COOPERATIVE FORESTRY RESEARCH UNIT

2009 Annual Report

**Sustainable Forests,
Sustainable Landscapes.**

COOPERATIVE FORESTRY RESEARCH UNIT

2009 ANNUAL REPORT

Spencer R. Meyer
Editor

About the CFRU

Founded in 1975, the CFRU is one of the oldest industry/university forest research cooperatives in the United States. We are composed of 28 member organizations including private and public forest landowners, wood processors, conservation organizations, and other private contributors. Research by the CFRU seeks to solve the most important problems facing the managers of Maine's forests.

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Credits

This annual report is compiled, designed and edited by Spencer R. Meyer, Associate Director. Individual sections are written by authors as indicated, otherwise by Spencer Meyer. Photography compliments of Spencer Meyer, CFRU archives, or as indicated.

A Note About Units

The CFRU is an applied scientific research organization. As scientists, we favor metric units (e.g., cubic meters, hectares, etc.) in our research, however, the nature of our natural resources business frequently dictates the use of traditional North American forest mensuration English units (e.g, cubic feet, cords, acres, etc.). We use both metric and English units in this report. Please consult any of the easily availabe conversion tables on the internet if you need assistance.

Contents

Northern Maine offers recreationists, conservationists and others almost limitless opportunities to experience first-hand the benefits of healthy forests managed for natural resources and kept open to the public.
(Spencer Meyer photo)

Executive Summary

In 2009, the CFRU celebrated its 34th year of conducting research on the sustainable forest management of Maine's forests. Together, 28 of Maine's landowners, managers, wood processors and conservation organizations partner with us at the University of Maine to improve our understanding about Maine's forests and how best to use them for all of society's values. Using over 8 million acres of our members' forestland as a laboratory, the CFRU is poised to address the myriad questions and concerns that arise about the forest. This report summarizes the significant accomplishments of the CFRU during 2009.

This year, the CFRU welcomed new member **Canopy Timberlands Maine, LLC** to our steadfast list of members. Additionally, long-standing member **Prentiss and Carlisle** showed their ongoing support by substantially increasing their enrolled acreage. Unfortunately the CFRU was not spared from the difficult financial times being faced by forest industry in Maine and beyond. Despite an approved, temporary reduction in membership dues this year to help alleviate industry financial stress, the CFRU total program value, including both direct contributions and leveraged funds) still reached a high-water mark of $973,615 in 2009. This includes a new $70,000 grant, awarded each year for five years, from the National Science Foundation's Center for Advanced Forestry Systems (CAFS). CFRU joined eight other distinguished universities and their industrial partners from around the United States to address the biggest challenges facing forest managers today.

With our membership acreage the strongest it has ever been and the influx of new ressearch funds from external sources, the CFRU was able to make terrific new progress in our three core areas of research: *Silviculture and Productivity*, *Wildlife Habitat* and *Biodiversity Conservation*. A total of 12 research projects were conducted this year, ranging from the first phase of developing a new reginoal growth and yield model, to the evaluation of deer wintering areas for habitat conservation.

A key way in which the CFRU serves sustainable forestry is by reaching out to our members and other constituents with the latest knowledge from our research. Partnering with the School of Forest Resources, Maine Forest Service and the Maine Society of American Foresters, CFRU hosted the day-long *Northeastern Forest Health Field Workshop*. CFRU scientists showcased results from several silviculture and forest health projects to about 50 scientists and managers from all over the eastern United States and Canada. Our most significant outreach program this year was the *Spruce Budworm: What's Past is Prologue* symposium in Caribou in October. With its roots firmly planted in the angst of the 1970s and 80s spruce budworm epidemic, the CFRU is the ideal group to begin the dialogue about possible future outbreaks.

Research Highlights

Silviculture & Productivity

Center for Advanced Forestry Systems

CFRU members joined industry and university partners from around the country in the Center for Advanced Forestry Systems, which is sponsored by the National Science Foundation. CFRU brings expertise in growth and yield modeling in natural forest systems to the group to complement the capabilities of other partners. The program brings $70,000 per year to the CFRU to fund new research. (...more)

Efficient Harvesting of Energy-Wood

This project assesses trail spacing to increase productivity during typically inefficient energy-wood harvests. Researchers found that narrower trail spacings did not lead to more productive operations and that in some cases the narrower spacing led to trail occupancy levels that were detrimental to long-term forest productivity. (...more)

Wildlife Habitat

Deer Wintering Areas (DWA)

This study evaluated the effectiveness of zoned DWA for protecting deer habitat between 1975 and 1991. Remotely sensed harvest histories found 60% of DWA had heavy harvests during this period. The harvesting in these zones led to a decline of 15% in mature softwood and a four and a half-fold increase in regenerating forest. (...more)

Hare-Lynx Dynamics

CFRU scientists have completed more than a decade of research to understand the implications of fluctuating snowshoe hare populations on Canada lynx. Results show that regular hare population cycles are an important factor in future landscape planning and lynx conservation. The probability of lynx occurrence plummets during the low periods of the natural hare population cycle. (...more)

Biodiversity Conservation

Quantifying Biodiversity

This biodiversity analysis uses stand- and landscape-scale indicators to assess the health of forest biodiversity. Using nine indicators, scientists found biodiversity values exist independent of landowner boundaries and need to be considered at appropriate scales. Historical trend analysis suggests all condition indicators will decline over the next 25 years if current partial harvesting strategies persist. (...more)

The Year in Review

Advisory Committee

In 2009, the Advisory Committee met on February 26 and April 15 in Orono and on October 28 in Caribou. Advisory members work with CFRU scientists and staff to develop and implement the research objectives of the program. The Advisory is also responsible for reviewing and approving all funded research projects carried out by the CFRU. In 2009 the Advisory reviewed research proposals for 12 new projects and funded seven ongoing projects and two new projects, which will be highlighted in future annual reports. New Advisory member, **Hugh Violette** joins the group with the membership of **Canopy Timberlands Maine, LLC**. We look forward to having Hugh's input to the group, as he brings his expertise in forest operations and client relations. The Advisory Committee was ably led again this year by **John Bryant** (Chair), **Mark Doty** (Vice-Chair), **Kenny Fergusson** (Financial Officer) and **Christopher "Kip" Nichols** (Member-at-Large). That staff wishes to thank them for their excellent leadership and support of the CFRU, particularly during the difficult discussions surrounding membership dues (see Financial Report).

Research Team

The CFRU enjoys a stable core staff and scientist team and has been fortunate to add two new members to the group this year. First, **Dr. Aaron Weiskittel** has joined the ranks of Cooperating Scientist this year. As an Assistant Professor in the School of Forest Resources, Aaron brings substantial experience and leadership in growth and yield modeling to the team and has embarked on an ambitious program to develop a new regional model for applied forest management. See examples of his group's early progress elsewhere in this report. Through a joint venture agreement between the U.S. Forest Service Northern Research Station, the School of Forest Resources and the CFRU, we have been able to bring **Dr. Matthew Olson** to the team as a post-doctoral research scientist. Matt will be focusing on the next generation of the Austin Pond Study, one of CFRUs oldest, most valuable long-term silvicultural experiments.

Northeastern Forest Health Field Workshop

On June 3, 2009 CFRU partnered with the **Maine Society of American Foresters**, **UMaine's School of Forest Resources** and the **Maine Forest Service** to host this day-long field meeting to discuss and investigate ways to manage Maine's forests with forest health in mind. About 50 forest researchers and managers from Quebec to Minnesota to West Virginia, including pathologists, entomologists and silviculturists convened at Schoodic Education and Research Center on the coast of Downeast Maine. Several recent and ongoing CFRU research projects were highlighted, including the Hardwood Regeneration, White Pine Silviculture, and Spruce Budworm Decision Support (see 2008 Annual Report and more coming in 2010). The workshop was a terrific success and participants came away with a better understanding of how to integrate forest health issues such as beech bark disease, white pine blister rust, and spruce budworm into forest management to mitigate risk. Many thanks go to our CFRU member hosts, **Black Bear Forest** (represented by American Forest Management) and **Maine Bureau of Parks and Lands**.

Spruce Budworm: What's Past is Prologue **Symposium**

On October 29, 2009, the day after the fall Advisory Meeting, the CFRU hosted over 60 scientists, forest landowners and managers, policy makers and others in Caribou for a 30-year retrospective on the last spruce budworm outbreak. With many foresters and scientists from the 1970s and 80s in or nearing retirement, the CFRU wanted to glean as much insight and wisdom as possible before it is too late. The expert panel was organized and moderated by **Spencer Meyer** and included **Bob Seymour**, **Lloyd Irland**, **Ron Lovaglio**, **Gordon Mott**, **Dave Struble**, **Chris Hennigar**, and **Jeremy Wilson**. These speakers spent their careers researching spruce budworm and looking for management solutions to the epidemic and were asked to share the most important lessons to be taken from the last outbreak with those foresters and managers who will be charged with surviving another outbreak. In the afternoon, CFRU member **Irving Woodlands** hosted the group for a field tour to showcase some of their management in preparation for a possible future spruce budworm outbreak. The event was showcased in the next day's Bangor Daily News. Presentations from the symposium are available through the CFRU website.


BANGOR DAILY NEWS

Conference in Caribou targets pests

John Bryant
Chair, Advisory

Chair's Report

As Chair of the Advisory Committee, year two was personally rewarding due to my continued interaction with, and support from, **Spencer Meyer**, **Bob Wagner**, CFRU scientists and staff, and the CFRU Advisory Committee. My thanks to the CFRU leadership, CFRU staff, and the CFRU Executive Committee members **Mark Doty**, **Kenny Fergusson** and **Kip Nichols** for their professional approach and oversight of CFRU business. Just when I thought year two as Chair would be easier than year one, the global economic downturn challenged CFRUs finances. Although membership reached a record 8,300,000 acres, the financial decline of the forest products industry spurred a decision by the Advisory Committee to approve a one-year 25% reduction in member dues. On a positive note, CFRU became a member of the Center for Advanced Forestry Systems (CAFS), which includes an annual grant for the next several years. The CAFS membership will strengthen CFRUs ability to conduct applied research.

CFRU welcomed **Canopy Timberlands Maine, LLC** into the CFRU membership. In addition, **Prentiss & Carlisle** increased their contributing membership acreage. The diversity of landowners represents an excellent cross section of Maine's working forest. CFRU staff changes included the addition of **Dr. Aaron Weiskittel** to the list of cooperating scientists and **Dr. Matthew Olson** as a post-doctoral scientist. The breadth of research will widen with the addition of Aaron and Matt.

In 2009, the spring and fall meetings focused on forest health. In June, CFRU participated in the Northeastern Forest Health Workshop with field sessions on the eastern Maine lands of **Black Bear Forest** and **Bureau of Parks and Lands**. The October meeting and field tour, held in Caribou, focused on lessons learned from the spruce budworm outbreak of the 1970's and 1980's. Thanks to **Irving Woodlands** for their assistance and use of their northern Maine lands for the tour.

I would like to thank the CFRU Advisory Committee members for their professionalism, patience and persistence as we worked through difficult discussions and challenging financial decisions in 2009. I continue to be impressed with the passion shown by cooperators, cooperating scientists, and staff as we maintain our collective focus on timely research and technology transfer to the field foresters and landowners. CFRUs long-standing commitment to forestry and wildlife priorities continues to build a strong legacy.

Lastly, I want to thank Spencer Meyer, Bob Wagner, and Kenny Fergusson for their strong guidance and assistance during my two years as Chair of the CFRU Advisory Committee. Without their help, who knows where we would be today.

Director's Report

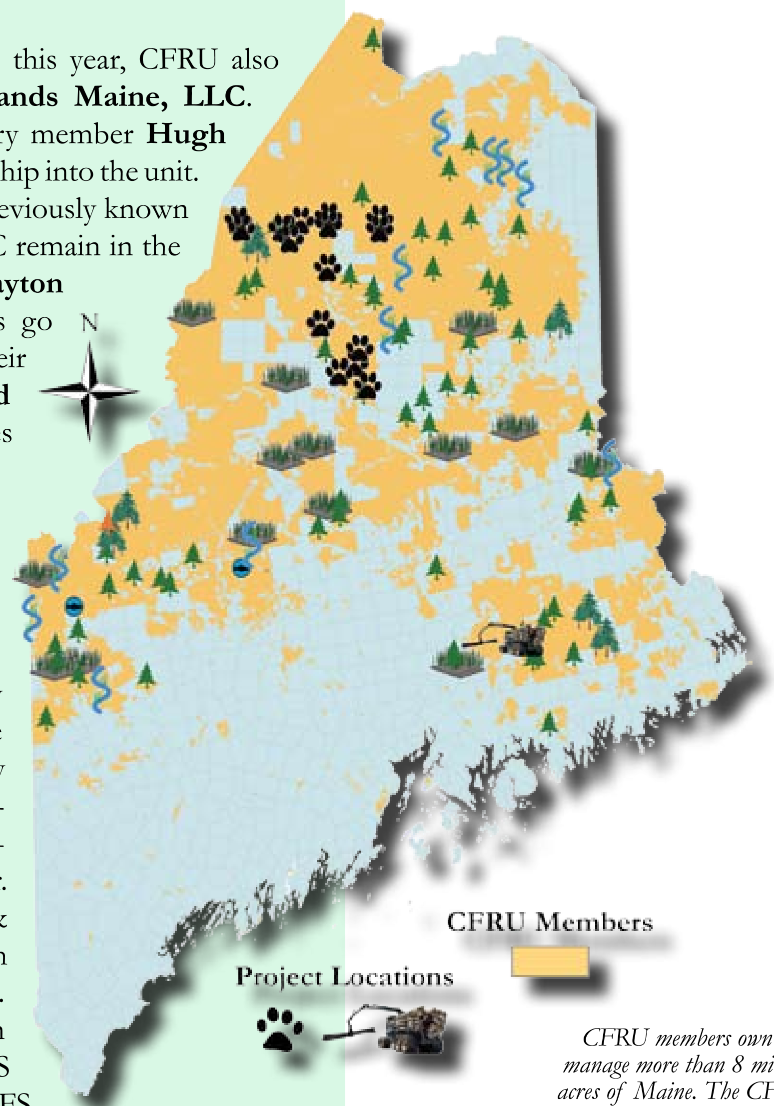
Fiscal year 2009 found the CFRU as vigorous as ever. Despite the continuing financial crisis in the forest products industry, CFRU members continued to support our efforts. For the first time in the history of the program, the Advisory Committee elected to reduce the annual dues by 25% to provide some relief to struggling members. This year more than any other, we deeply appreciate the confidence that your membership represents in the University of Maine and the program that we deliver together. The CFRU plays a vital role in connecting UMaine to your forest. This connection makes the entire UMaine forest resources program more relevant by directly engaging faculty and students in helping solve the problems of managing forestland in Maine. There is a tremendous long-term and intangible value to this cooperative that transcends the actual value of the research we do.

Robert G. Wagner

Robert G. Wagner
CFRU Director

In addition to maintaining our membership this year, CFRU also welcomed new member **Canopy Timberlands Maine, LLC**. We thank **John McNulty** and new Advisory member **Hugh Violette** for bringing this 317,000 acre ownership into the unit. We also were pleased to have the landbase previously known as Clayton Lake and Tall Timbers Trust, LLC remain in the CFRU this year under new ownership as **Clayton Lake Woodland Holdings, LLC**. Thanks go to **Claude Dufour** and her clients for their membership. Thanks also go to **Prentiss and Carlisle** for bringing more than 100,000 acres in additional client acres this year.

