbohydrate relations, cold tolerance and winter injury of chestnut seedlings. We will establish a series of American chestnut progeny plantings in a replicated design under three levels of silvicultural overstory removal (full, moderate and partial removal) on the Green Mountain National Forest. Seed sources will include genetic lines from throughout the species' range, but emphasize sources from the Northern Forest to more comprehensively detect those sources adapted

to northern climates. By replicating the provenance planting over three silvicultural treatments we will be able to assess how genetics, the environment (overstory retention) and genetic x environmental interactions influence cold tolerance and carbon storage (growth and carbohydrate status) of planted stock. Both genetics and silvicultural treatment could influence cold tolerance and growth. Silvicultural treatments could also alter levels of cold exposure that incite injury. In addition to identifying genetic stock and management alternatives that may bolster American chestnut cold tolerance, the plantings established will be a long-term resource for evaluating the influence of genetics and management on American chestnut restoration in the north. Research Topic: Biological Processes: Ecophysiological responses of commercial tree species to silvicultural practices.

2009 NSRC Projects

The Role of Silvicultural Intensity and Species Composition Objectives on the Growth, Dynamics, and Carbon Balance of Northeastern Forest Stands

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Abstract

The NSRC Theme 3 project entitled "Role of silvicultural intensity and species composition objectives on the growth, dynamics, and carbon balance of Northeastern forest stands" is in its third year and the funds for this project have been used to (1) maintain the long-term measurements of the Silvicultural Intensity and Species Composition (SIComp) experiment on the Penobscot Experimental Forest, (2) prepare two peer-reviewed journal publication documenting the response of young stands to various management intensities, and (3) support travel to an international conference to present results.

During the past fiscal year, funds for this project supported a four-person field crew to collect the long-term measurements of the SIComp experiment. The SIComp experiment is a 3 x 3 + 1 factorial of silvicultural intensity (thinning / release, thinning / release plus enrichment planting, and intensively managed plantations) and compositional objectives (hardwood, mixed-wood, and conifer). Each of the 10 treatments are replicated four time for a total of 40 treatment plots, each with 100 crop trees. In the recent inventory, height, diameter, and crown width were measured for every crop tree. In addition, fixed area plots were measured to document stand level responses to the various treatments. Over the past year, the long-term measurements of the SIComp experiment were analyzed, resulting in two journal publications.

Both publications analyzed stand level responses of the various treatment of the SIComp experiment, but were separated by treatment intensity. One publication entitled "Early stand production of hybrid poplar and white spruce in mixed and monospecific plantations in eastern Maine" is currently in press in the journal New Forests. In this publication, we investigated the productivity of hybrid poplar and white spruce plantations over a six year period after planting. The analysis consisted of comparing biomass growth and yield of three plantation treatments – pure white spruce, pure hybrid poplar, and white spruce-hybrid poplar mixed plantations. In addition, the analysis compared the performance of four hybrid poplar clones. The four clones compared included three Populus deltoides × P. nigra clones (D51, DN10, and DN70), and one P. nigra × P. maximowiczii (NM6) clone. In the mixed plantation treatment, each treatment plot was divided into four quarter plots and one hybrid poplar clone was randomly assigned to each. This allowed us to test whether white spruce production differed when planted with the different hybrid poplar clones. Six years after planting, biomass yield was greatest for the pure hybrid poplar treatment followed by the mixed plantation and lastly the pure spruce plantations. This was expected given the inherent fast early growth of hybrid poplar and slower early growth of white spruce. In both the pure hybrid poplar and mixed treatments, the NM6 clone was the superior performer, followed closely by DN70, while the D51 and DN10 clones had poor performance and survival in both treatments. In the mixed treatment, white spruce performance exhibited a negative exponential relationship with increasing hybrid poplar performance even though the hybrid poplar cuttings were clumped to reduce early asymmetric competition with the white spruce.

The second peer-reviewed publication focused on the stand level response of the naturally regenerated stands subjected to contrasting treatments designed to shift the stands in different successional trajectories. The publication is entitled "Influence of management intensity on the productivity of early successional Acadian stands in eastern Maine", and is currently in review in the journal Forestry. The focus was on two management intensities (low-thinning/release and medium-thinning/release plus enrichment planting) and three compositional objectives (hardwood, mixed-wood, and conifer), plus an untreated control. The treatments were designed to provide a range of management techniques available in the region including hardwood thinning, conifer release, and a combination of the two to manage mixed-wood stands. Seven years after treatment, the low and medium intensity hardwood treatments had similar yields to the untreated control but with substantially lower densities. In the low and medium conifer treatments, removal of hardwoods promoted conifer dominance, but hardwoods re-established in the gaps without conifers. As previous research has shown, these stands will likely result in conifer-dominated mixed-wood stands. The low and medium mixed-wood treatments had greater yields than the conifer treatments because of intentional hardwood retention. Overall, the investigation corroborates results found from other conifer release treatments in the region, but also provides an alternative strategy for perpetuating early successional hardwood composition, a useful strategy for bioenergy supply. Additionally, many stands in the region have mixed-wood composition, but management techniques for these stands are not well defined. Our results suggest that species composition can be shifted to conifer-dominated mixed-wood composition early in stand development with combinations of conifer release and hardwood thinning techniques.

Although the grant is in its final year of funding, we plan to use the remaining funds to develop growth equations for early successional hardwood species. We will use the repeated measurements from the crop-trees in the SIComp experiment. Most of the 4,000 crop trees are aspen species, birch species, and red maple. Growth equations for these species are rare, yet early successional composition comprises a large proportion of forestlands in Maine. We plan to use the crop trees measurements to test various model forms and covariates, including management intensity and species composition of the different treatments. The results from this investigation will be integrated into larger growth and yield modeling efforts in the region.

Spencer Meyer

MERGING LANDSAT TIME-SERIES AND FIA DATA TO DEVELOP VULNERABILITY MAPS FOR SPRUCE BUDWORM DEFOLIATION DECISION SUPPORT

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Abstract

The primary goal of this project is to establish methods to predict and map the vulnerability of northern forest stands to spruce budworm defoliation using Landsat satellite imagery and forest attribute data provided by USFS Forest Inventory and Analysis (FIA) plots. Spatial vulnerability models are based on known relationships with host and non-host species relative abundance and forest age, and are used to map vulnerability classes across a 4 million acre study area in northwest Maine. Results are incorporated into an existing spruce budworm decision support system (SBWDSS: MacLean et al. 2001; Hennigar et al. 2007) used to evaluate alternative outbreak scenarios across a 300,000 acre trial area. SBWDSS outcomes are intended to demonstrate the suitability of satellite-derived forest attribute maps for large-scale spatial forest planning.

Summary of Year 3 Progress

To overcome multiple deficiencies of established methods of modeling and mapping tree species distributions, we have developed a novel approach based on advanced machine learning algorithms known as support vector machines (SVMs; Brereton and Lloyd 2010). SVMs are capable of modeling categorical and continuous response variables, enabling a two-stage strategy where species occurrence is first modeled and mapped, and species relative abundance is subsequently modeled at locations where the species is predicted to occur. This approach reduces the negative impact of a large proportion of zero-abundance or low-abundance observations, typical of species with limited distributions. SVMs are capable of modeling highly relationships using a large number of predictors (both continuous and categorical) with limited reference data. Our algorithms utilize satellite-derived predictor variables as well as ancillary predictors derived from climate, terrain, and soil data. SVMs require the specification of several parameters, and inappropriate parameter settings can have strong deleterious effects. We use a genetic algorithm (GA) to simultaneously parameterize SVM models, select an optimal subset of predictors, and exclude from model calibration reference samples that degrade model performance (based on cross-validation using all samples). Our GA implementation enables the simultaneous optimization of competing model objectives. This allows for the nearly automated specification of models that minimize both prediction error and systematic bias, including attenuation bias.