A major advance for CFRU this year was our joining the Center for Advanced Forestry Systems (CAFS). CAFS is a National Science Foundation program that includes a consortium of nine forest industry / university forest research cooperatives from across the country. CFRU will benefit tremendously from this national collaboration on forest research issues, as well as the increased financial support that comes from being a member. **Dr. Aaron Weiskittel** is leading the growth & yield modeling effort for natural stands, which is UMaine's primary focus in CAFS research. **Matt Russell** is continuing his participation in CFRU as a PhD student working on CAFS research. We look forward to the role that CAFS will play in enhancing CFRU efforts.



CFRU members own and manage more than 8 million acres of Maine. The CFRU conducts research all across the vast Maine North Woods.

ADVISORY COMMITEE

John Bryant, *Chair*
American Forest Management

Mark Doty, *Vice Chair*
Plum Creek Timber Company, Inc.

Kenny Fergusson, *Financial Officer*
Huber Resources Corporation

Kip Nichols, *Member-at-Large*
Seven Islands Land Company

Greg Adams
JD Irving, Ltd.

John Brissette
USFS Northern Research Station

Tom Charles
Maine Bureau of Parks and Lands

Steve Coleman
Landvest

Brian Condon
The Forestland Group, LLC

David Dow
Prentiss & Carlisle Company, Inc.

Claude Dufour
Landvest

Gordon Gamble
Wagner Forest Management

Laurie McElwain
Baskahegan Company

Kevin McCarthy
Sappi Fine Paper

Marcia McKeague
Katahdin Forest Management, LLC

Jake Metzler
Forest Society of Maine

William Patterson
The Nature Conservancy

David Publicover
Appalachian Mountain Club

Carol Redelsheimer
Baxter State Park, SFMA

Jim Robbins
Robbins Lumber Company

Dan Russell
Huber Engineered Woods, LLC

Hugh Violette
Canopy Timberlands Maine, LLC

G. Bruce Wiersma
University of Maine, CRSF

MEMBERSHIP

MAJOR COOPERATORS

Appalachian Mountain Club
Baskahegan Company
Baxter State Park, Scientific Forest Management Area
Black Bear Forest, Inc.
Canopy Timberlands Maine, LLC
Clayton Lake Woodlands Holdings, LLC
EMC Holdings, LLC
The Forest Society of Maine
The Forestland Group, LLC
Frontier Forest, LLC
Huber Engineered Woods, LLC
Huber Resources Corporation
Irving Woodlands, LLC
Katahdin Forest Management, LLC
Maine Bureau of Parks and Lands
The Nature Conservancy
Plum Creek Timber Company, Inc.
Prentiss & Carlisle Company, Inc.
Robbins Lumber Company
Sappi Fine Paper
Seven Islands Land Company
Timbervest, LLC
Wagner Forest Management

OTHER COOPERATORS

Field Timberlands
Finestkind Tree Farms
LandVest
Mosquito, LLC
Peavey Manufacturing Company

Research Team

STAFF

Robert G. Wagner, PhD
CFRU Director,
Director of School of Forest Resources

Spencer R. Meyer, MS
Associate Director

Matthew Olson, PhD
Research Scientist

Matthew Russell, MS
Forest Data Manager

Rosanna Libby
Administrative Assistant

COOPERATING SCIENTISTS

Jeffrey Benjamin, PhD
Assistant Professor
of Forest Operations

Daniel J. Harrison, PhD
Professor of Wildlife Ecology

Robert S. Seymour, PhD
Curtis Hutchins Professor of
Forest Resources

Aaron Weiskittel, PhD
Assistant Professor of
Forest Biometrics and Modeling

PROJECT SCIENTISTS

William B. Krohn, PhD
Leader, Maine Cooperative
Fish and Wildlife Research Unit

Erin Simons, PhD
Assistant Scientist,
Center for Research on Sustainable Forests

Andrew A. Whitman, MS
Natural Capital Initative Leader,
Manomet Center for
Conservation Sciences

Jeremy S. Wilson, PhD
Associate Professor of
ForestManagement

Center for Advanced Forestry Systems (CAFS)

CFRU Members Join a new NSF Industry/University Partnership

PARTNER UNIVERSITIES

NC STATE UNIVERSITY

Oregon State University OSU

PURDUE UNIVERSITY

UF UNIVERSITY of FLORIDA

The University of Georgia

University of Idaho

1865 THE UNIVERSITY OF MAINE

W UNIVERSITY of WASHINGTON

VirginiaTech

A successful proposal this year by **Bob Wagner** and **Aaron Weiskittel** to the National Science Foundation (NSF) Industry/University Cooperative Research Centers Program (I/UCRC) resulted in CFRU members creating a new University of Maine research site for the Center for Advanced Forestry Systems (CAFS). This new 10-year program will provide $70,000 per year for the first five years to the University of Maine and CFRU members to advance growth & yield models for natural forest stands in the Northeast – the highest research priority for CFRU members. This funding will support two graduate students over the next several years to develop research projects to address some of the key challenges associated with improving these models. In addition, it makes CFRU members and researchers part of a national consortium of leading university forest research programs across the country that also have strong forest industry / university research cooperatives like CFRU.

CAFS researchers from around the United States discuss Douglas fir silviculture in the Pacific Northwest during a CAFS annual meeting field trip to Portland, Oregon.

HISTORY OF CAFS

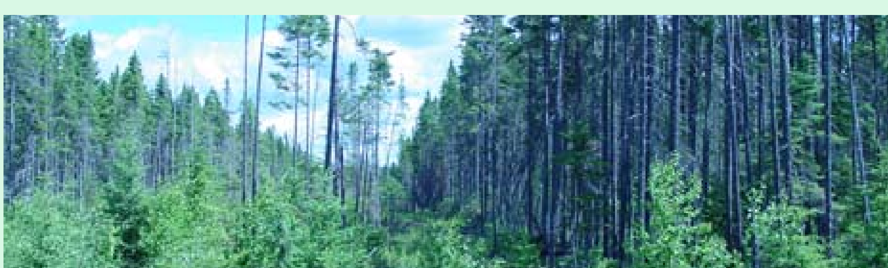
CAFS was established in 2007 with four member institutions; North Carolina State University (NCSU — lead institution), Oregon State University, Purdue University, and Virginia Polytechnic Institute and State University. In addition to UMaine, the University of Georgia and University of Washington were also added to CAFS research sites this year. The University of Idaho and University of Florida have also applied to join CAFS this year. Thus CAFS now consists of nine forest industry / university research cooperatives, and provides one of the first opportunities to coordinate industry-sponsored forest research across the country. CAFS is enabling novel forms of collaboration at multiple scales and solutions to industry-wide problems through multi-faceted and interdisciplinary approaches.

UMAINE'S UNIQUE CONTRIBUTION TO CAFS

Most of the CAFS research sites are focused on research related to planted forests, including: 1) tree improvement, clonal forestry, and forest biotechnology, 2) managing site resources availability in forest plantations, 3) interactions between genetics and plantation culture, and 4) modeling growth, yield and quality of forest plantations. UMaine's research focus as a national research site will be to expand the CAFS framework by emphasizing improvement of models on the productivity of managed natural forests, thus further developing and strengthening the overall capabilities of CAFS. UMaine has had a long history of applied research in natural forest management and a long-standing collaborative relationship with Maine's forest industry through the CFRU.

UMAINE'S FIRST-YEAR PROGRESS ON CAFS

Advertisements were distributed nationally this year for two graduate students to work on CAFS projects under Weiskittel and Wagner. A new PhD student (**Matt Russell**) was hired this year to work on the CAFS effort. Matt has a MS degree and strong forest biometrics background from Virginia Tech, and recently completed the *30-Year* database project for the CFRU. So, Matt comes well qualified to the program. Matt's dissertation project focuses on the Refinement of the Forest Vegetation Simulator project, which was approved at the 2009 CAFS annual meeting in the South Carolina and is being led by Aaron Weiskittel, Bob Wagner, and **Bob Seymour**. First year results are presented in the detailed research report for the project, beginning on page 44.



UMaine and CFRU researchers are uniquely positioned to better our understanding of growth and yield in forests that are natually regenerated, like this one in the Telos area of northern Maine.

Financial Report

Despite the severe economic conditions experienced by the forest products and other sectors this year, CFRU membership remained strong. We actually enhanced our acreage this year, reaching nearly 8.4 million acres, an all-time high for the CFRU. Twenty eight members representing roughly half of Maine's forestland kept our program strong during difficult times (Table 1). Reiterating their support for the longevity of the CFRU, members discussed the possibility of reducing membership dues for the 2009 fiscal year in an effor to avoid losing members to the short-term economic crisis. After much deliberation and thoughtful planning the Advisory Commitee at their February 26, 2009 meeting, voted unamimously to offer members the option to pay only 75% of the regularly scheduled dues in the current year only. Sixteen members (Table 1) took the option and payed the reduced dues. The net result was a reduction from $490,077 in projected dues to $382,206 in collected dues.

Although the decision did not come during the dues discussions and was apparently unrelated, the CFRU was disappointed to lose one of our corporate owners, **Hancock Lumber Company**. We thank them for their several years of support since 2003 and hope to welcome them back to the CFRU in the future. The CFRU welcomed new member **Canopy Timberlands Maine, LLC** to the group this year. We thank **John McNulty** and new Advisory member **Hugh Violette** for bringing this 317,000 acre ownership into the CFRU. We are pleased to have the landbase previously known as Clayton Lake and Tall Timbers Trust, LLC remain in the CFRU this year under new ownership as **Clayton Lake Woodland Holdings, LLC**. Advisory Member, **Claude Dufour** continues to represent the ownership on behalf of the new owners. The CFRU thanks Claude and her clients for their ongoing contributions to the group. The CFRU also thanks **Prentiss and Carlisle** for bringing more of their landowner clients into the group, increasing their membership acreage by more than a 100,000 acres this year.

CFRU scientists and staff came in on, or under budget on all approved projects again this year. In total, they spent $461,600 on research and administration (Table 2), returning a surplus of $29,070, or 5.7% of the total approved budget, to the CFRU reserve account (Table 3). Represented in the approved project amounts are efforts by CFRU scientists to reduce ongoing project budgets to help alleviate stress placed on the unit by the approved dues reduction for the current year. Collectively, scientists and staff were able to reduce their ongoing budgets by almost $20,000 (Table 3) to maintain program momentum while absorbing the dues reduction.

Cooperator	2009 acres/tons	Projected Dues	Actual Dues[1]	Discount[2]
Landowners/Managers	**8,371,607 ac**	**$ 465,852**	**$ 359,230**	
Irving, J. D. Ltd.	1,255,000 ac	67,750	50,813	25%
Wagner Forest Management, Ltd.	1,155,997 ac	62,800	47,100	25%
Black Bear Forest Inc.	968,673 ac	53,355	40,016	25%
Plum Creek Timberlands	925,600 ac	51,094	38,321	25%
Prentiss and Carlisle	816,392 ac	45,361	34,020	25%
Seven Islands Land Company	775,950 ac	43,237	32,428	25%
Maine Bureau of Parks and Lands	390,000 ac	22,425	16,819	25%
Huber, J. M. Corporation	384,000 ac	22,080	16,560	25%
Canopy Timberlands Maine, LLC	317,000 ac	18,228	18,228	0%
Katahdin Forest Management, LLC	299,000 ac	17,193	12,894	25%
The Forestland Group, LLC	249,153 ac	14,326	10,745	25%
Clayton Lake Woodland Holdings, LLC	245,000 ac	14,088	14,088	0%
The Nature Conservancy	180,064 ac	10,354	7,765	25%
Timbervest, LLC	121,129 ac	6,965	5,224	25%
Baskahegan Lands	101,709 ac	5,848	4,386	25%
Frontier Forest, LLC	53,338 ac	3,067	3,067	0%
Appalachian Mountain Club	37,093 ac	2,133	1,600	25%
Baxter State Park, SFMA	29,537 ac	1,698	1,698	0%
Robbins Lumber Co.	27,224 ac	1,565	1,174	25%
EMC Holdings, LLC	23,526 ac	1,353	1,353	0%
Mosquito, LLC	16,222 ac	933	933	0%
Wood Processor Members	**1,829,509 tons**	**$ 20,189**	**$ 20,189**	
Sappi Fine Paper	1,829,509 tons	20,189	20,189	0%
Corportate Members		**$ 4,037**	**$ 2,787**	
Huber Engineered Woods, LLC		1,500	1,500	0%
Forest Society of Maine		1,000	750	25%
Hancock Lumber Company		1,000	—	100%
LandVest Inc.		200	200	0%
Peavey Corporation		137	137	0%
Field Timberlands		100	100	0%
Finestkind Tree Farms		100	100	0%
Total Dues From All Members		**$ 490,077**	**$ 382,206**	**22%**

[1] CFRU Dues are paid in year preceding FY in which they will be spent. Dues collected in FY 2009 are expended in FY 2010.

[2] Discount reflects members' decisions regarding optional 25% discount offered to members this year only. See text for more information.

Table 1. CFRU membership dues for FY 2009. This year the Advisory Committee approved an optional, one-time 25% discount on annual dues to help alleviate the financial conditions for our members. See text for more information.

CFRU spent 64% of its expenditures on research projects and 36% for administration, including staff/scientist salaries and other expenses (meetings, field tours, web maintenance, database, travel, computers, safety, phones, printing, and office supplies). Research expenses were

PROGRAM FUNDING SOURCES 2009

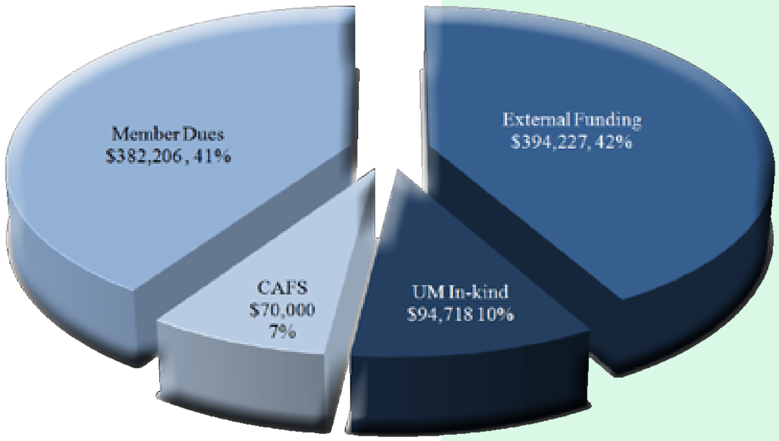


Figure 1. Individual CFRU members continue to receive excellent leverage from other members , external funding sources and University of Maine in-kind contributions. In addition to these other sources, the NSF CAFS program added $70,000 to the program this year. This year, due in part to the reduced dues contributions of most members, the average large CFRU member leverages a huge $21 for every $1 contributed.

2009 Direct Revenues[1]	
CFRU Member Dues	$ 382,206
NSF CAFS Program	70,000
Subtotal	$ 452,206
2009 Direct Expenses[1]	
Administration	$ 168,052
Research Programs	293,548
Subtotal	$ 461,600
Fiscal Year Balance	**$ (9,394)**

[1] Direct revenues and expenses exclude leveraged funds which also support ongoing CFRU research efforts.