Our modeling strategy is amenable to the prediction of forest disturbance, and we are working on an adaptation of our software to predict and map disturbance using a time series of Landsat imagery and reference data obtained from the visual interpretation of satellite imagery and aerial photography. Moreover, we are implementing an active learning strategy using our multi-objective GA to minimize reference data requirements. The result is a highly efficient and accurate strategy that discriminates stand-replacing and partial canopy disturbances.

Lastly, we have invested considerable effort in map accuracy assessment. Cross-validation strategies have been applied to all PLSR and SVM models. Validation of stand-replacing disturbance and budworm vulnerability classes has proved to be more difficult. We originally proposed independent field assessments, but the resources required were not supported in our project award. In lieu of a fully independent validation dataset, we have combined FIA plot data with satellite image and air photo interpretations over FIA plot locations to validate maps of stand-replacing disturbance and budworm vulnerability. FIA data are used to identify stand composition and level of maturity. For immature stands, image interpretations are used to date the stand-replacing disturbance that initiated the dominant cohort.

2010 NSRC Projects

Forest Regeneration Differences between Whole-Tree and Conventional Harvesting Methods in Northern Hardwoods: A Concern for Sustainable Bio-Fuel Production?

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Abstract

Whole-tree harvesting (WTH), where all aboveground 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 for 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.

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

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Abstract

We proposed to use a forest landscape model, LANDIS-II (LANDscape DIsturbance and Succession), to simulate the coupled dynamics of forest management and periodic spruce budworm disturbance across a 10 million acre northern Maine study area. LANDIS-II produces spatially-explicit simulations of disturbance and forest succession that provide information about future forest conditions critical to evaluating interactions between resource management and ecosystem processes. Supporting objectives include 1) mapping forest composition, disturbance history, age structure, and spruce budworm vulnerability, 2) parameterization and calibration of LANDIS-II to northeastern tree species assemblages and current forest conditions, 3) design and execution of simulation experiments consisting of alternative management strategies, policy constraints, and budworm outbreak scenarios, and 4) evalua-

tion of future forest conditions (2009-2109) under alternative scenarios. Our goal is to provide a better understanding of how forest management practices and periodic budworm outbreaks interact to influence forest-level productivity and the sustainable supply of wood products over large spatial scales and long time periods.

Summary of Progress

LANDIS-II simulates disturbance and succession of cohorts principally defined by age and species. To ensure meaningful simulation outcomes that capture the disturbance and succession dynamics of economically and ecologically important species, we have expended considerable effort to map tree species relative abundance, disturbance history, and age using a nearly 40 year time series of Landsat imagery (1973-2009). Reference data are provided by USFS Forest Inventory and Analysis (FIA) field plots (Confidential plot locations provided under USFS Agreement No. 2011-MU-11242305-035). We initially adopted a modeling framework based on partial least squares regression (PLSR), previously developed under NSRC support to model and map budworm host species abundance. Preliminary results highlighted several critical deficiencies of PLSR, most notably the inability to model nonlinear relationships, sensitivity to zero-inflated data and extreme values, inability to incorporate categorical predictor variables (e.g., soil attributes), and tendency to produce models with a strong attenuation bias, where values are overestimated at low relative abundance and underestimated at high relative abundance. A strong bias can lead to unrealistic patterns of species abundance and unrealistic distributions of species-age cohorts.

To overcome deficiencies of established methods including PLSR, we have developed a novel approach to species distribution modeling based on advanced machine learning algorithms known as support vector machines (SVMs). SVMs are capable of modeling highly nonlinear relationships using a large number of predictors (both continuous and categorical) with limited reference data. Our algorithms utilize satellite-derived predictor variables as well as ancillary predictors derived from climate, terrain, and soil data. SVMs require the specification of several parameters, and inappropriate parameter settings can have strong deleterious effects. We use a genetic algorithm (GA) to simultaneously parameterize SVM models, select an optimal subset of predictors, and exclude from model calibration FIA plots that degrade model performance (based on cross-validation using all plots). Our GA implementation yields models that simultaneously minimize both prediction error and systematic bias, including attenuation bias. Additionally, for species with limited distributions, model calibration can be negatively influenced by a large proportion of zero-abundance or low-abundance observations. We have therefore adopted a twostage strategy where species occurrence is first modeled and mapped as a categorical variable, and species relative abundance is subsequently modeled at locations where the species is predicted to occur. We are adapting our support vector classification methods to map forest disturbance. Our disturbance mapping algorithm exploits the statistical properties of SVM models to minimize calibration data requirements using an active learning strategy, where only highly informative locations are targeted for reference data collection (e.g., air photo acquisition and interpretation). The result is a highly efficient and accurate algorithm that objectively discriminates standreplacing and partial canopy disturbances.

While developing and implementing our methods for species distribution and disturbance modeling, we have initialized LANDIS-II over a 4 million acre subset of our study area using species-age cohort maps compiled from existing disturbance maps, FIA age distributions, and preliminary species abundance data from our PLSR models. Initialization using preliminary results over a sizable portion of our study area has enabled us to parameterize LANDIS-II to the tree species and species assemblages that will be included in the final distribution maps. Model parameterization and calibration included an initial global sensitivity analysis to identify parameters whose values most strongly influence simulation outcomes. We have invested considerable effort in identifying appropriate settings for these parameters, using FIA data as a reference for model calibration and verification. We have designed and successfully implemented several alternative management scenarios across the 4 million acre subset of our study area. To guide the design of harvesting scenarios, we have calculated recent and past harvest rates using existing Landsat-derived disturbance data. LANDIS-II is capable of simulating different management strategies across different management units, and we have calculated recent and past harvest rates for all large landowners so that simulation outcomes reflect the aggregate effects of observed ownership-level patterns.

Our baseline harvesting scenario predicts future forest conditions in the absence of a budworm outbreak, assuming future harvest rates match recent (2000-2009) clearcut and partial harvest rates. Figure 25 shows total live biomass and spruce-fir live biomass over the next 100 years under our baseline scenario and an alternative scenario that models elevated rates of clearcutting similar to those observed to have occurred shortly before and coincident with the full implementation of the Maine Forest Practices Act (1988-1993). Based on our preliminary results, both total live biomass and spruce-fir live biomass are predicted to be higher under the baseline harvest scenario over the next 100 years (Figure 25). Initial biomass values closely match estimates provided by FIA data, providing additional verification of LANDIS-II parameterization and initialization.

To incorporate spruce budworm into our simulation experiments, we have parameterized the LANDIS-II Biological Disturbance Agent (BDA) extension to model spruce budworm outbreak dynamics in Maine. The BDA extension was designed to simulate tree mortality following outbreaks of insects or disease. Outbreak dynamics are governed by both temporal patterns (e.g., average outbreak interval) and spatial patterns (e.g., host species dominance). Tree mortality is predicted based on user-defined classes of susceptibility to defoliation and vulnerability to mortality. We have defined susceptibility and vulnerability classes based on known relationships with host species and age. Alternative outbreak scenarios vary in regional outbreak magnitude and return interval. Preliminary outcomes provide realistic patterns of mortality over the spatial and temporal scales of interest.