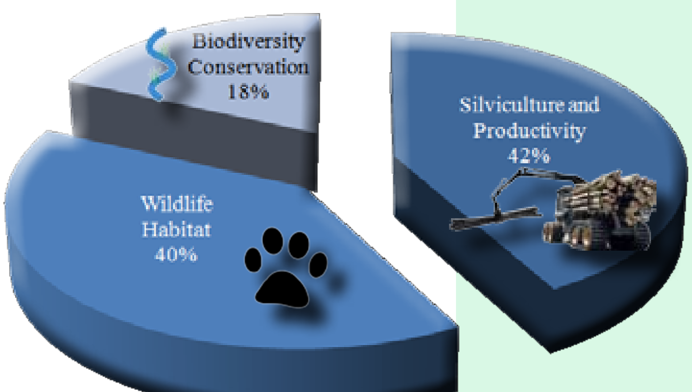
Table 2. Actual revenues (not including leveraged external funding) were $452,206. Expenses exceeded revenues by $9,394 in 2009, however dues collected in FY 2008 were actually expended in 2009. This apparent deficit is well within the annual fluctiation for the CFRU (only 2%) and was approved by the Advisory Committee.

divided among seven silviculture projects (42%), four wildlife ecology projects (40%), and two biodiversity conservation projects (18%) (Table 3).

Using contributions from CFRU members, project scientists were able to leverage an impressive $464,227 (including the new $70,000 from the CAFS program) from external sources to support CFRU-sponsored research projects. When added to the $94,718 of in-kind contributions from the University of Maine, total contributions supporting CFRU research during this fiscal year was **$941,151 or almost two and half times that of member contributions** (Figure 1). CFRU scientists were able to increase external funding this year to help offset the reduced dues contribuions. Though not a source of sustainable revenue growth, external funding proved to be a vital part of the CFRU program this year.

Figure 2. This year CFRU research programs funded approximiately the same amount of research in our *Silviculture and Productivity* and *Wildlife Habitat* programs (42% and 40%, respectively). Biodiversity Conservation research comprised 18% of the total research budget.

PROGRAM EXPENSES BY RESEARCH AREA 2009



A substantial amount of internal leveraging comes from CFRU members pooling their resources. For example, every dollar contributed by our five largest members this year, yielded $8.09 from other member contributions, $9.37 from external funding sources, and $1.38 from in-kind contributions from the University of Maine. Therefore, every dollar contributed by the largest CFRU members leveraged an additional $21.38 to support their highest priority research projects. While the CFRU members perenially enjoys strong leveraging ratios for their contributions, due to the reduced dues this year and an over=reliance on external funding, these leverage numbers are unusually high for the CFRU (see previous Annual Reports for historical ratios).

Project	Investigators	Approved	Revised Approved	Amount Spent	Balance	Total Leverage
Total Administration		**$186,540**	**$186,540**	**$168,052**	**$18,488**	$47,536
Administration			$175,156	$165,792	$9,364	$-
Silviculture Post-Doc			$11,384	$2,260	$9,124	$47,536
Ongoing Research Projects						
Silviculture and Productivity:		**$149,603**	**$133,121**	**$123,198**	**$9,923**	**$175,910**
Commercial Thinning Research Network	Wagner et al.	$31,482	$15,000	$15,000	$-	$5,775
Improving the Species Composition of Hardwood Regen.	Wagner	$12,786	$12,786	$12,786	$-	$22,359
Refinement of FVS-NE Invidvidual Tree Model	Weiskittel	$28,685	$28,685	$28,534	$151	$80,452
Crop Tree Silviculture of White Pine in Mixed Stands[1]	Seymour	$43,773	$43,773	$43,494	$279	$16,853
Evaluation of Biomass Harvest Systems	Benjamin & Wagner	$8,580	$8,580	$2,239	$6,341	$24,803
Capturing Value of 30 Years[2]	Meyer	$24,297	$24,297	$21,145	$3,152	$25,668
Wildlife Habitat:		**$120,275**	**$117,275**	**$116,764**	**$511**	**$140,612**
Trends in Habitat Supply	Harrison & Krohn	$38,000	$35,000	$35,000	$-	$22,175
DWA Synthesis	Pekins	$12,375	$12,375	$12,329	$46	$-
Long-term Monitoring of Snowshoe Hare Populations	Harrison	$34,900	$34,900	$34,436	$464	$13,437
Documenting the Response of Lynx to Hare Populations	Vashon	$35,000	$35,000	$35,000	$-	$105,000
Biodiversity Conservation:		**$53,734**	**$53,734**	**$53,586**	**$148**	**$124,888**
Quantifying Biodiv. Values Across Managed Landscapes	Harrison & Hagan	$43,734	$43,734	$43,586	$148	$12,705
ForCAST Initiative	Wiersma et al.	$10,000	$10,000	$9,999	$1	$112,183
Fiscal Year Balance		**$510,152**	**$490,670**	**$461,600**	**$29,070**	**$488,945**

[1] Approved amount includes $17,505 approved as carryover from FY 2008 surplus.
[2] Approved amount includes $24,297 approved as carryover from FY 2008 surplus.
[3] Approved amounts represents project amounts approved prior to dues reduction
[4] Revised Approved represents project amounts after voluntary current FY reductions offered by scientists at 4.15.09 Advisory meeting

Table 3. CFRU expenditures for FY 2009. Leverage amounts represent additional funds acquired from external sources to fund CFRU approved projects.

Commercial thinning Research Network

Crop Tree Silviculture of White Pine in Mixed Stands

Energy-Wood Harvest Systems for Improving Low-Value, Beech-Dominated Hardwood Stands in Maine

Hardwood Regeneration Improvement and Spatial Ecology of Beech-Dominated Understories in Maine

Capturing the Value of 30 Years of CFRU Research

Refinement of the Forest Vegetation Simulator Northeastern Variant growth and yield model: Phase 1

Silviculture

Commercial Thinning Research Network

Authors

Spencer Meyer
Robert Seymour
Robert Wagner
Aaron Weiskittel

INTRODUCTION

The CFRU Commercial Thinning Research Network (CTRN) completed its 9th season this year. As outlined in the last several CFRU Annual Reports, the network consists of two controlled studies examining commercial thinning responses in Maine spruce-fir stands. A dozen study sites were established on CFRU cooperator lands across the state beginning in 2000. The first study was established in mature balsam fir stands on six sites that had previously received precommercial thinning (PCT) and quantifies the growth and yield responses from the timing of first commercial thinning (i.e., now, delay five years, and delay 10 years) and level of residual relative density (i.e., 33% and 50% relative density reduction). The second study, also established on six sites, was installed in mature spruce-fir stands without previous PCT ("No-PCT") to quantify the growth and yield response from commercial thinning methods (i.e., low, crown, and dominant) and level of residual relative density (i.e., 33% and 50% relative density reduction). See previous Annual Reports for more thorough description of the experimental design and implementation.

Last year, the CFRU Advisory approved funds to establish three new sites to investigate the same PCT treatments we are already testing but on intermediate sites, as opposed to the existing high-quality sites. These new medium-quality sites (MQ-PCT) will supply data to make the growth and yield efforts more robust (see Refining FVS project) and will help us better understand the applicability of commercial thinning treatments across an array of site conditions.

FIELD SEASON

This year, efforts were focused on completing the annual remeasurement schedule for the PCT and No-PCT sites and to establish the new MQ-PCT sites. The summer field crew consisted of Kyle Gay, Matt Russell, Matt Olson, Andrew Nelson, Ben Rice, and Joe Pekol. Spencer Meyer led the overall effort and oversaw the site reconaissance and installation of the new sites. The annual remeasurement cycle called for a light year of work. This year we decided to do only site checks for the No-PCT sites, ensuring site integrity and making note of any widespread disturbances, but not making any tree-level measurements. All PCT sites received extensive measurments, including DBH and tree status.

"With the three new MQ-PCT sites, the complete CTRN database now contains about 98,879 unique tree measurements on 15 sites across the state of Maine."

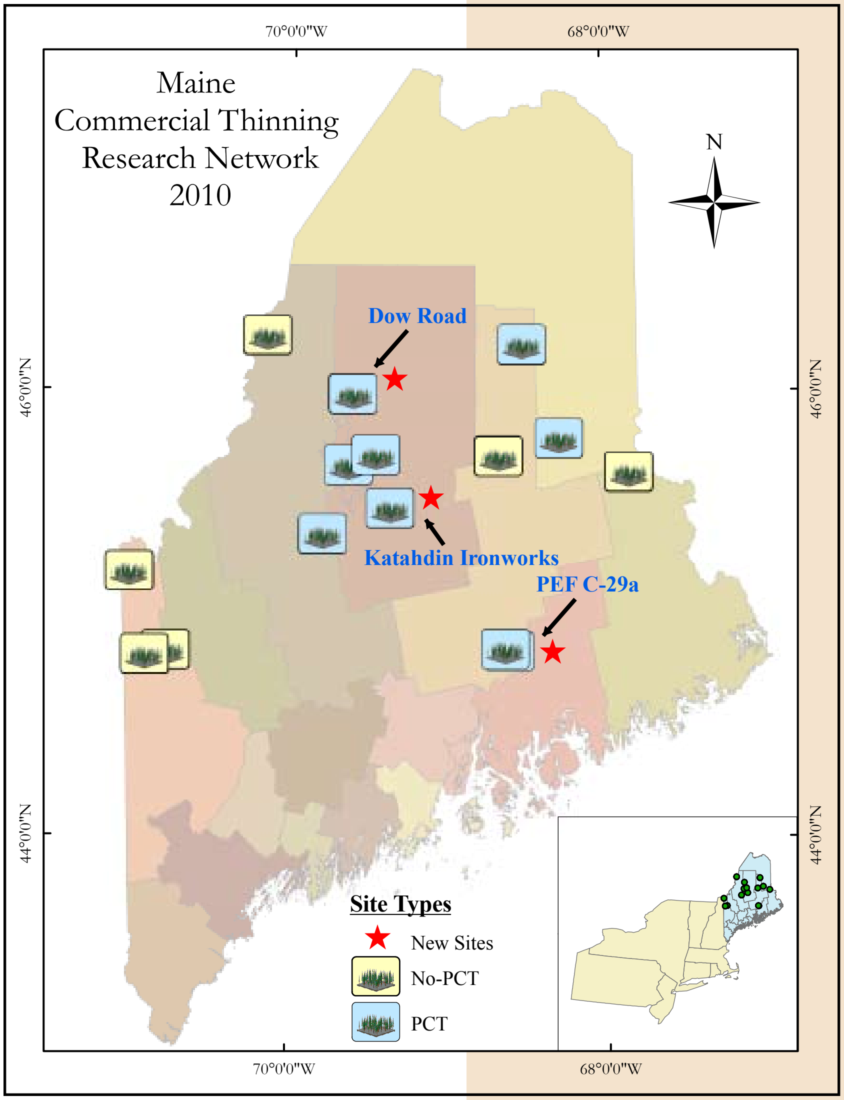


Figure 3. With the addition of the three new MQ-PCT sits, the CTRN study now consists of 15 sites on 12 different landowners.

Most of the effort this year was concentrated on locating three ideal sites for the MQ-PCT locations and installing the research plots once the sites were found. With many thanks to **Katahdin Forest Management**, **Prentiss and Carlisle**, the **Appalachian Mountain Club** and the **U.S. Forest Service**, we surveyed more than a dozen stands across the Maine woods, trying to meet the following criteria:

1) Well-stocked, fir/spruce,
2) Precommerically thinned sometime before 1990, at a spacing of 8x8 ft or 7x7 ft,
3) Briggs site class 3-4 (somewhat poorly to poorly drained) soils,
4) Site index of roughly 45-60, and
5) 25-40 years old.

In the end, we chose three sites, *PEF Compartment 29a* on the Penobcot Experimental Forest, *Dow Road* (so-named for brothers **Kevin** and CFRU Advisory member **David Dow**) on land managed by Prentiss and Carlisle, and *Katahdin Ironworks* on land owned by the Appalachian Mountain Club and manged by Huber Resources (Figure 3). We are very grateful to the land managers, including Kevin and Dave Dow, **Kenny Fergusson**, **Ted Shina**, **David Publicover**, **John Brissette**, **Al Kimball**, and **Robin Avery** for their support in getting these new sites initiated. We also thank the landowners of these properties for their ongoing support of the study and of the CFRU. Now, with 15 sites representing 12 CFRU members, the CTRN has truly become a CFRU-wide research study.

For more information about this project, please contact Spencer Meyer.

CONCLUSION

With the three new MQ-PCT sites, the complete CTRN database now contains about 98,879 unique tree measurements on 15 sites across the state of Maine. This long-term database is already being used by Cooperating Scientist **Dr. Aaron Weiskittel** and his graduate students to develop a new regional growth and yield model (see Refining FVS project). With the added support of the CAFS program, we are bringing a new MS student to the University of Maine to work with the CTRN database. In 2010, we will begin conducting a complete analysis of commercial thinning regimes in Maine.

Crop Tree Silviculture of White Pine in Mixed Stands

The growth, yield, and financial performance of isolated eastern white pine reserve trees

AND

Patterns of Regeneration of Eastern White Pine as Influenced by Large Isolated Reserve Trees and Precommercial thinning

Authors

Robert S. Seymour
Chris Zellers
Kate Zellers

INTRODUCTION

Field work for these companion studies was completed during the 2008 field season by MS students Chris and Kate Zellers, who defended their theses during spring, 2010. The overall goal of this research is to examine growth response of two-aged, white pine-spruce-fir stands, with pine reserve trees left as isolated emergent during otherwise complete overstory removal cuttings carried out between 1984 and 1994. Chris Zellers studied the response of the emergent pines, and Kate studied the stocking and quality of the pine in the regenerating sapling stand.

METHODS

Reserve pines on each site (Table 4) were sampled using large 0.1-ha plots, from which a subsample of 77 trees was selected for detailed study (Tables 5 and 6). These trees were cored at breast height and the top of the first log, where Girard Form Class was assessed with a bark thickness measurement. Detailed branch measurements were made on 9 of these trees by climbing and recording the basal diameters and heights of all living branches. Three branches per tree were removed to the lab and the foliage removed and weighed; from these data, equations to predict branch and tree leaf areas were formulated. Equations to predict tree leaf area from DBH and crown length were fitted by non-linear regression analysis. Leaf area was then related to volume increment using mixed-effects nonlinear regression including random site terms (Figure 4); this relationship was then used to forecast growth of all 77 trees 40 years into the future for the purpose of analyzing growth response and financial performance. Trees were hypothetically sawn into 1-inch boards using Dr. Benjamin's CantSim program, modified so as to optimize log value (Figure 6). Diameter at the time of release was assumed to comprise the butt log's knotty core; the sawing pattern involved making a cant of this thickness, then grade-sawing the outer knot-free zone into the widest boards possible. Wholesale lumber values were assessed using the latest 5-year averages from Random Lengths; logging, trucking and sawmilling costs totally $363 per MBF were then

"At a discount rate of 4%, financial maturity of these released trees peaked approximately 40-50 years after release, and a net present value of nearly twice their value at release"

Site	Location	Harvest Year	Soil Drainage Class	Sample Size	Climbed Sample Size
Dead River Twp.	N 45° 12’, W 70° 16’	1984	3 – Somewhat poorly drained	9	1
Long Pond Twp.	N 45° 36’, W 70° 02’	1989	4 – Poorly drained	9	0
Penobscot Forest, Comp. 2	N 44° 52’, W 68° 39’	1984	3 – Somewhat poorly drained	20	2
Topsfield Twp.	N 45° 28’, W 67° 51’	1992	4 – Poorly drained	7	1
T3 R12	N 45° 56’, W 69° 15’	1987	4 – Poorly drained	10	2
T4 R12	N 45° 58’, W 69° 11’	1991	3 – Somewhat poorly drained	9	2
T5 R12	N 46° 06’, W 69° 15’	1994	5 – Very poorly drained	4	0
T39 MD	N 45° 01’, W 68° 18’	1980	--	9	0

Table 4. Study stand locations, harvest years, soil drainage class (Briggs, 1994), sample size, and sample size of climbed trees.