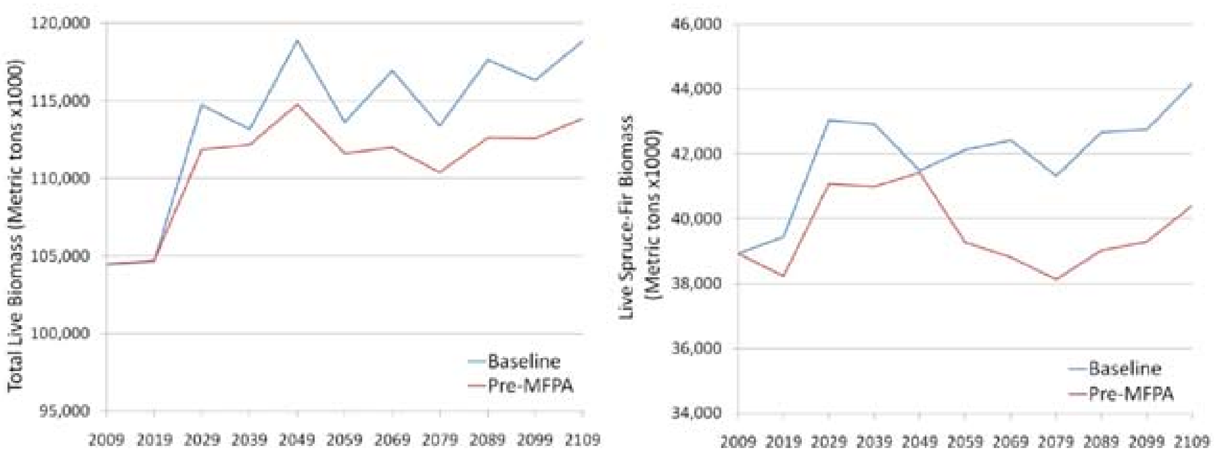

Figure 25. Total live biomass and spruce-fir live biomass simulated under baseline and pre-MFPA harvesting scenarios. Baseline and pre-MFPA scenarios predict future forest conditions in the absence of a budworm outbreak, assuming future harvest rates emulate recent (2000-2009) and past (1988-1993) ownership-level clearcut and partial harvest rates, respectively.

SILVICULTURAL EFFECTS ON ENVIRONMENTAL CONDITIONS AND RESULTING ABOVEGROUND PRODUCTIVITY AND CARBON SEQUESTRATION OF NORTHEASTERN MIXED-WOOD FORESTS.

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Summary of Progress

During the second year of the NSRC Theme 3 project, "Silvicultural effects on environmental conditions and resulting aboveground productivity and carbon sequestration of northeastern mixed-wood forests", funding was used to collect field data for investigations of (1) aboveground biomass, (2) leaf area, and (3) white spruce resource-use efficiency.

During the summer of 2011, trees were destructively sampled from the Silvicultural Intensity and Species Composition (SIComp) experiment on the Penobscot Experimental Forest for the biomass and leaf area investigations. We selected five naturally regenerated hardwood species (red maple, bigtooth aspen, trembling aspen, paper birch, and gray birch), four hybrid poplar clones (three Populus deltoides x P. nigra and one P. nigra x P. maximowiczii), and planted white spruce. In total 105 trees were sampled, including 15 individuals per hardwood species, 5 per hybrid poplar clone, and 10 white spruce across a range of diameters. For each tree, branch diameter, branch length, length of foliage, and angle were measured for all branches. Then a subset of branches was randomly selected for leaf area measurements. After field measurements, the entire trees were dried in the lab and weighed by component (foliage, branch, and bole).

We anticipate that each of the three investigations will result in peer-reviewed publications. So far, the aboveground component biomass data were used to fit biomass models in a manuscript entitled "Development and verification of aboveground biomass equations for small diameter naturally regenerated and planted tree species in eastern Maine". The manuscript was submitted to the journal Biomass and Bioenergy and is currently in review. In the investigation, oven-dry biomass data were used to develop a set of additive component biomass equations for each of the species. We used nonlinear seemingly unrelated regression, a statistical technique that adjusts parameter estimates for each component equation to ensure biomass estimates sum to modeled total aboveground biomass. In addition, we used the biomass measurements to validate various biomass equation used in northeastern North America, including the current equations used by the United States Department of Agriculture, Forest Service, Forest Inventory and Analysis program (FIA). Current FIA state-wide biomass estimates in Maine decreased by 49% with the recent change in biomass equations by the program. Our results showed that the FIA small tree equation underestimated woody biomass of the various naturally regenerated hardwood species between 67% and 77%. We hypothesize that the 49% decrease in Maine biomass estimates is due to poor performance of the new equations and the prevalence of small diameter trees in the region due to harvesting practices.

Leaf area estimates collected from the destructively sampled trees are being used in an investigation modeling total leaf area and vertical leaf area distribution of the naturally regenerated hardwood species, hybrid poplar clones, and white spruce. We are currently finalizing this analysis and writing the manuscript. The analysis involves testing various distributions and covariates to model vertical leaf area. The majority of vertical leaf area distribution studies have focused on conifer species and use depth into crown of branch insertion on the main bole to model foliage location. This is not an appropriate metric for hardwood species due to their sympodial crown forms and often steep branch angles. Therefore, we are testing metrics that incorporate branch angle, including branch-tip height and location of the start of foliage on a branch. We plan to use modeled leaf area distributions to estimate crown shape and crown surface area, and test for differences among species and size classes.

Funds for this project were also used to measure resource-use efficiency of planted white spruce in various growing conditions in the SIComp experiment. Four treatments were chosen for comparison: pure white spruce plantations, white spruce – hybrid poplar mixed plantations, enrichment planting in conifer dominated stands, and enrichment planting in conifer-hardwood mixedwood stands. Twelve trees in each treatment were selected across a range of height classes. Diameter, height, crown radius, and spatial location of all competitors in a 5 m radius around each white spruce tree were measured in Fall 2011. We plan to model annual light interception of each white spruce tree using the MAESTRA model that incorporates light competition using data on the size and location of competitor trees. Light interception and biomass growth (estimated using the biomass equations) will be used to compare light-use efficiency (light interception ÷ biomass growth) of the planted white spruce in the four different treatments. We also plan to compare water-use efficiency of planted white spruce in the different treatments using measurements of stable carbon isotope fractionation. Foliage samples from current-year shoots were collected in Fall 2011 from the white spruce trees and sent to a off-campus lab for isotope analysis. Resource-use efficiency (light and water) will be analyzed with regression techniques, incorporating distance-dependent competition indices, and soil physical and chemical variables. We plan to use the remaining funds for this project to collect a second year of measurements for this investigation to test for temporal changes in resource-use efficiency. These measurements will be collected in the Fall of 2012.

RESPONSE OF TREE REGENERATION TO COMMERCIAL THINNING IN SPRUCE-FIR FORESTS OF THE NORTHEAST

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Introduction

Traditional silvicultural thinning is implemented to boost growth and final yield of crop trees with no specific intention of triggering a regeneration response. However, there is reason to anticipate thinning will initiate some tree regeneration. After all, thinning is a form of canopy disturbance that temporarily increases resource availability and some tree species have evolved their regeneration strategies to take advantage of such opportunities.

In stands dominated by shade-tolerant species even light thinning may stimulate a response in tree regeneration similar to an establishment cut in a shelterwood system. Spruce-fir stands of the Northeast U.S. and Southeast Canada likely respond this way to thinning. For example, Pothier and Prevost (2008) observed substantially higher densities of red spruce and balsam fir regeneration (0.3-4.0 m tall) in stands treated with a light shelterwood establishment cut (~15% of merchantable BA removed) compared to unharvested stands ten years after treatment (>75,000 vs. <5,000 trees per ha, respectively). Post-thinning regeneration development in spruce-fir stands has implications for the sustainability of silvicultural systems in the Northeastern U.S. since landowners there are often interested in commercial thinning. Commercial thinning treatments are generally applied when trees have larger diameters and stands are in a stage of stand development when foresters are starting to consider regeneration harvest options. Knowing what response to expect from forest regeneration after thinning would aid foresters who are managing spruce-fir stands beyond a single rotation. Unfortunately, there are only a few studies that evaluate tree regeneration response to thinning in the Northeastern U.S. spruce-fir forest.