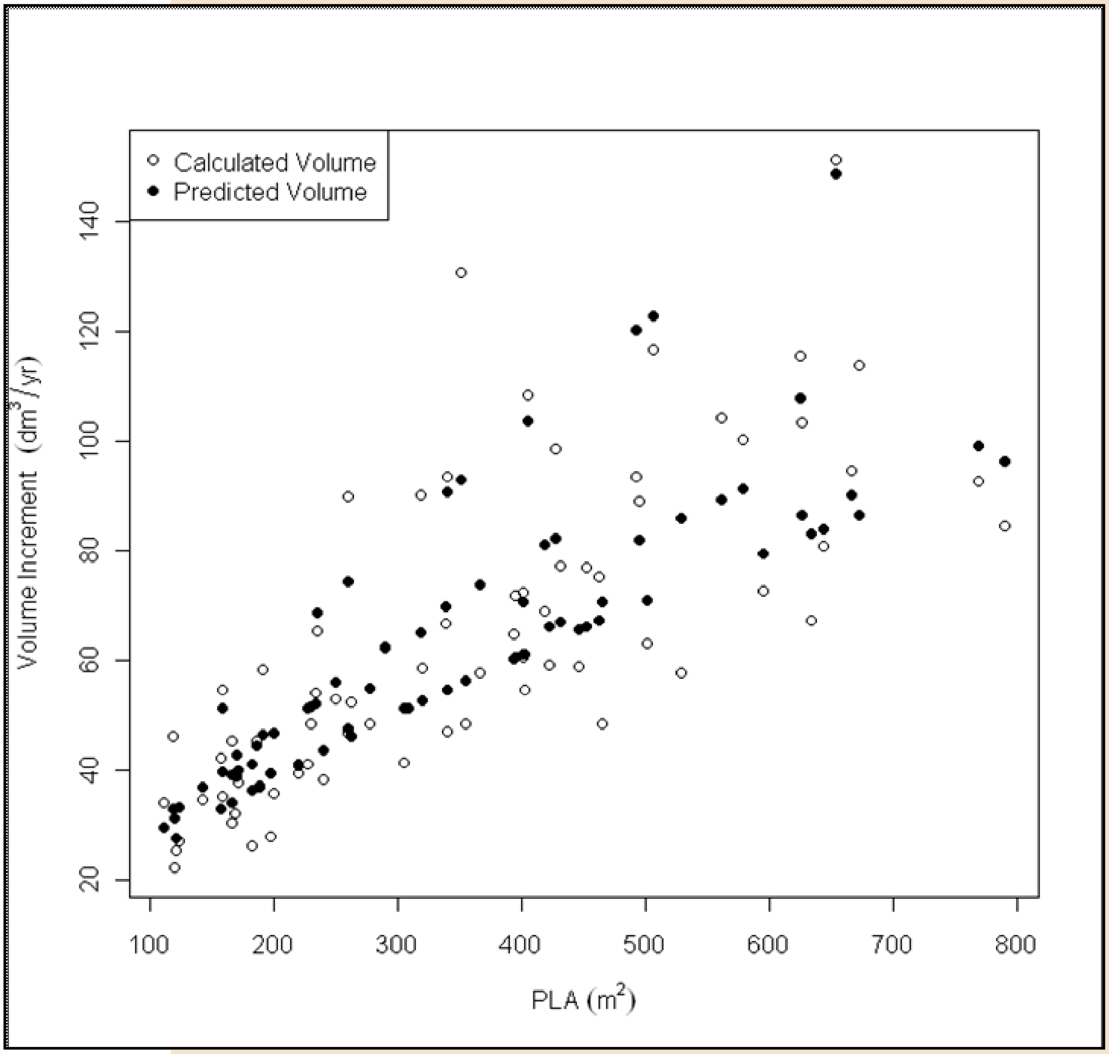


Figure 4. Annual volume increment (dm^3·yr^{-1}) as a function of projected area (m^2). Open circles represent stemwood increment calculated with Honer’s (1967) equation, filled circles represent fitted model [eqn 3].

subtracted to obtain stumpage values of the standing trees. Top logs were all assumed to yield standard grade lumber. Saplings were sampled with small .001-ha circular plots, on which all vegetation was measured and the quality of pine saplings assessed relative to weevil attack, branch size, and blister rust infection.

Site	Mean DBH (cm)	Mean HT (m)	Mean CL (m)	Mean CPA (m^2)	GFC
Dead River Twp.	54.2	21.8	16.3	221.7	77.6
Long Pond Twp.	42.5	21.4	13.4	172.3	78.0
Penobscot Forest, Comp. 2	55.8	25.6	15.8	345.4	81.1
Topsfield Twp.	52.6	24.1	14.4	275.6	77.0
T3 R12	48.4	22.9	14.0	273.0	78.9
T4 R12	42.5	21.3	11.7	203.0	78.1
T5 R12	48.3	21.9	11.2	218.3	80.4
T39 MD	60.6	26.0	13.2	351.1	79.3

Table 5. Summary statistics for all trees included in this study. Attributes include diameter at breast height (DBH), total height (HT), crown length (CL), crown projection area (CPA), stem class form (GFC).

RESEARCH HIGHLIGHTS

1) On all but one site, these large old emergent trees responded well to the regeneration cutting that left them isolated (Figure 5); on average, growth increased by nearly 50% comparing 15 years pre- and post-harvest volume increment.

2) At a discount rate of 4%, financial maturity of these released trees peaked approximately 40-50 years after release, and a net present value of nearly twice their value at release (Figure 8).

3) Growth response and financial performance varied wide by both site and tree condition. In general the younger (age 70-80) sites (Dead River, Topsfield, T3R12) responded more vigorously

Table 6. Mean volume estimates for study trees by site. Standard errors in parentheses. Whole tree cubic feet estimates derived from Honer (1967). Board foot estimates derived from Leak, et al (1970).

Site	Tree Vol. (ft^3)	Tree Vol. (bd ft)	Butt Log Vol. (bd ft)	Top Log Vol. (bd ft)	Vol. in Butt Log (%)
Penobscot Forest Comp. 2	90.6 (4.8)	610.8 (34.5)	220.2 (10.0)	390.6 (24.8)	36.70 (0.01)
T39 MD	113.8 (24.7)	779.0 (179.7)	262.2 (47.8)	516.8 (122.5)	35.86 (0.02)
Topsfield	74.8 (9.5)	495.3 (69.0)	190.4 (18.9)	304.9 (50.3)	42.2 (0.0)
Long Pond	42.3 (2.3)	259.0 (16.3)	115.2 (7.2)	143.8 (9.7)	44.6 (0.0)
T4 R12	43.7 (5.3)	269.7 (38.4)	117.3 (10.5)	152.4 (28.2)	46.0 (0.0)
T5 R12	89.3 (59.9)	600.8 (435.3)	196.5 (110.5)	404.3 (324.9)	48.0 (0.1)
T3 R12	61.2 (7.6)	396.4 (55.2)	154.5 (17.4)	241.8 (37.9)	40.6 (0.0)
Dead River	74.4 (9.0)	492.3 (35.2)	200.7 (21.8)	291.5 (44.2)	42.1 (0.0)
Summit	106.3 (15.2)	724.5 (110.6)	232.8 (28.9)	491.7 (83.3)	32.8 (0.0)

and performed best financially. Small rapidly growing trees at all sites obviously performed best financially, as their initial values at release were relatively small, whereas trees over approximately 18” DBH earned relatively less because they were already reasonably valuable at the time of release.

4) The quality of the regeneration was generally good to excellent on all sites where PCT was not done. In the 5 sites where PCT where pines were left as crop trees, all attributes were inferior after PCT. Maximum branch size was twice as large, weevil attach was three times as frequent (Figure 7), and blister rust infection was much more common, although even in the PCT sites, rust was not a serious problem.

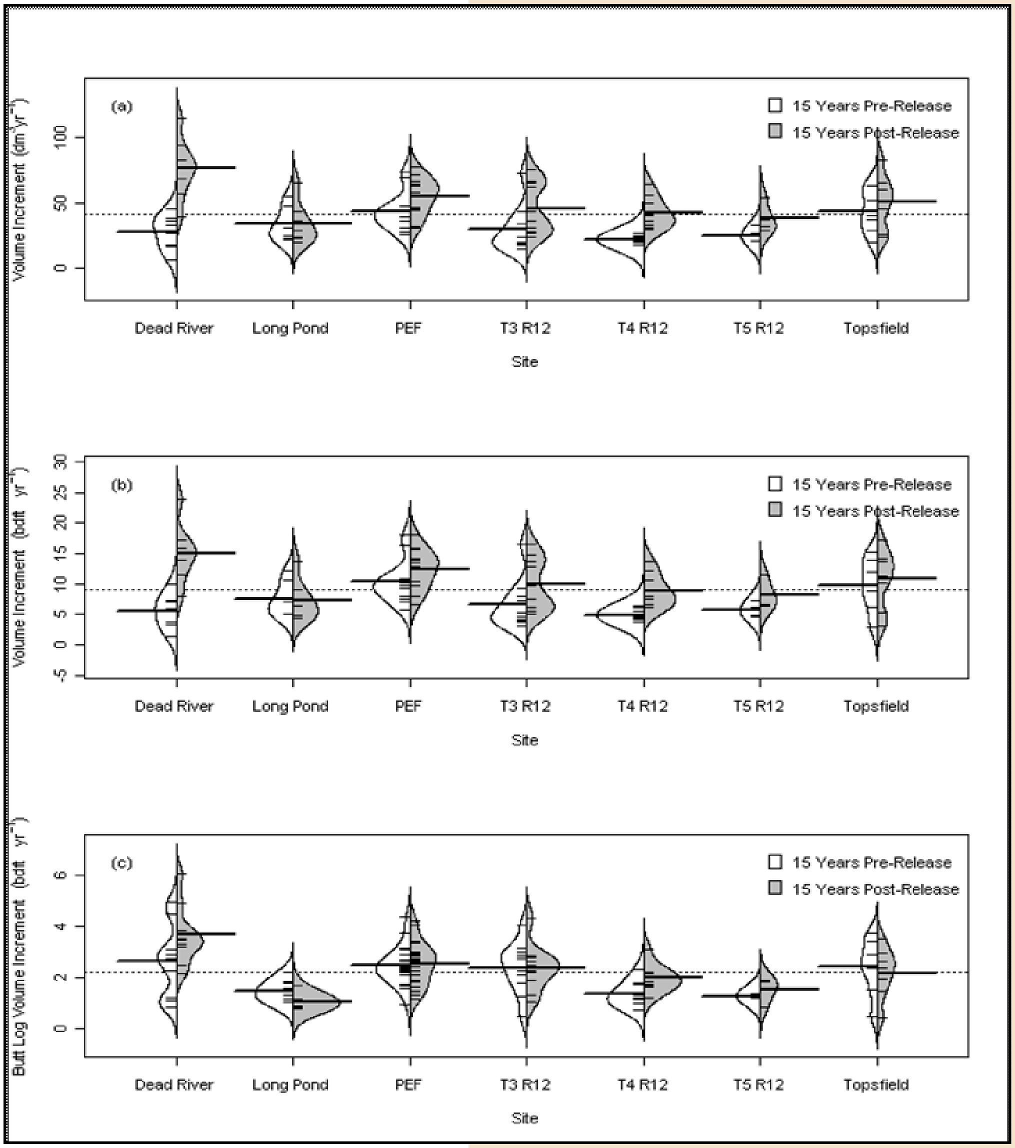


Figure 5. Beanplot of pre- and post- release volume increments by site, (a) for whole tree merchantable volume ($dm^3 yr^{-1}$), (b) Whole tree merchantable volume ($bdft\ yr^{-1}$), and (c) butt log merchantable volume ($bdft\ yr^{-1}$). Small horizontal lines represent individual observations, and large horizontal lines represent site means. Dashed line across entire figure represents grand mean.

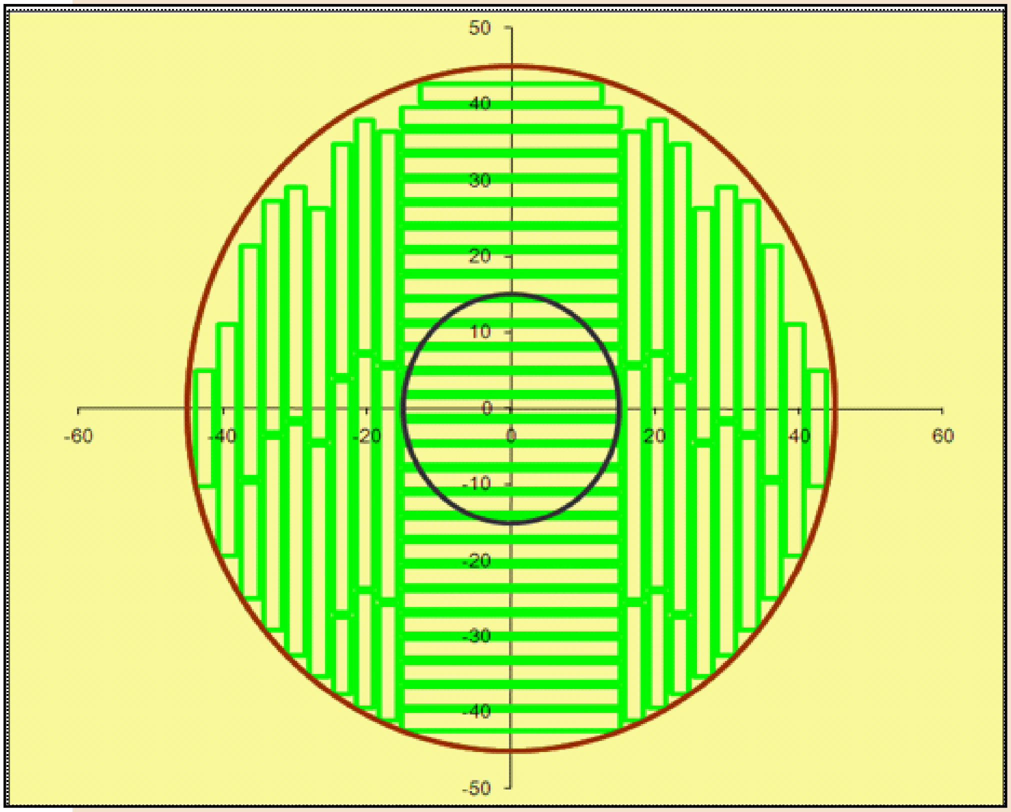


Figure 6. Example of graphical output of the CantSim sawmill simulator (Benjamin, 2006). Black inner circle demarcates knotty defect core.

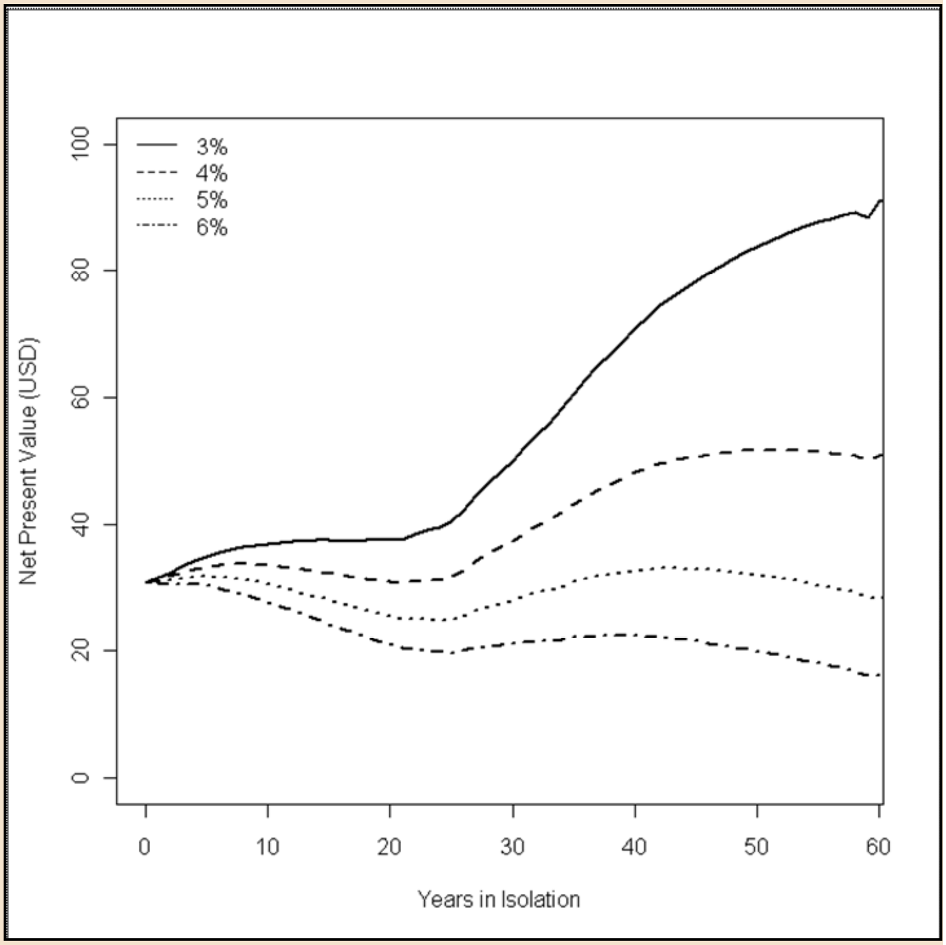
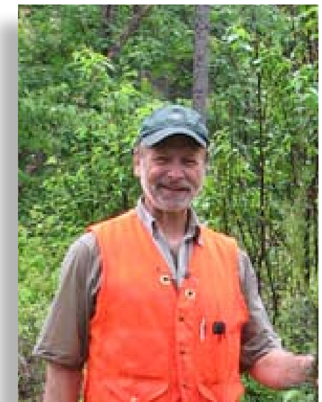
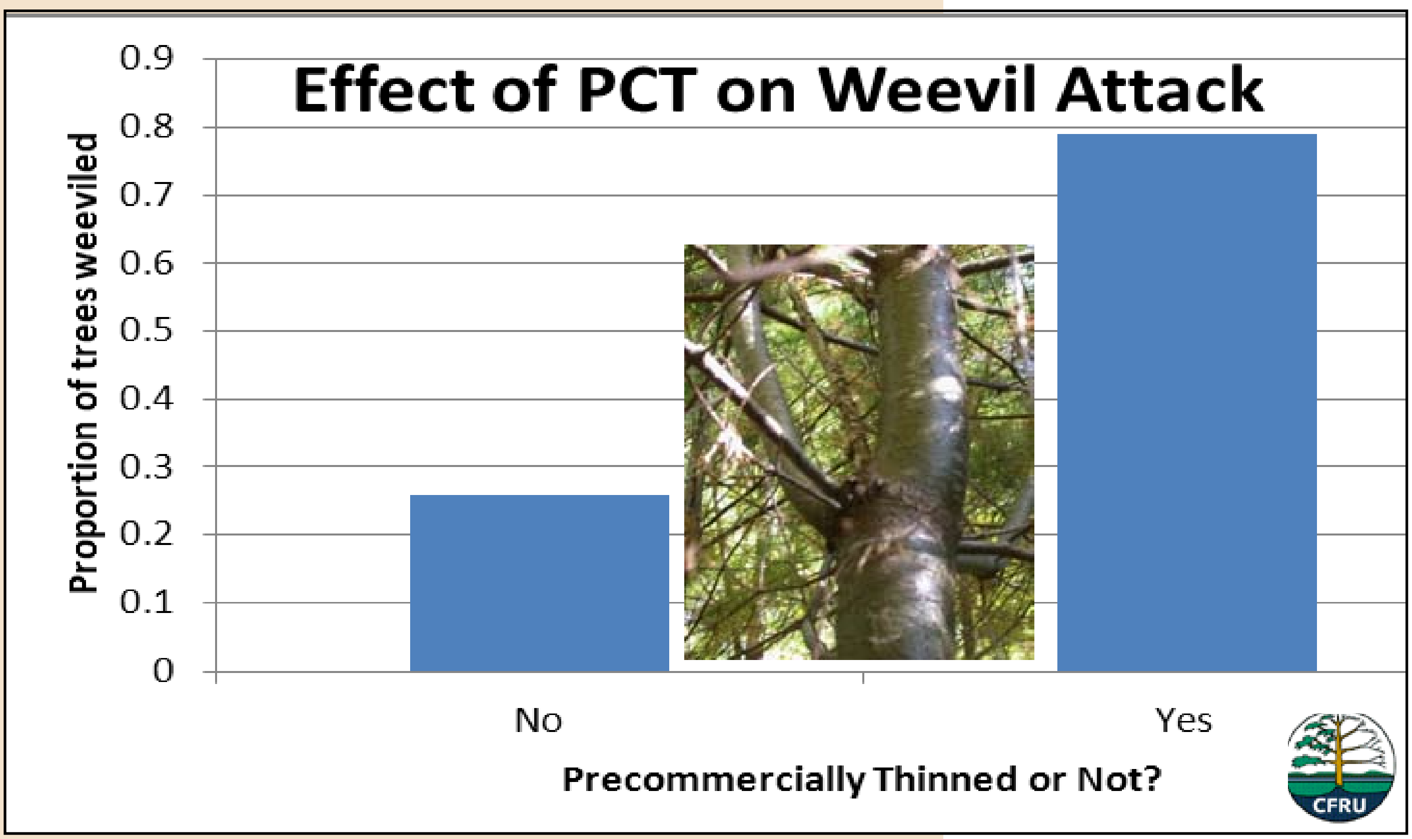


Figure 8. Net present values for unpruned scenario averaged for all study trees, under guiding rates of return ranging from 3 to 6% and 0 to 60 years after complete release. Values were discounted to time of release.



For more information about this project, please contact Bob Seymour.

Figure 7. Proportion of trees with evidence of white pine weevil damage compared in PCT and non-PCT stands.



Energy Wood Harvest Systems for Improving Low-Value, Beech-Dominated Hardwood Stands in Maine

Authors

Jeffrey G. Benjamin
Robert G. Wagner

"Results of the trail area study confirmed that narrower trail spacing resulted in trail occupancy levels that could negatively influence long term forest management."

INTRODUCTION

With a broad goal of helping Maine's forest managers meet the challenges of the bioenergy and bioproducts industry, an investigation of an operational and silvicultural approach for rehabilitating young beech stands was initiated in 2007. This research was jointly funded by the Forest Bioproducts Research Initiative (FBRI) and the CFRU and it provided support for the training of a graduate student within the School of Forest Resources. The following report is a summary of the relevant findings from the final dissertation by Chuck Coup (Coup 2009) entitled: A Case Study Approach for Assessing Operational and Silvicultural Performance of Whole-Tree Biomass Harvesting in Maine.

This research investigated three different aspects of an energy wood harvest conducted in a northern hardwood stand in Central Maine. A detailed productivity and site impact study of a tracked feller-buncher harvesting energy wood at two trail spacings was completed in 2007. This study was followed by an assessment of the effectiveness of a pre-harvest herbicide treatment to control root and stump sprouting of American beech and an assessment of residual stand damage in 2008. All three studies used the same sites.

STUDY AREA

The study area consisted of a mid-site northern hardwood stand located near Springy Brook Mountain in Township 32, Hancock County Maine on lands managed by Huber Resources Corporation. The site was comprised of a sugar maple (*Acer saccharum* Marsh.), American beech (*Fagus grandifolia* Ehrh.), and yellow birch (*Betula alleghaniensis* Britt.) overstory, but had regenerated primarily to a beech dominated mid-story and understory with a high component of striped maple (*Acer pensylcanicum* L.). The beech component of the stand included some larger and older residual trees left during previous harvesting but primarily consisted of a dense sapling and pole component that occupied much of the area. Beech trees in all size classes were largely infected with beech bark disease, greatly reducing their economic value.

STUDY DESIGN

Three replicate study blocks, each 1.2 ha (73.2 m x 165.0 m) in size, were established within the study area (Figure 9). Average basal area was similar among all three blocks. Trees less than 10 cm DBH accounted for over 95 percent of the total stems in all blocks. Beech comprised

65–76% of stems ≥ 2.5 cm and 67% or more of the total basal area on each of the three blocks. More than 90% of beech stems occurring in all three blocks were less than 10 cm DBH.

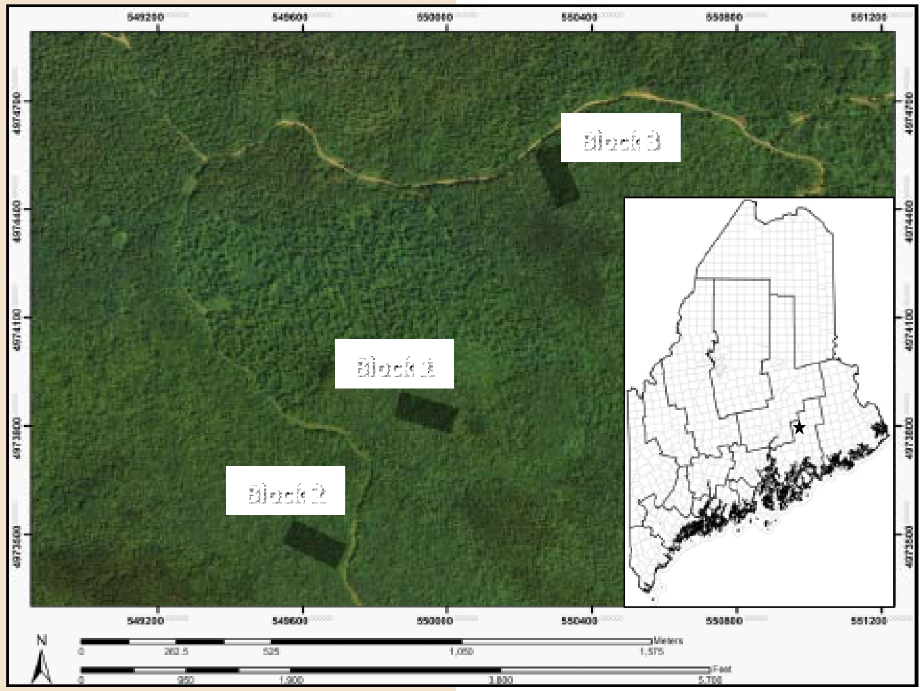


Figure 9. Location of the three study block replicates within the study area, T32, Hancock County, Maine. Imagery captured during the 2006 growing season, prior to harvesting.

A factorial study design was employed, which combined the use of energy wood harvesting with pre-harvest herbicide treatment. Each of the three study blocks were divided in half to give a total of six harvest treatment blocks (0.6 ha, 36.6 m x 164.0 m). Harvest treatments included mechanized whole-tree harvesting using a trail spacing of either 36.6 m or 12.2 m. The harvest prescription was the same for both spacings and consisted of an improvement cut aimed at removing the existing beech-striped maple understory, utilizing all stems ≥ 2.5 cm DBH, while leaving sugar maple and yellow birch. Harvest treatments were randomly assigned to each block pair so productivity and residual stem damage could be compared with trail spacing.

Each harvest treatment block was divided into thirds (0.2 ha, 36.6 m x 55.0 m) to form a total of 18 equally sized vegetation management treatment plots (Figure 10). One of the three vegetation treatment plots in each harvest block was randomly assigned a pre-harvest herbicide injection treatment. The remaining two plots were assigned as controls and did not receive herbicide treatment. Ultimately an additional post-harvest vegetation management treatment will be randomly assigned to one of the two control blocks in each harvest block, providing a complete randomized 2x3 factorial study design with six treatments and three replications. The four combined harvesting and vegetation management treatments included:

- Mechanized whole-tree harvest using an 36.6-m trail spacing, and pre-harvest herbicide injection,
- Mechanized whole-tree harvest using an 36.6-m trail spacing, and no herbicide treatment,
- Mechanized whole-tree harvest using a 12.2-m trail spacing, and pre-harvest herbicide injection, and
- Mechanized whole-tree harvest using a 12.2-m trail spacing, and no herbicide treatment.

The pre-harvest injection treatment consisted of stem injecting all beech and striped maple trees > 7.6 cm DBH with glyphosate (Accord Concentrate®) using TSI hypo-hatchets® at approximately one hack per 2.5 cm DBH, administered at waist height around the circumference of

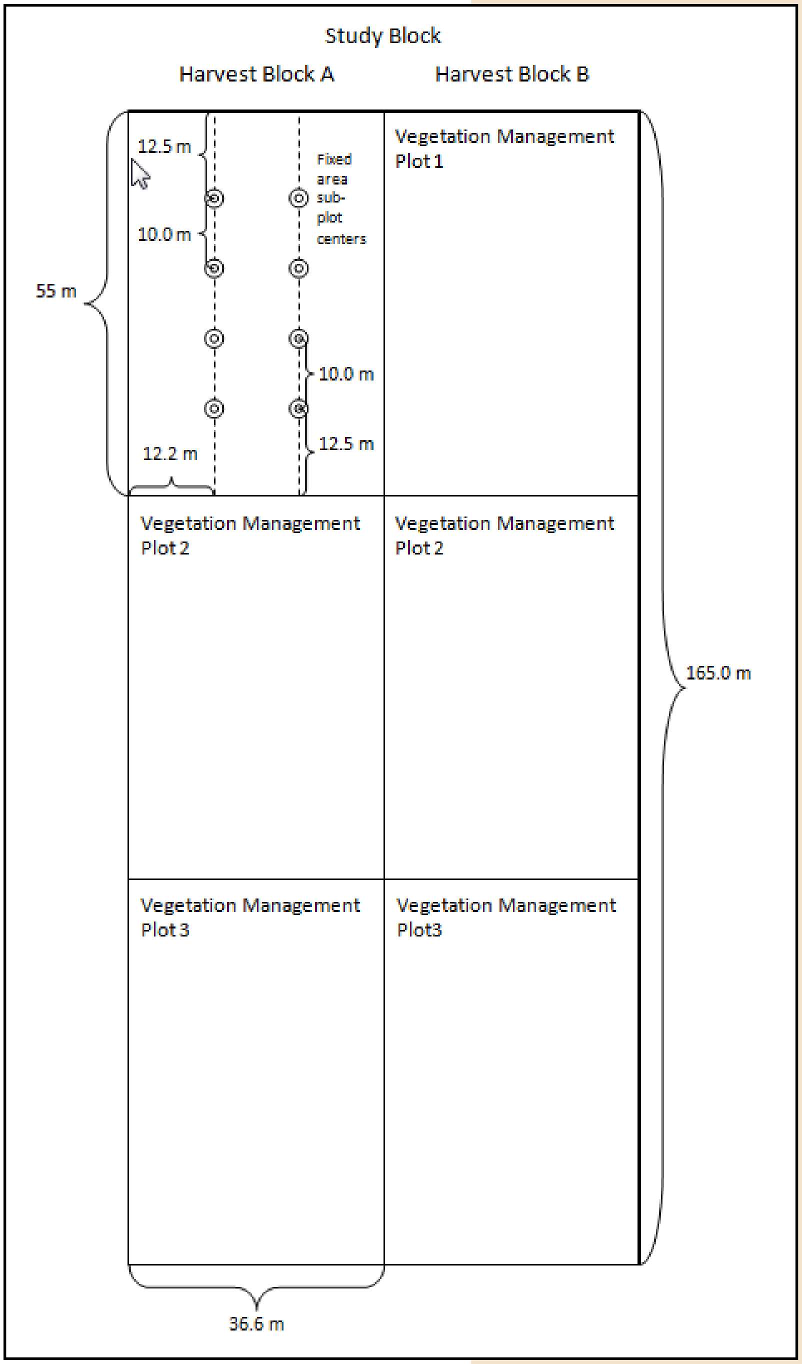


Figure 10. Layout and dimensions of study blocks, harvest treatment blocks, vegetation management treatment plots, and permanent fixed-area sub-plot centers.

the tree. The injection treatment was carried out in mid July 2007, 23–38 days prior to harvesting. Herbicide treatment efficacy was evaluated by comparing post-harvest stem counts and percentage of ground coverage by species in treated plots versus control plots in each harvest treatment one year after harvesting.