The goal of this project was to increase our understanding about the influence of commercial thinning on the development of viable regeneration in Northeastern spruce-fir stands during the first decade after treatment. We evaluated understory regeneration on the Cooperative Forestry Research Unit's Commercial Thinning Research Network (CTRN). CTRN is a long-term thinning experiment in Maine investigating commercial thinning treatments in spruce-fir stands with and without a history of precommercial thinning (PCT and No-PCT, respectively). We tested the hypothesis that commercial thinning increases the density of softwood regeneration in spruce-fir stands of the Northeastern U.S. (i.e., the de facto shelterwood effect). Additionally, we compared regeneration between PCT and No-PCT stands to test the hypothesis that softwood regeneration density is greater in No-PCT stands than the PCT stands. This is based on our expectation of greater softwood advance regeneration development in the older, No-PCT stands prior to commercial thinning and under a higher rate of canopy mortality due to blowdown since thinning (Meyer et al. 2007). Presented here are preliminary findings and conclusions of this investigation.

Methods

To test our hypotheses, we sampled forest regeneration at six sites of the CTRN. Of these, three stands had previously been precommercially thinned and then commercially thinned (PCT study) and three were only commercially thinned (No-PCT study). Generally, the PCT study sites are dominated by balsam fir, originated in the late 1970s to early 1980s, and have relatively high site indices, while the No-PCT study sites are generally dominated by red spruce with a significant balsam fir component, are considerably older, and are typically of lower site quality. Within each of the sites we tested two levels of commercial thinning intensity (33% and 50% relative density reductions) and an unthinned control. Data on tree regeneration and other vegetation measurements were collected in summer 2011. Analysis of variance (ANOVA) was used to test for effects of thinning treatments and Tukey's Honest Significant Difference was used to identify specific differences among treatments.

Results

The findings of this investigation supported our hypothesis of higher densities of softwood regeneration in thinned stands compared to the controls ten years after treatment. ANOVA detected a significant effect of thinning treatments ($p<0.1$) on small (0.1-0.6 m tall) and medium (0.6-1.4 m tall) spruce regeneration density in the No-PCT study and small balsam fir regeneration density in the PCT study. Specifically, mean separations revealed that differences were evident between thinned treatments and the control, while densities were comparable between thinned treatments (i.e., 33% vs. 50%). No effects of thinning treatments on large softwood regeneration (1.4 m tall to 6.3 cm DBH) were detected, which could be due to insufficient time for recruitment into this size class.

Spruce dominated the regeneration pool of thinning treatments in the No-PCT study. Mean density of small spruce regeneration in the 33% and 50% thinned stands was 81,537 and 68,056 trees per ha, respectively, which was substantially greater than in the control (2,688 trees per ha). Similarly, the densities of medium spruce regeneration were also much greater in thinned stands of the No-PCT study (5,953 and 6,607 trees per ha in 33% and 50% treatments, respectively) compared to the control (59 trees per ha in the control). Although not statistically significant, the density of large spruce regeneration was highest in the 50% treatment (2,004 trees per ha), intermediate in the 33% thinning (675 trees per ha), and lowest in the control (79 trees per ha). Interestingly, balsam fir regeneration was more abundant than spruce in controls of the No-PCT study, particularly in the medium size class (861 vs. 59 trees per ha of balsam fir vs. spruce, respectively). Pothier and Prevost (2008) also observed a higher density of balsam fir than red spruce in the understories of unthinned, spruce-dominated stands.

Balsam fir was the most abundant regeneration in the PCT study, while the low abundance of spruce regeneration precluded ANOVA. Mean densities of small balsam fir regeneration in the PCT study were substantially greater in the 50% and 33% treatments (37,500 and 56,825 trees per ha in, respectively) than in the control (3,274 trees per ha). ANOVA results for medium balsam fir regeneration density were not reported since transformations were unable to improve the data to meet model assumptions; however, abundance was greatest in the 50% (437 trees per ha), intermediate in the 33% (179 trees per ha), and lowest in the control (119 trees per ha). Although not statistically significant, the density of large fir regeneration was highest in the 50% treatment (506 trees per ha), lowest in the 33% (208 trees per ha), and intermediate in the control (357 trees per ha).

The findings of this investigation also supported the hypothesis that softwood regeneration was more abundant in the No-PCT study. Mean density of softwood regeneration in the 33% treatment was nearly two-fold more abundant in the No-PCT, while mean softwood regeneration density in the 50% treatment of the No-PCT experiment was more than double that of the PCT (Figure 26). Interestingly, softwood regeneration density was greater in the lighter 33% removal treatment than the 50% treatment for both PCT and no-PCT studies, which may be related to greater recruitment into medium and large regeneration classes in the 50% treatment.

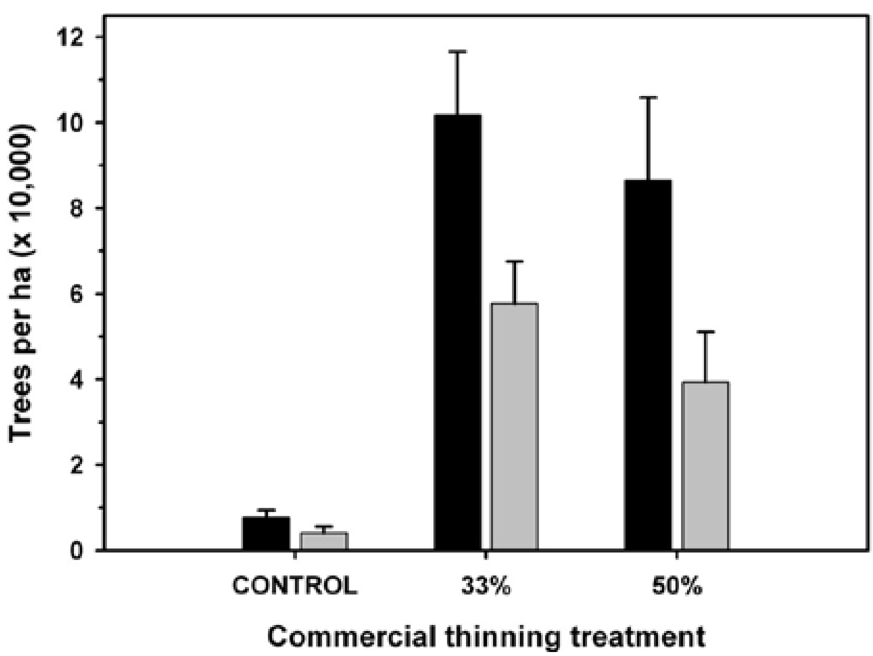

Figure 26. A comparison of mean softwood regeneration density (0.1-m tall to 6.3-cm DBH) between No-PCT (dark bars) and PCT (gray bars) studies by thinning treatment for the Commercial Thinning Research Network in Maine. Error bars are standard errors (2x).