Initial inventories were carried out on each 0.2-ha vegetation management treatment plot to provide biomass estimates for the harvesting study and to monitor treatment effects on subsequent regeneration. Sampling of standing trees ≥ 2.5 cm DBH was conducted on nine permanent, fixed area sub-plots, each 0.002 ha in size (8% sampling intensity). Species and DBH were recorded for each tree included in the sample. Residual standing biomass ≥ 2.5 cm DBH was re-evaluated directly following harvesting in summer of 2007 using a complete inventory of all standing trees.

Regeneration, including all stems ≥ 2.54 cm tall and < 2.5 cm DBH, was monitored on 0.00045-ha fixed area plots nested within each overstory plot (1.8% sampling intensity). A count of the number of stems and an ocular estimate of ground cover percentage were recorded in the count by species for each stem occurring within the plot. Stump sprouts were recorded as individual stems. Post-harvest evaluation of regeneration plots was conducted in early July 2008, approximately 11 months after harvesting.

Differences in the residual composition between the two harvest treatments among the three study blocks were evaluated using one-way analysis of variance (ANOVA). Dependent variables included mean DBH, residual basal area, and residual stem density. Treatment effects among the four vegetation management and harvest treatment combinations were evaluated using two-way ANOVA. Dependent variables for this two-way ANOVA included regeneration stem counts and percent cover for beech, striped maple, sugar maple, and yellow birch regeneration. All statistical analyses were performed using a significance level of a = 0.05.

PREHARVEST HERBICIDE TREATMENT SUMMARY

This silvicultural potential of using energy wood harvesting was evaluated in conjunction with vegetation management to rehabilitate unproductive northern hardwood stands overtaken by dense thickets of

American beech and other shade tolerant competitors. Research has shown that harvesting alone will only exacerbate this problem (Nyland et al. 2006) and that successful rehabilitation strategies require some sort of understory control using herbicides (Ostrofsky and McCormack 1986). Although not appraised from a financial standpoint, energy wood markets may render an opportunity to economically conduct these rehabilitation treatments by providing a market for the low-value harvested material.

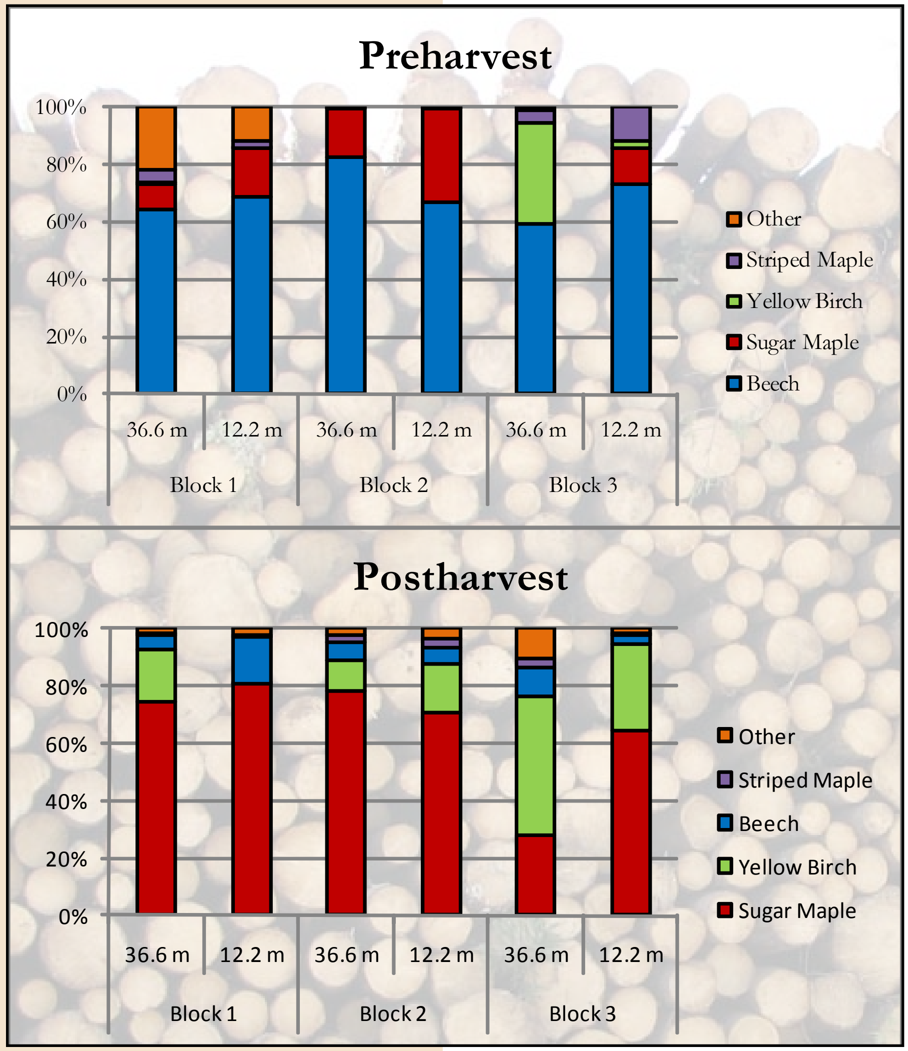


Figure 11. Comparison of pre-harvest and post-harvest species composition by study block and treatment.

This study evaluated the efficacy of pre-harvest glyphosate injection of beech and striped maple trees using hypo-hatchets in controlling stump sprouting and root suckering following intensive energy wood harvesting. The purpose of the study was to report the impact of the energy wood harvest and early injection treatment results from the first growing season following the treatments. Eventually an additional post-harvest foliar application aimed at controlling undesirable regeneration will be incorporated as part of this research as well.

The results of the study indicated that harvesting removed most of the understory beech and striped maple component from the stands (Figure 11). Pre-harvest vegetation management using the glyphosate treatment successfully controlled post-harvest beech reproduction as the density of stems on plots treated with the herbicide injection was lower than controls one year after harvest. Regeneration abundance from the first growing season following harvesting is summarized by species and treatment in Table 7. Results of the ANOVA indicated that mean density (stems·ha^{-1}) of beech on plots treated with the pre-harvest glyphosate injection were different than control plots (p = 0.0012). Density differences between harvesting treatments were not significant (p = 0.7966). The herbicide treatment generally proved ineffective at controlling striped maple one year after harvest.

ENERGY WOOD HARVEST SUMMARY

This portion of the study focused on the challenge of maintaining operational productivity while harvesting Energy Wood. Specifically, we evaluated the effects of modified trail spacing on the productivity of a typical feller-buncher while harvesting energy wood. In order to remain productive when harvesting energy wood, larger volumes of material must be handled to compensate for the low piece size. The study pro-

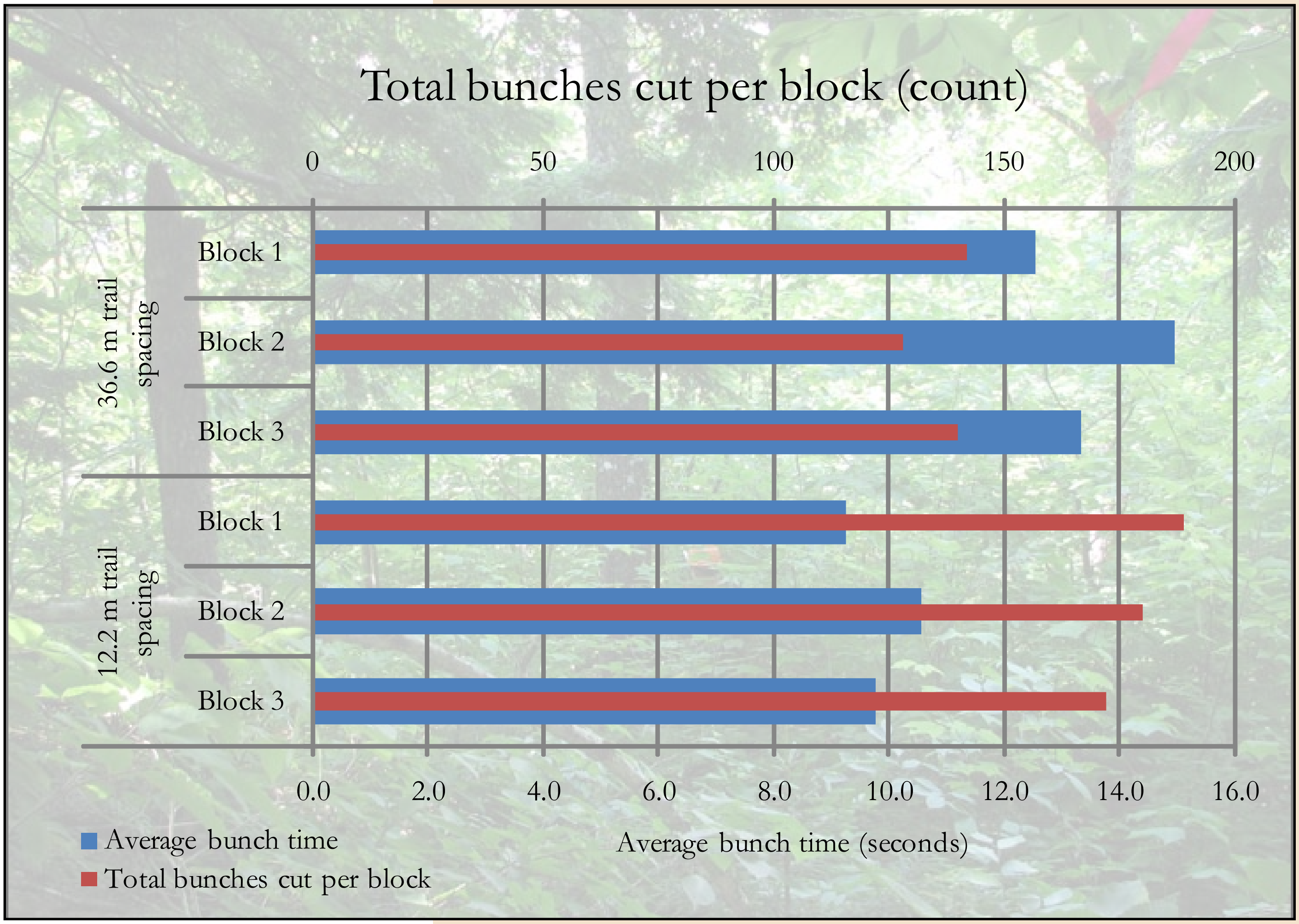


Figure 12. Comparison of average bunching time with total number of bunches produced by harvest and block treatment. Thick black bars represent the average time to carry out the bunching element (s.ss) and are read off of the lower time scale. Narrow grey bars represent the total number of bunches cut in each block and are read off of the upper count scale.

posed using narrower trail spacing as a means of reducing travel and bunching time for the feller-buncher. Time and motion studies were conducted on a single machine with the same operator while harvesting using one of two trail spacings. Because reducing trail spacing results in higher levels of trail occupancy on a site, the density of trails produced at each spacing was also evaluated. The operation was considered to be an integrated energy wood harvest as some pulp material was sorted at the landing.

The results did not indicate any substantial increases in productivity between the two trail spacings. This lack of difference was due to a tradeoff between efficient bunching and the number of bunches produced (Figure 12). In other words, extra time saved on bunching was offset by having to make more bunches, and vice versa. Results of the trail area study confirmed that narrower trail spacing resulted in trail occupancy levels that could negatively influence long term forest management.

RESIDUAL STAND DAMAGE SUMMARY

This phase evaluated the residual damage resulting from the energy wood harvest described above. Because energy wood harvesting typically is integrated with intermediate silvicultural treatments where a portion of the stand remains after harvesting (Manley and Richardson 1995), it is important to evaluate the residual impacts of the harvest, particularly when using modified methods. A complete inventory and evaluation of residual trees was conducted shortly after harvesting and skidding operations were completed. Assessment of damage was conducted using a modified version of Ostrofsky et al. (1986) that considered wound size, location, and severity.

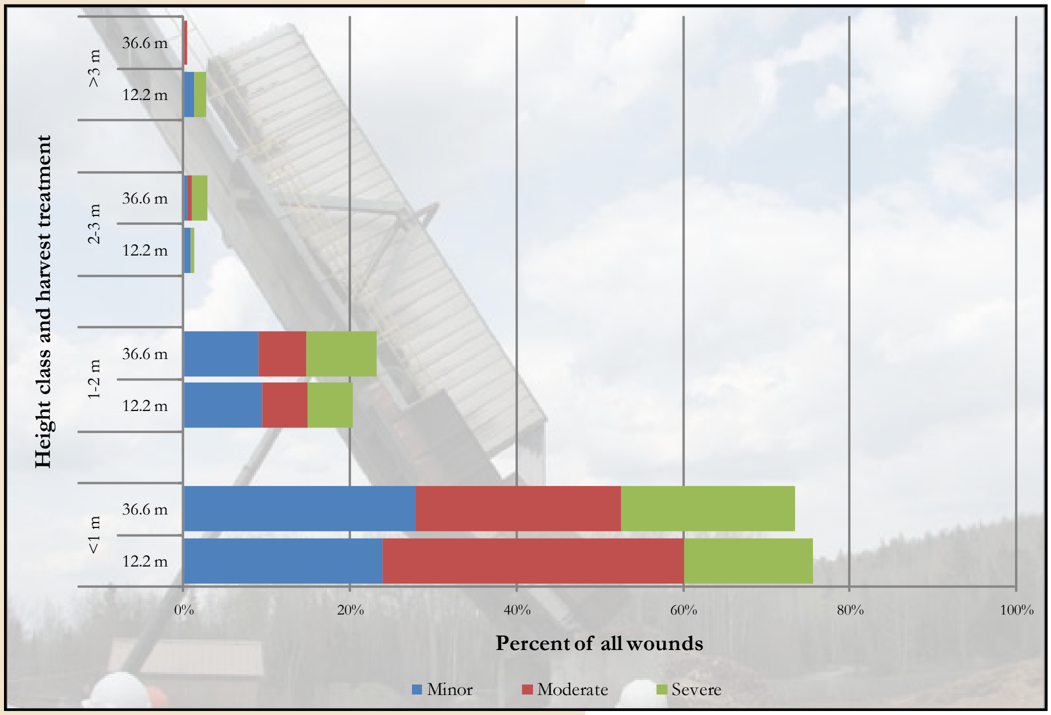


Figure 13. Proportions of wounds by height class, harvest treatment, and damage rating.