Hardwood regeneration also increased following commercial thinning. ANOVA detected a significant effect of thinning on the combined density of small and medium hardwood regeneration (0.1-1.4 m tall) in both No-PCT and PCT studies. According to mean separations of hardwood regeneration in both studies, the differences among treatments were between both thinning treatments and the control, but not between thinning treatments. In the case of the No-PCT study, mean density in the 50% treatment was nearly twice that of the 33% treatment (10,813 vs. 5,738 trees per ha), yet mean separation failed to detect a difference. In the PCT study, mean hardwood density was nominally, but not significantly, greater in the 33% (5,258 trees per ha) than the 50% treatment (3,472 trees per ha). Although statistical testing for thinning effects was inconclusive, mean densities of large hardwood regeneration increased with increasing thinning intensity (i.e., control < 33% < 50%) in both No-PCT and PCT studies. Greater hardwood abundance in thinned stands was likely due to sprouting initiated by the removal of hardwoods during thinning. Sprout clump densities were substantial higher in thinned stands of the PCT study, which were mainly red maple.

Preliminary Conclusions

Our early findings indicate that commercial thinning has stimulated the development of natural softwood regeneration within the first decade following treatment in a manner similar to a shelterwood establishment cut. Therefore, commercial thinning has the potential to serve as a "de facto shelterwood" entry in similar spruce-fir stands while still providing the benefit of concentrating growth on fewer crop trees.

Higher densities of hardwood sprout clumps initiated by thinning in PCT sites suggests that sprout clumps could have a stronger, negative effect on the development of softwood regeneration in younger PCT stands following commercial thinning. If this scenario is true, then additional cultural treatments may be needed to control hardwood sprout clumps in favor of desirable softwood regeneration.

Whether these demonstrated regeneration responses carry enough softwood stems through the final overstory removal to truly act as a shelterwood remains to be seen, however, our results indicate commercial thinning may be act as a viable establishment cut.

EFFECTS OF NONSELECTIVE PARTIAL HARVESTING IN MAINE'S WORKING FORESTS

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Current Project Status

The NSRC Theme 3 funded research project "Effects of nonselective partial harvesting in Maine's working forests" is currently proceeding as planned. There have been no major revisions to the project described in the grant proposal. Minor refinements continue to be implemented to better meet the project objectives. Fieldwork began in July 2010 and is currently on-going. Below the status of the each objective is given in greater detail.

Objective 1. Compare post-harvest inventory measurement methods

A list of 250 partially harvested stands within the study area was obtained from the Maine Image and Analysis Laboratory (MIAL). Through analysis of Landsat satellite images these stands were determined to have been partially harvested between 1988 and 2007 with <70% canopy removal. The information provided by the MIAL includes the location, approximate harvest boundaries, and the period of harvest (generally within a three-year period). Twenty-five stands were randomly selected from the larger list provided by the MIAL and a total of 16 stands were sampled for this objective.

Six inventory methods were tested in these stands. Data collection began in summer of 2010 and was completed in 2011. Data analysis is also completed and a publication describing the results of this study is currently in preparation.

Objective 2. Conduct preliminary analysis

A copy of the most current FIA dataset for Maine has been received from the Maine Forest Service. We are currently exploring opportunities to compare stand level, FIA and remote sensing data.

Objective 3. Compare current stand characteristics

Data collection is currently underway in support of this research objective. As of June 15, 2012, overstory and regeneration data have been collected for 29 stands. It is anticipated that data will be available for at least 50 stands upon completion of the fieldwork. Data collection is expected to be complete by August 2012. Preliminary analyses of the data are currently ongoing.

Objective 4. Project future stand conditions

Data collected for Objective 3 will be used in projecting future stand conditions. Once fieldwork is completed, data analyses will begin.

EFFECTS OF CLIMATE CHANGE ON GROWTH, PRODUCTIVITY, AND WOOD PROPERTIES OF WHITE PINE IN NORTHERN FOREST ECOSYSTEMS

Ronald S. Zalesny Jr., U.S. Forest Service

Accomplishments and Highlights

1. As indicated in the proposal, the Ganaraska Forest trial in Ontario was sampled during October 2009 to establish sampling protocol and associated proof-of-concept methodologies before submitting our proposal (see attached protocol document). In addition, compilation of certain establishment data was conducted at the proposal stage. Furthermore, Bruce Birr of the U.S. Forest Service surveyed the Wisconsin and Michigan sites during May 2010.
2. Ron Zalesny, Adam Wiese, and Bruce Birr of the U.S. Forest Service conducted initial field reconnaissance of the Wisconsin and Michigan sites during February 2011 (see attached report). They also traveled to the Cass Lake, MN trial during May 2012 but were unable to successfully survey both the Design IV and Design II plantations because their integrity was so low. Here is a summary of their assessment:

   "The Design IV is largely gone; only scattered trees remained but in its current condition stand boundaries weren't even noticeable. The Design II was there but we were unable to locate any tags identifying the provenances of individual trees and, to make matters worse, the plantation was about twice the size that it should have been based on the establishment report and subsequent field maps/datasheets. We were also unable to locate any records explaining the size difference; our best guess is that other trees were planted there and probably marked at one point in time, but currently there is no way to tell where our Design II starts."
3. As a result of not being able to sample the Cass Lake site, the study will include the seven sites outlined in the proposal and shown in Figure 27. As of May 2012, all seven sites have been sampled according to the attached protocol, and all samples have been sent to the research team at the Ontario Ministry of Natural Resources (Steve Colombo, Pengxin Lu, Bill Parker, Ngaire Eskelin).
4. At the OMNR, increment core processing from the two Ontario sites was conducted and completed during 2010-2011. In addition, those from Manistique, MI (n=184), Pine River, MI (n=186), Newaygo, MI (n=396), Penobscot, ME (n=132), and Wabeno, WI (n=122) provenance trial study sites were dried, mounted, sanded, and scanned for further analysis using WinDendro software during the period July 1, 2011 to June 30, 2012. These cores included those collected from study site trees and adjacent white pine trees used to construct a master chronology

for each trial location. Tree ring analysis using WinDendro has been completed for the Penobscot (ME), Manistique, Pine River, and Newaygo (MI), and Wabeno (WI) trial locations. Increment cores from 1442 trees for all five U.S. and two Ontario (Ganaraska and Turkey Point) trial study sites were dried and shipped to Les Groom et al. (U.S. Forest Service) for analysis of wood properties using x-ray densitometry.

5. Les Groom and his team have begun the x-ray densitometry work.

Figure 27. Seven provenance trials sampled in the current study. All sites with green trees were part of an original range-wide IUFRO white pine study established in the early 1960's in the eastern United States and Canada. Trees with an "X" indicate trials that no longer exist, while the status of those marked "?" is uncertain. The Cass Lake, MN trial was visited but could not be sampled given lack of integrity of the plantation.

6. Conference calls were held, when necessary, to discuss field procedures and post-sampling processing techniques, including sample storage and shipment.

7. Research joint venture agreements were established in 2011 and 2012 between the University of Maine and the U.S. Forest Service (Zalesny's team), and an international research joint venture agreement was established in 2011 and modified in 2012 between Zalesny's team and Bill Parker's team at the OMNR. In addition, Zalesny established an intra-regional agreement with John Brissette and an inter-regional one with Les Groom.

PREDICTING DYNAMICS OF WHITE PINE ADVANCE REGENERATION UNDER SHELTERWOOD SILVICULTURE

Robert S. Seymour, University of Maine
Emma Louise Schultz, University of Maine

Abstract

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 (a) pine is a dominant forest type, (b) shelterwood establishment cutting has occurred, and (c) 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 (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, will develop regression equations relating the understory light environment to overstory metrics, and will 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.

2011 NSRC Projects

Predicting Effects of Even-aged Silviculture on Commodity Production, Carbon Sequestration, and Wildlife Habitat Characteristics in Northern Hardwood Stands

Ralph D. Nyland, SUNY College of Environmental Science and Forestry

Eddie Bevilacqua, SUNY College of Environmental Science and Forestry

Abstract

This project will revamp and expand an existing stand simulator initially prepared for use with uneven-aged silviculture by developing and substituting growth and mortality functions using response variables pertinent to managed even-aged stands. In addition, it will formulate new functions for forecasting tree and stand structural characteristics commonly used with wildlife habit evaluation, but for single-cohort communities. Existing carbon and wood volume equations will convert tree and stand data to estimates of standing crop and harvested products. Projections by the simulator will describe changes due to a thinning or other intermediate treatments, as well as subsequent production and sequestration for an ensuing time period. Output data will also portray effects on stand structural characteristics, including those related to wildlife habitat elements. The proposed simulator, which will include Monte Carlo methods to account for uncertainty in model predictions, will accommodate a variety of initial conditions and management objectives, and provide useable output for a single cutting cycle, or a series of them appropriate to a 100-year planning horizon. Once constructed, the simulator will support experiments to compare outcomes from intermediate treatments of different kinds and intensities.

The output information will facilitates decisions about managing even-aged northern hardwood stands with respect to sustainable production and yields of wood and carbon, and selected wildlife habitat characteristics. Findings will be summarized as guidelines that decision-makers can use to compare management alternatives, given a specified set of initial set of stand conditions and landowner objectives.

Managing an Aging Resource: Influence of Age on Leaf Area Index, Stemwood Growth, Growth Efficiency, and Carbon Sequestration of Eastern White Pine

Robert S. Seymour, University of Maine

Abstract

The white pine resource of New England is overwhelmingly dominated by mature stands of old-field origin that are rapidly reaching rotation ages where conventional wisdom would suggest they be regenerated. Countering this view, however, is

the emerging scientific consensus that old forests play a disproportionally important role in sequestering the world's carbon, not to mention their well-known roles in conserving biodiversity and enhancing landscape aesthetics. Although past research on eastern white pine (Pinus strobus L.) is voluminous, surprisingly little of it addresses the productivity of biologically old forests, leaving the region's scientists and foresters uncomfortably reliant on extrapolating simulation models beyond their limits.

Addressing this important regional question requires a detailed understanding of the production ecology of eastern white pine over a complete range of ages (a so-called "chronosequence"), from newly regenerated sapling stands to the old-growth stage. This study proposes to remeasure and augment such a sequence of long-term remeasured plots on 12 separate sites within the University of Maine's School Forests. The main goal is to quantify stemwood growth, leaf area index, carbon sequestration, and stemwood growth efficiency over a 200-year chronosequence. Allometric leaf-area prediction equations will be developed from a combination of archived data and 15-25 additional trees to strengthen representation in age classes over 100; these equations will be validated against long-term litterfall records on most plots. We hypothesize that the leaf area index of white pine stands peaks fairly early in stand development, but that growth efficiency (stemwood growth per unit of leaf area) peaks much later, contrary to the general pattern documented by Ryan et al (1997). If true, such a finding offers promise that long-rotation management of eastern white pine could become a viable option for landowners seeking to maximize carbon sequestration without sacrificing growth and harvest of large-diameter forest products.

HOW SILVICULTURAL TREATMENTS AFFECT CARBON STORAGE IN A NORTHERN CONIFER FOREST: A 60-YEAR PERSPECTIVE

Aaron Weiskittel, University of Maine
John Brissette, U.S. Forest Service
Ivan Fernandez, University of Maine
Laura Kenefic, U.S. Forest Service
Randy Kolka, U.S. Forest Service
Lindsey Rustad, U.S. Forest Service

Abstract

The goal of this project is to evaluate the influence of nearly 60 years of different silvicultural and harvesting regimes on carbon storage on the Penobscot Experimental Forest (PEF) in central Maine. The objectives of the project are to evaluate the effects of reference, selection cutting (10-year cycle), three-stage shelterwood cutting, and commercial clearcut treatments on current (2012) carbon stored in overstory live trees, dead wood, understory plants, soils, and harvested wood products. It is currently hypothesize that average total ecosystem carbon (carbon stored in overstory live trees, deadwood, understory plants and soils) will be greater for reference stands (uncut since the 1800s) than recently harvested stands (cut since the 1950s). However, when carbon storage in wood products is added to total ecosystem carbon, reference stands and stands managed under the selection system will store similar levels of carbon and will have greater average carbon storage than stands managed under the shelterwood system and commercial clearcutting. it is also hypothesized that stand and site characteristics will affect carbon storage.

To accomplish the stated objectives, two replicates of the reference, selection cutting (10-year cycle), three-stage shelterwood cutting, and commercial clearcut treatments will be inventoried in the summer of 2012. Overstory live trees, deadwood, understory plants and soil attributes will be measured on permanent sample plots

within management units (MUs). Locally derived biomass equations and values for wood density and carbon concentration will be used to estimate carbon in live trees and some deadwood components, material from standing snags, the herbaceous community and soils will be sampled to determine carbon concentrations for these attributes. Long-term data collected from the permanent sample plots will be used to determine carbon storage in harvested wood products.A mixed-effects analysis of variance with treatment as a fixed effect and MU and plot within MU as random effects will be used for statistical comparisons.

The primary result from this study will be the recommendation of certain silvicultural and harvesting regimes for maximizing carbon storage in stands that are similar to those on the PEF.

To date, the NSRC funds have been successfully leveraged with additional funding from Penobscot Experimental Forest Research and Operations Team as well as the University of Maine Analytical Lab. These leveraged funds will be used to conduct additional analyses of the plant tissue and soil samples, which will be highly beneficial for this and future efforts. To complete the necessary field work this summer, a crew of 5 undergraduate students has been hired. These measurements will be the foundation for the Ph.D. project of Joshua Puhlick, who is leading this effort. Currently, the NSRC funds have been primarily used to hire the student workers and acquire the necessary field equipment.

Overall, the project is on track and will soon begin conducting a preliminary analysis of the data collected this summer. This data will form the basis of the three dissertation chapters as well as several technical presentation and reports.

Spencer Meyer

U.S. Forest Service scientist, Laura Kenefic talks about the rich 60-year history of the Penobscot Experimental Forest during a field tour.

APPENDICES

PUBLICATIONS AND OUTREACH

This year, CRSF researchers published 57 articles, including peer-reviewed journals, book chapters, research reports, proceedings, and theses. Additionally, our scientists and students delivered 90 presentations at scientific conferences, stakeholder meetings, and other venues.

Journal publications

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Lilieholm, R.J. Acadian Internship in Regional Conservation and Stewardship. University of Maine at Augusta, Augusta, Maine. February 2012.

Lilieholm, R.J. Acadian Internship in Regional Conservation and Stewardship. Bowdoin College, Brunswick, Maine. February 2012.

Lilieholm, R.J. Acadian Internship in Regional Conservation and Stewardship. Colby College, Waterville, Maine. February 2012.

Lilieholm, R.J. Co-developing Place-based Scenarios of Alternative Futures with Stakeholders. Maine GIS User's Group, Bowdoin College, Brunswick, ME (Johnson presenting, with Meyer, Lilieholm, and Cronan). November 2011.

Lilieholm, R.J. Landscape Modeling in Maine and Africa. Newforest Institute, Brooks, Maine. September 2011.

Lyons, P., Leahy, J., Lindenfeld, L., and Silka, L. Seeing the Stakeholders for the Trees: Research Knowledge Transfer Models. Society of American Foresters National Convention. November 2011. Honolulu, HI.

Meyer, S.R., M.L. Johnson, R.J. Lilieholm, and C.S. Cronan. 2012. Land Use Conflicts and Opportunities in Central Maine: A University-Stakeholder Partnership for Modeling Couple Human and Natural Systems. U.S. Regional Association of the International Association for Landscape Ecology. Coupled Human and Natural Systems Symposium. Newport, RI. April 8-12, 2012. (Invited)

Meyer, S.R., M.L. Johnson, R.J. Lilieholm, and C.S. Cronan. 2012. Using Stakeholders to Develop a Watershed-Scale Land Use Suitability Model. Joint Maine Municipal Association and Maine GIS Users Group Technology Conference. Portland, ME. March 1, 2012.