Results did not indicate a substantial difference in the level or pattern of residual damage caused by the harvest operation at either trail spacing (Figure 13). Patterns of residual damage were expected to be similar since the same mechanical system and operators were used at both spacings; however, the frequency of damage was expected to be greater at the narrower of the two trail spacings because of the increased trail density. The lack of dissimilarity was not easily explained from the data collected and was further limited by the low sample size. While damage levels were disconcertingly high at both trail spacings, they were comparable to results from other published studies of mechanized whole-tree harvest operations in hardwood stands.

DELIVERABLES

In addition to annual CFRU reports in 2007 and 2008, two key outputs directly resulted from this work including a paper that was presented at the 2008 Council on Forest Engineering (Coup et al. 2008b) and a poster than was judged 4th out of 25 at the 2008 ECANUSA Forest Science Conference (Coup et al. 2008a). The research area has also been used as a demonstration site for field tours related to biomass harvesting and forest health.

Indirectly this research supported a state-wide initiative to develop woody biomass retention guidelines (Benjamin 2010), and initiated a study of the use of statistical process control techniques for forest operations (Coup 2009).

ACKNOWLEDGEMENTS

This project was supported by the Forest Bioproducts Research Initiative (FBRI) through National Science Foundation under Grant No. EPS-0554545 and by the Cooperative Forestry Research Unit (CFRU) at the University of Maine. Appreciation is extended to Huber Resources Corporation for use of their land, and for their cooperation and support during the execution of this study. We also thank Wayne Peters Logging for their cooperation in carrying out the harvest operations of this study.

	36.6-m trail spacing				12.2-m trail spacing			
	Pre-harvest Injection		Control		Pre-harvest injection		Control	
Species	Number of stems (#/ha)	Percent Cover (%)	Number of stems (#/ha)	Percent Cover (%)	Number of stems (#/ha)	Percent Cover (%)	Number of stems (#/ha)	Percent Cover (%)
Beech	8,288	8.5	27,947	8.6	7,367	8.9	37,616	14.0
Striped Maple	10,682	5.0	6,906	3.4	6,630	3.3	11,464	5.7
Sugar Maple	8,748	6.1	5,295	3.7	6,998	2.9	5,801	4.6
Yellow Birch	1,565	0.7	4,282	1.6	2,578	0.9	1,750	4.8
Other*	13,813	5.2	460	1.0	12,155	1.0	2,118	1.8
Total	43,095	25.5	44,891	18.3	35,728	17.0	58,749	30.8

* Other species includes white ash (*Fraxinus americana* L.), red spruce (*Picea rubens* Sarg.), eastern white pine (*Pinus strobus* L.), hophornbeam (*Ostrya virginiana* (Mill.) K. Koch), eastern hemlock (*Tsuga canadensis* (L.) Carr.), and northern red oak (*Quercus rubra* L.).

Table 7. Average stem count and percent cover for regeneration ≥ 2.54 cm tall and < 2.54 cm DBH one year after treatment by species and treatment.

For more information about this project, please contact Jeff Benjamin.

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Hardwood Regeneration Improvement and Spatial Ecology of Beech-Dominated Understories in Maine

Authors

Andrew S. Nelson
Robert G. Wagner

INTRODUCTION

The fourth-year of the hardwood regeneration improvement project focused on: 1) measurement and analysis of third year results from an experiment evaluating methods for improving the species composition of beech-dominated understories in stands that were recently shelterwood harvested, and 2) spatial patterns of beech and sugar maple regeneration in the understory of recently harvested stands. Both studies were part of a MS thesis completed Andrew Nelson this year.

IMPROVING THE COMPOSITION OF NATURAL REGENERATION IN HARDWOOD STANDS WITH BEECH-DOMINATED UNDERSTORIES: 3RD YEAR RESULTS

Concerns of CFRU members about future productivity losses in northern hardwood stands with beech-dominated understories prompted the development of this study in 2006. The experiment consists of twelve combinations of glyphosate herbicide (Accord Concentrate®) and surfactant (Entreé 5755®) to determine an optimal treatment for selectively reducing beech regeneration while preserving more desirable tree species (sugar maple, yellow birch, and red maple). Measurements have been made annually for three years after herbicide application to document the post-treatment dynamics of hardwood regeneration. Details about the experimental design can be found in the 2008 CFRU Annual Report. The third-year results, from data collected during summer 2009, were consistent with those reported during the second-year (see 2008 CFRU Annual Report), and suggest that the treatments tested were successful in substantially reducing understory beech density while preserving the density of sugar maple and red maple regeneration.

"Third-year post-treatment results indicated that beech control remained greater than 70% while sugar maple mortality was less than 20% for the most effective treatment combinations. In particular, the 1 lb/ac glyphosate and 0.25-0.5% surfactant combinations maximized beech control while minimizing injury to sugar maple."

Third-year post-treatment results indicated that beech control remained greater than 70% while sugar maple mortality was less than 20% for the most effective treatment combinations (Figure 14). In 2008, we showed that a rate of glyphosate between 0.5 and 1.0 lb/ac with between 0.25-0.5% surfactant can successfully reduce beech density while preserving sugar maple density. The third-year results indicated that these treatments are still the optimal combination for shifting species composition. In particular, the 1 lb/ac glyphosate and 0.25-0.5% surfactant combinations maximized beech control while minimizing injury to sugar maple. Although beech control was relatively high and sugar

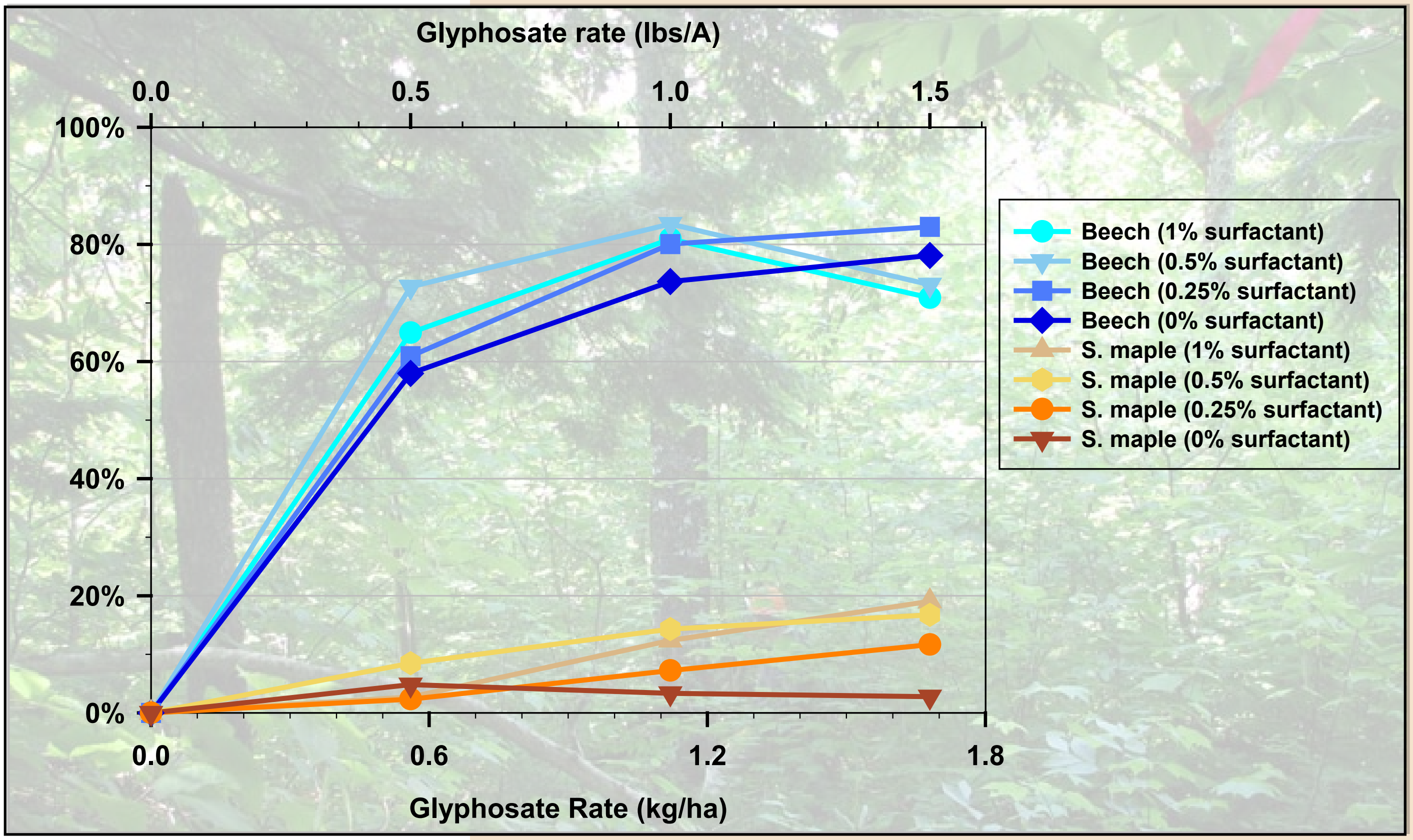

Figure 14. Third-year control of beech and sugar maple stem count following three rates of glyphosate herbicide (Accord Concentrate) and four concentrations of surfactant (EnTreé 5735). These data are from the hydraulic nozzle study.

maple mortality low in treatments without surfactant, we recommend that some surfactant be added to the herbicide mixture to increase the control of striped maple and other undesirable species.

This study also was able to document the relative susceptibility of five major hardwood species to the treatments. In 2008, we reported the following order of decreasing susceptibility to glyphosate herbicide treatment: beech > yellow birch > striped maple > red maple > sugar maple. Although most of the results between the two measurement periods were not different, one important change was the increase in yellow birch stems (Figure 15). A 12% increase in yellow birch stems shifted its ranking relative to striped maple so that the new rank order of tree species was: beech > striped maple >yellow birch > red maple > sugar maple (Figure 16). As of 2009, the three most desirable species (sugar maple, yellow birch, and red maple) were showing the lowest mortality, while beech and striped maple had the greatest control, 73% and 45%, respectively.

Another important facet of the study was to test for differences between two methods of herbicide application: 1) hydraulic nozzle sprayer (used to accurately test the twelve glyphosate rate and surfactant combinations) and 2) mistblower (most likely to be used operationally for understory treatments). Due to the nature of the backpack mistblower application, these treatments delivered three-fold more spray volume (and therefore rate of glyphosate) than the hydraulic nozzle sprayer, which resulted in application rates of 1.5, 3.0, and 4.5 lb/ac of glyphosate. Although the mistblower treatments delivered substantially higher rates of application, the third-year results indicated that there were no substantial differences in the levels of control between the two application methods for any of the five hardwood species (Table 8). Thus, it appears that the ability of glyphosate treatments to control beech and preserve more desired tree species (such as sugar maple, yellow birch, and red maple) are consistent across a range of application methods and herbicide rates. This result is operationally important because understory herbicide applications from tractor-mounted mistblowers tend to deliver variable rates of herbicide deposition in shelterwood understories. Therefore, the results described in this study are likely to be relatively robust under operational forestry conditions.

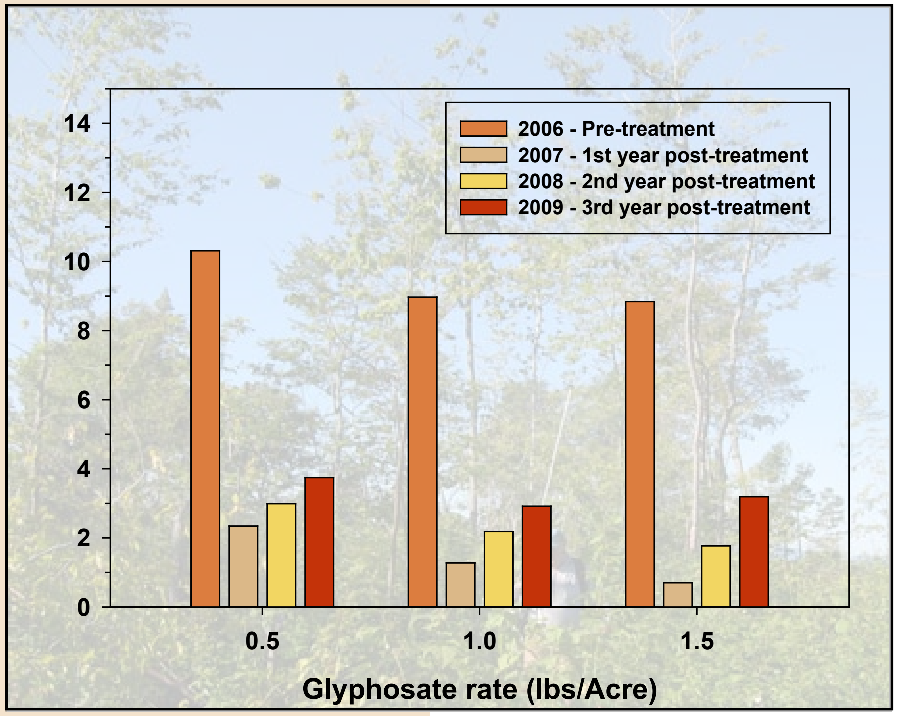

Figure 15. Change in yellow birch stem counts from 2006 (pre-treatment) through 2009 (third-year post-treatment) for each of the three glyphosate rates tested (hydraulic nozzle data).

SPATIAL PATTERNS OF BEECH AND SUGAR MAPLE REGENERATION IN THE UNDERSTORY OF BEECH-DOMINTAED STANDS

The benefit of the herbicide treatments described above will be of value primarily when there is a relatively uniform spatial distribution of desired tree species among beech in the understory to take advantage of any new space created by treatment. However, if beech regeneration is evenly distributed and the desired tree species are spatially clumped, an effective treatment will remove the beech but leave areas of the understory unstocked or understocked with desired tree species. In addition, the spatial patterns of beech and sugar maple strongly influence future stand dynamics and species composition, so are important to understand.

Various spatial patterns of regeneration are possible in post-harvest stands: (1) beech are randomly dispersed throughout the understory while sugar maple occurs in patches within a beech-dominated matrix; (2) randomly distributed beech understories are stratified over randomly distributed sugar maple regeneration, or (3) overlapping patches of both species. Such spatial patterns may change over time, and therefore it is important to understand the timeframe where post-harvest stocking is high and well dispersed so that understories can still positively respond to silvicultural treatments directed at managing beech and maple. Therefore, the objective of this companion study was to examine the spatial distribution of beech and sugar maple in the understory of beech-dominated stands that were recently shelterwood harvested.