Meyer, S.R., M.L. Johnson, R.J. Lilieholm, and C.S. Cronan. 2012. Using Stakeholders to Develop a Watershed-Scale Land Use Suitability Model. American Association of Geographers. New York, NY. February 24, 2012.

Meyer, S.R., M.L. Johnson, R.J. Lilieholm, and C.S. Cronan. Forestry Futures Stakeholder Focus Group. Lisbon Falls, ME. April 24, 2012.

Meyer, S.R., M.L. Johnson, R.J. Lilieholm, and C.S. Cronan. Agriculture Futures Stakeholder Focus Group. Falmouth, ME. April 5, 2012.

Meyer, S.R., M.L. Johnson, R.J. Lilieholm, and C.S. Cronan. Conservation Futures Stakeholder Focus Group. Falmouth, ME. March 29, 2012.

Meyer, S.R., M.L. Johnson, R.J. Lilieholm, and C.S. Cronan. Economic Development Stakeholder Focus Group. Portland, ME. March 28, 2012.

Meyer, S.R., M.L. Johnson, R.J. Lilieholm, and C.S. Cronan. Alternative Futures Stakeholder Workshop. November 18, 2011.

Nelson, A., Weiskittel, A. and Wagner, R.G. 2011. Production ecology and dynamics of early-successional mixed-wood stands in central Maine. Northeastern Mensurationists Organization Annual Meeting. Quebec City, Quebec. October 3-4.

Nelson, A.S., R.G. Wagner, M.R. Saunders and A.R. Weiskittel. 2011. Influence of silvicultural intensity and compositional objectives on the productivity of regenerating Acadian mixed-wood stands in Maine, USA. pp. 90-92 in Proceedings of the 7th International Vegetation Management Conference. IUFRO Unit 1.01.04 Forest Vegetation Management. Valdivia, Chile. November 7-10.

Olson, M.G., S.R. Meyer, R.G. Wagner, and R.S. Seymour. 2012. Response of tree regeneration to commercial thinning in spruce-fir stands of Maine: 1st-decade results from the Commercial Thinning Research Network. ECANUSA Forest Science Conference. Durham, NH. November 1-3, 2012.

Quartuch, M., Leahy, J., Bell, P.K., Colby-George, J. 2011. "The Future of Maine's Changing Family Forests: Preliminary Analysis of Tipping Points in Landowner Attitudes and Behaviors." Poster Presentation. Maine EPSCoR State Conference. Orono, Maine, USA.

Rice, B. Partially Harvested Stands and Inventory- A Comparison of Inventory Methods. Northeastern Mensurationists Organization 2011 Annual Meeting. Quebec City, Quebec, Canada. October 2, 2011

Rice, B., Weiskittel, A. and Wagner, R.G. 2011. Partially harvested stands and inventory: A comparison of methods. Northeastern Mensurationists Organization Annual Meeting. Quebec City, Quebec. October 3-4.

Roxby, Gabriel. 2012. Effects of Whole-Tree Harvesting on Site Productivity and Species Composition in Northern Hardwood Forests. Poster Presented at the 2012 New England Society of American Foresters' Annual Meeting, Amherst, MA.

Roxby, Gabriel. 2012. Effects of Whole-Tree Harvesting on Site Productivity and Species Composition in Northern Hardwood Forests. Oral Presentation at the 2012 New England Society of American Foresters' Annual Meeting, Amherst, MA.

Russell, M.B., A.R. Weiskittel, and J.A. Kershaw Jr. Compatible height and height-to-crown base increment models for the primary Acadian species. 2011 Northeast Mensurationists Conference, 2 - 4 October, 2011. Québec City, QC, Canada.

Russell, M., Weiskittel, A., and Radtke, P. 2012. Evaluation of the Northeast Variant of the Forest Vegetation Simulator. 4th Forest Vegetation Simulator Conference. Fort Collins, CO. April 17-19.

Russell, M. and Weiskittel, A. 2011. Compatible height and height to crown base increment models for the primary Acadian tree species. Northeastern Mensurationists Organization Annual Meeting. Quebec City, Quebec. October 3-4.

Russell, M.B., Weiskittel, A.R., Wagner, R.G. 2011. Refinement of regional growth and yield models for naturally-regenerated, mixed species stands in the Northeast. National Science Foundation Center for Advanced Forestry Systems Annual Meeting. Seattle, WA. June 14-16.

Russell, M.B. and Weiskittel, A.R. 2011. Modeling individual tree increment in the mixed-species Acadian Forests: Are species-specific equations required? Western Mensurationists Annual Meeting. Banff, Alberta. June 19-21.

Wagner, R.G. 2011. Overview of University of Maine's Cooperative Forestry Research Unit. Presentation at the Plum Creek Forester's Meeting. May 8, Greenville, ME.

Wagner, R.G. 2011. Importance of Wood and Management of Maine's Forests. The Acadian Internship in Regional Conservation and Stewardship, Schoodic Education and Research Center Institute, July 12, Schoodic Point, ME.

Wagner, R.G. 2011. Reflections on CIPS Mission, Vision, Goals, Projects, and Strategic Plan. Invited presentation to CIPS Steering Committee Meeting, Center for Intensive Planted-forest Silviculture (CIPS), August 24, Vancouver, WA.

Wagner, R.G. 2011. Maine Forests, Forestry, and Emerging Trends. Invited presentation at Conservation Forestry's Annual Conference, New England Outdoor Center, October 4, Millinocket, ME.

Wagner, R.G. 2011. Overview of University of Maine's Cooperative Forestry Research Unit. Invited presentation at the Maine Legislators Breakfast Meeting, Maine Forest Products Council Forestry Tour, Pelletier's Restaurant, October 25, Millinocket, ME.

Wagner, R.G. 2011. Forty-year results from CFRU Austin Pond Study. CFRU Fall Field Tour, October 27, Somerset County, ME.

Wagner, R.G. and A.R. Weiskittel. 2012. Commercial Thinning Research Network: 10-year growth and mortality patterns. CFRU Foresters workshop: Capturing value through thinning, May 16th, Orono, ME

Weiskittel, A.R. 2011. The Spruce Budworm 'Sea of Wood': How did we get here and what do we have?. CFRU Fall Field Tour, October 27, Somerset County, ME.

Weiskittel, A.R. 2012. Growth and Yield Modelling Update. CFRU Winter Advisory Committee Meeting. February 2nd, 2011, Orono, ME.

Weiskittel, A., M. Russell, and Kershaw, J.A. 2012. Development and evaluation of the Acadian Variant of the Forest Vegetation Simulator. 4th Forest Vegetation Simulator Conference. Fort Collins, CO. April 17-19.

Conference Proceedings

McCloskey, J.T., R.J. Lilieholm, R. Boone, R. Reid, D. Nkedianye, S. Sader, M. Said, and J. Worden. 2011. A Participatory Approach for Modeling Alternative Future Land Use Scenarios around Nairobi National Park using Bayesian Belief Networks. Ecology and the Environment 144:43-57.

Nelson, A.S. and R.G. Wagner. 2011. Herbicide treatments can selectively improve the composition of natural hardwood regeneration in American beech-dominated understories in Maine, USA. pp. 16-18 in Proceedings of the 7th International Vegetation Management Conference. IUFRO Unit 1.01.04 Forest Vegetation Management. November 7th-10th, Valdivia, Chile.

Nelson, A.S., R.G. Wagner, M.R. Saunders, and A.R. Weiskittel. 2011. Influence of silvicultural intensity and compositional objectives on the productivity of regenerating Acadian mixed-wood stands in Maine, USA. pp. 90-92 in Proceedings of the 7th International Vegetation Management Conference. IUFRO Unit 1.01.04 Forest Vegetation Management. November 7th-10th, Valdivia, Chile.

Nelson, A.S., A.R. Weiskittel and R.G. Wagner. 2011. Crown and total biomass equations of young, naturally regenerated hardwood species in Central Maine. 15th Annual Northeastern Mensurationists Organization Meeting, October 3-4, Quebec City, Quebec, Canada.

Olson, M.G., R.G. Wagner, J.C. Brissette, and A.S. Nelson. 2011. Forty years of spruce-fir stand development following herbicide release and precommercial thinning in central Maine, USA. pp. 34-36 in Proceedings of the 7th International Vegetation Management Conference. IUFRO Unit 1.01.04 Forest Vegetation Management. November 7th-10th, Valdivia, Chile.

Schaberg, P.G.; Saielli, T.M.; Hawley, G.J.; Halman, J.M.; Gurney, K.M. In press. Growth and shoot winter injury of American chestnut seedlings grown in common garden at the species' northern range limit. Accepted for inclusion in a NRS-GTR associated with the Central Hardwood Forest Conference, March 26-28, 2012, Morgantown, WV.

Shultz, E.L. and R.G. Wagner. 2011. Forest Research Capacity in Universities and the U.S. Forest Service in the Northeast: Preliminary Results. In Proc. 2011 Society of American Foresters National Convention, Honolulu, HI. November 2-6, 2011.

Wagner, R.G., and A.S. Nelson. 2011. Improving the Composition of Beech Dominated Northern Hardwood Understories in Northern Maine. In Proceedings of the Canadian Institute of Forestry (CIF) 103rd annual general meeting and conference, Huntsville, Ontario, September 18 - 21, 2011.

Posters

The Acadian Internship in Regional Conservation and Stewardship. 10/11. Acadia National Park Science Symposium, Schoodic Education and Research Center, Winter Harbor, Maine (Gaul presenting, with Lilieholm, Levitt and Davis).

Alternative Futures Modeling in Kenya's National Parks and Reserves. 11/11. Society of American Foresters National Convention, Honolulu, HI (Lilieholm presenting, with Sader, Boone, Reid, Said, Worden, Kifugo, Nkedianye and Stabach).

Lilieholm, R.J. Acadian Internship in Regional Conservation. 06/12. Convergence 2012, College of the Atlantic, Bar Harbor, ME.

Lessons Learned from Evaluating Co-produced Spatial Models of Land Use Suitability in Central Maine. 04/12. U.S. Regional Association of the International Association of Landscape Ecology, Newport, RI (Johnson presenting, with Lilieholm, Meyer, Cronan, Tremblay, Gallandt, and Wilson).

Meyer, S.R., M.L. Johnson, R.J. Lilieholm, C.S. Cronan, J. Tremblay, J.T. McCloskey, E.G. Gallandt, J.W. Wilson. 2011. Alternative Future Scenarios In Maine: Using Stakeholders to Co-Develop a Land Use Suitability Model. Poster presentation at the national EPSCoR Conference. Coeur D'Alene, ID. October 24-27, 2011.

Meyer, S.R., M.L. Johnson, R.J. Lilieholm, C.S. Cronan, J. Tremblay, J.T. McCloskey, E.G. Gallandt, J.W. Wilson. 2011. Alternative Future Scenarios In Maine: Using Stakeholders to Co-Develop a Land Use Suitability Model. Poster presentation at the Maine EPSCoR Conference. Orono, ME. September 26, 2011.

Mobilizing Diverse Interests to Address Invasive Species Threats: The Case of the Emerald Ash Borer in Maine. 11/11. Society of American Foresters National Convention, Honolulu, HI (Daigle presenting, with Quigley, Lilieholm, Ranco, Secord, Neptune, Livingston and Lizotte).

Predicting High-quality Sites of Fraxinus nigra (Black Ash) in Maine and Northern New York: An Approach to Prioritizing Regional Response to Environmental Stressors. 04/12 New England Meeting of the Society of American Foresters, University of New Hampshire (Lorion presenting, with Livingston, Daigle, Lilieholm, and Ranco).

Other

Daigle, J., E. Quigley, R.J. Lilieholm, D. Ranco, T. Secord, J. Neptune, W. Livingston, and M. Lizotte. 2011. Mobilizing Diverse Interests to Address the Emerald Ash Borer. Journal of Forestry 109(8):582.

SJohnson, M.L., S.R. Meyer, R.J. Lilieholm, and C.S. Cronan. Co-developing Place-based Scenarios of Alternative Futures with Stakeholders. Abstract in Proceedings of the American Association of Geographers Annual Meeting, New York, NY.

Lilieholm, R.J., S. Sader, R. Boone, R. Reid, M. Said, J. Worden, S. Kifugo, D. Nkedianye, and J. Stabach. 2011. Alternative Futures Modeling in Kenya's National Parks and Reserves. Journal of Forestry 109(8):580.

Sharik, T.L., and R.J. Lilieholm. 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.

Lilieholm, R.J. 7/11. The Acadian Internship in Regional Conservation and Stewardship. UMaine webpage.

Lilieholm, R.J. 7/11. Alternative Futures for Kenya's Wildlife Reserves. Narrated video slide show on the UMaine webpage.

Tessema, M.E., R.J. Lilieholm, 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.

Lilieholm, R.J. 5/12. An Introduction to Professional Ethics in Forestry. Invited lecture to UMaine's Forestry Summer Camp, Acadia National Park (Louis Morin, Instructor).

Lilieholm, R.J. 4/12. Alternative Futures Modeling in Maine and Africa. Hampden Academy (Kathryn King, Instructor), Hampden, Maine.

Lilieholm, R.J. 4/12. Natural Resources Management. WILD 4910 Senior Capstone course. Utah State University, Logan.

chaberg, P.G., T.M. Saielli, G.J. Hawley, J.M. Halman, and K.M. Gurney. 2011. Nut cold hardiness as a factor influencing the restoration of American chestnut in the northeastern United States. ESA Annual Meeting, Austin, Texas, August 11. p.126.

Saielli, T.M., P.G. Schaberg, G.J. Hawley, J.M. Halman, and K.M. Gurney. 2011. Genetics and silvicultural treatment influence the growth and winter shoot dieback of American and Chinese chestnut seedlings grown in Vermont, USA. ESA Annual Meeting, Austin, Texas, August 11. p.137. (Abstract)

Saielli, T., P.G. Schaberg, G.J. Hawley, J.M. Halman, K.M. Gurney. 2011. Cold as a possible limitation for the restoration of American chestnut. The 4th Annual Disease and Insect Resistance in Forest Trees Conference, Valley River Inn, Eugene, OR. (Oral presentation and poster).

Saielli, T.M.; Schaberg, P.G.; Hawley, G.J.; Halman, J.M.; Gurney, K.M. 2011. Could freezing injury threaten American chestnut restoration in the north? Proceedings of the Annual Meeting of the Vermont Monitoring Cooperative, Burlington, VT, October 31, p23 (Abstract).

Schaberg, P.G.; Saielli, T.M.; Hawley G.J.; Halman, J.M.; Gurney, K.M. 2012. Winter injury of American chestnut seedlings grown in a common garden at the species' northern range limit. Proceedings of the 18th Central Hardwood Forest Conference, West Virginia University, Morgantown, WV. March 27, 2012. p. 30 (Abstract).

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