At each of the three sites used for the above beech control study, a 24 x 24-m grid was installed in the untreated portions of each stand where the density and spatial location of regenerating beech and sugar maple stems were quantified. Specific objectives for this study were to: 1) describe the patterns of spatial distribution for beech and sugar maple regeneration, and 2) determine whether beech and sugar maple regeneration coexist within the grids so that inferences could be made about potential competition and exclusion of sugar maple by beech. Regeneration densities were separated into three height classes: h1 (≤30 cm tall), h2 (31-90 cm tall) and h3 (>90 cm tall, but < 4 cm DBH) and the average age of each height class was assessed to estimate approximate time of establishment. The origin of beech regeneration from seed or root suckers also was determined.

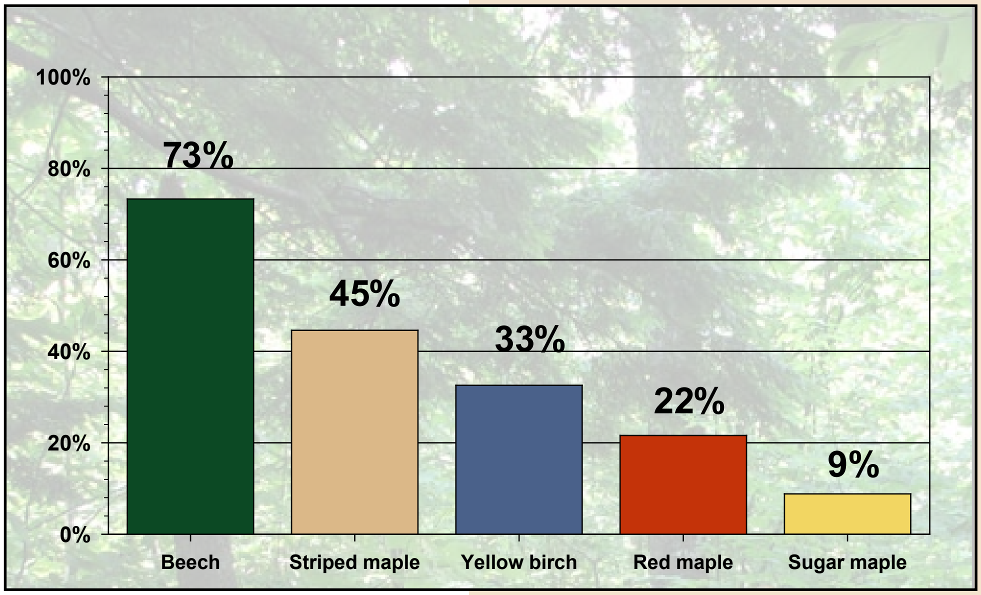

Figure 16. Difference in hardwood species susceptibility to all glyphosate treatments based on third-year changes in stem count for all three sites (hydraulic nozzle data). Species ranking were similar among treatments.

The age of beech and sugar maple regeneration in each of three height classes was similar among the three sites, with seedlings in the h3 height class (7-10 yrs old) generally establishing as advance regeneration before harvest and seedlings in the h1 height class (2-4 yrs old) establishing after harvest. Seedlings in the h2 height class (4-5 yrs old) generally established near the time of shelterwood harvest on each site. Seed-origin beech averaged from 79% and 93% on all three sites, surprisingly indicating that root suckering was a minor form of the beech regeneration on these sites.

The spatial patterns of both species (among height classes and total) were patchy; suggesting a relatively uneven stocking across the understories (Figure 17). Average patch size among the sites were calculated and indicated that beech advance regeneration had an average patch size of 8.0 m, while seedling sugar maple had an average patch size of

Figure 17. Regeneration densities of the three beech and sugar maple height classes and total regeneration at site T2R7 for the spatial ecology investigation. Densities increase from green to white.

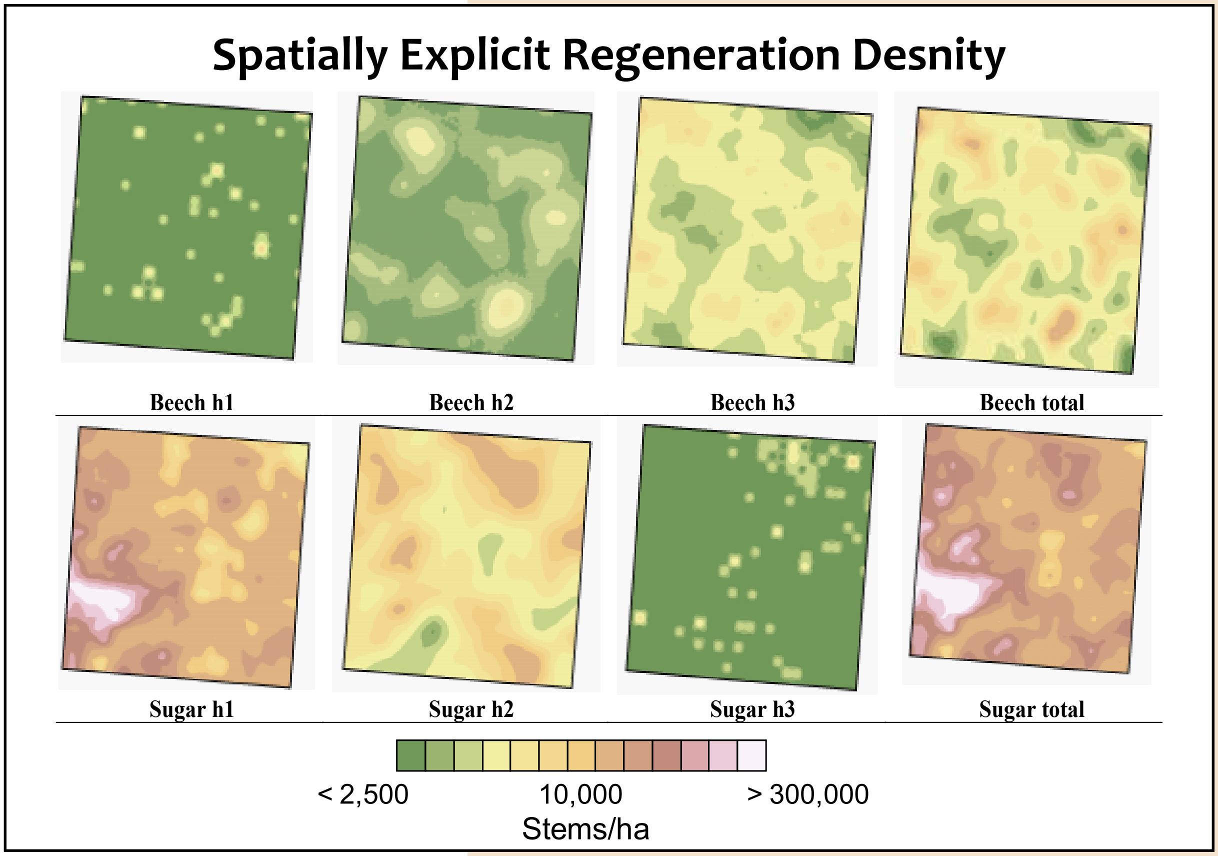

Figure 18. The Seet Spot treatment, 1 lb/ac glyphosatewith 0.5% surfactant leads to excellent beech control after four years. Photos: A) 2006, pre-treatment, B) 2007, post-treatment, C) 2008 and D) 2009.

Application Method	Species				
	Beech	Striped maple	Yellow birch	Red maple	Sugar maple
Hydraulic	72	43	30	23	12
Mistblower	82	39	43	19	20

Table 8. Third-year post-treatment results comparing the hydraulic nozzle and the backpack mistblower applications. The values are averaged for the three hydraulic nozzle & mistblower rates (0.5 lb/ac – 0.25%, 1.0 lb/ac – 0.5%, and 1.5 lb/ac – 1.0%).

11 m. These results suggested that beech and sugar maple regeneration coexisted within the grids as overlapping distributions of regeneration patches. Two major conclusions were suggested from this spatial pattern analysis: 1) without silvicultural intervention to reduce beech densities these stands will likely develop into beech-dominated stands over the long-term, and 2) with an appropriate method of selectively reducing beech densities (such as with the above glyphosate treatments) the spatial distribution of sugar maple is sufficient to shift understory species composition towards sugar maple dominance (Figure 18).

ACKNOWLEDGEMENTS

We thank the CFRU and H.W. Saunders Chair for financially supporting this work. We also thank Huber Resources Corp., Katahdin Forest Management, and Prentiss & Carlisle Co. for study sites and logistical support in completing this project.

For more information about this project, please contact Robert Wagner.

Capturing the Value of 30 Years of CFRU Research

Authors

Matthew Russell
Spencer R. Meyer
Robert G. Wagner

INTRODUCTION

Since 1975, CFRU data have accumulated with few guidelines for information management. Data as a whole within the CFRU have traditionally been managed by individual scientists and labs and a system for managing data collected from the Unit as a whole was nonexistent. Because maintaining and managing data from forestry and ecological studies is an integral component of long-term research (Irland et al. 2006), having the tools in place to effectively manage data gathered from individual projects benefits any research organization.

Research priorities are continually changing as new problems are encountered and novel questions are asked. The CFRU, not unlike any other research unit, faces these changes with a turnover of scientists and other researchers along with a technology and software standards that are constantly changing. With respect to data that are collected, researchers who go leave an irreplaceable institutional memory, and data left behind can soon became extinct if not migrated to current software. This is especially true of long-term research installations (e.g., the Austin Pond and Weymouth Point studies), as data collected from these studies are uniquely valuable and essential to our understanding of forest development and ecosystem processes. Furthermore, data collected in a certain experiment may have research value as part of additional investigations, or in applications supplementary to their original intent. Nevertheless, a system for managing data gathered from the various CFRU research projects was lacking.

Through merging past, present, and future research, the Capturing the Value of 30 Years project was initiated to serve the information management needs of the CFRU. The objectives of the 30 Years project, completed in 2009, were:

1) To identify, compile, and archive relevant and important past and present CFRU datasets for future use, and

2) To develop protocols for archiving future CFRU project datasets.

Above image courtesy of US Forest Service arcjoves.

METHODS AND RESULTS

Identifying Projects and Compiling Data

All projects	Subset of projects
Research objectives	Funding
Type of research	Research site location(s)
Start year/end year	GIS data layers
Experimental design	
Key results	
Principal investigators	
Species studied	
Supporting documents	
Species examined	

Table 9. Types of metadata compiled from CFRU research projects.

We identified a total of 103 complete or ongoing research projects initiated since the inception of CFRU. Many of these projects were short-term in nature coupled with specific research questions while others were components of extensive long-term research studies. These projects were identified through analyzing historical CFRU records, such as Annual Reports, research project publications, and documents archived on the CFRU website. The mean duration of all completed CFRU Projects was 4.4 years. Non-funded projects (i.e., those projects which submitted proposals but did not receive funding) were also identified to track the reach priorities of the Unit.

Defined as coarse-level information of a project, metadata for each CFRU project were documented. Compiled metadata varied depending on the information available for each project (Table 9). Research reports or some other publication often contained desired metadata, and principal investigators for recent research projects were contacted to obtain important information (e.g., key project results and research site locations).

Measurement data, the detailed data collected in the field or lab, were primarily obtained from principal investigators. Measurement data might include the diameters of balsam fir trees in a research plot or the count of snowshoe hare fecal pellets along a transect traversing a forest stand. We used a prioritization system for obtaining measurement data, given the difficulties with regard to time and effort in recovering older datasets. Multidisciplinary, long-term, growth and yield, and thinning study datasets were examples of high priory datasets, while short-term (e.g., 1-year) projects and datasets already well documented in other labs were deemed low priority for compiling measurement data. Of all completed CFRU research projects, measurement data were found to be accessible for 59% of all projects (for projects that initiated since 1995, this value was 78%).

Archiving and Future Data Management

A relational database management system (RDMS) was developed to associate the similarities of information gathered from all CFRU projects. The RDMS, termed the CFRU Projects Database (CFRU PDB), was developed in Microsoft Access and allows relationships to exist among separate data tables (Figure 19). For example, one data table may contain a list of all scientists affiliated with CFRU complete with contact information, which is linked to a data table associating each scientist to

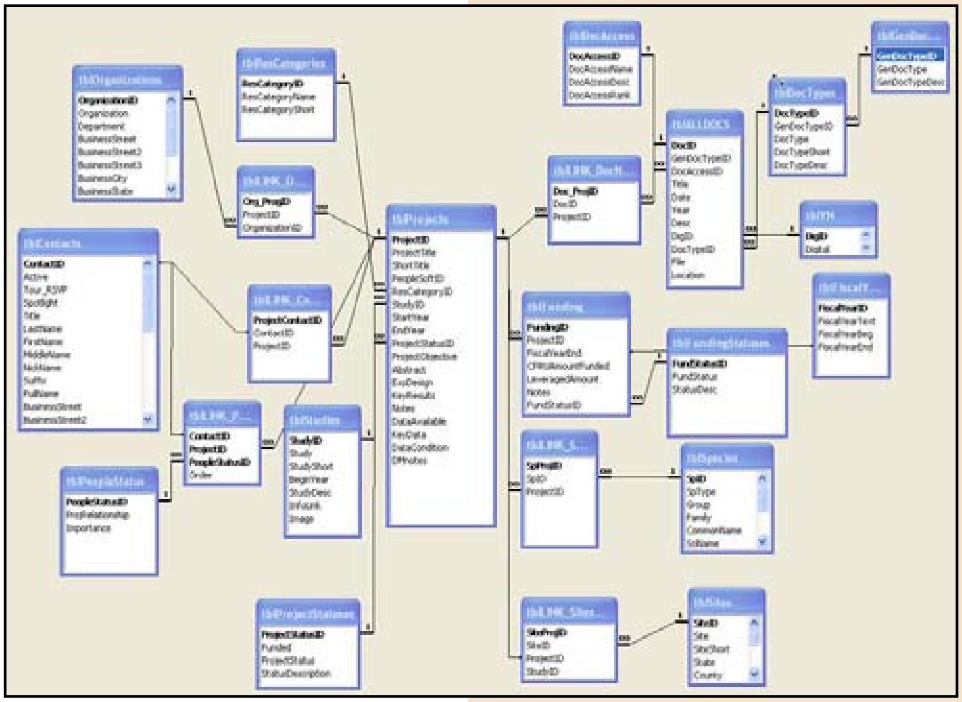

Figure 19. A relational database management system was developed for the CFRU Projects Database because of the complex relationships existing among all CFRU research projects.

each project they are associated with. The RDMS provides a means to relate this information. A well-developed RDMS has the capability to relate different types and levels of data under a single framework. The RDMS was designed and datasets were managed in a manner in accordance with general guidelines for ecological data (Borer et al. 2009). The CFRU PDB can be easily updated and provides a user-friendly interface between archived data and the user.

All project metadata were entered into the CFRU PDB. Supporting documents that contained important project information were also linked to each project. These documents include publications (e.g., Annual Reports, peer-reviewed articles), CFRU internal documents (e.g., project proposals and digitized presentations), and data files (e.g., a MS Excel file containing field measurements and scanned datasheets). Seven hundred and thirty-four documents were included and linked to each research project, and on average, six documents were associated with each identified research project. In total, 2.4GB of information was centrally archived and referenced in the CFRU PDB.

The CFRU PDB serves as a clearinghouse for all historical CFRU project information in addition to a tool for retrieving desired information (Figure 20). Given the breadth of research topics and large volume of projects investigated, included in the PDB is the ability to search the database according to parameters that are specific to CFRU research. A summary page exists for each CFRU project, whereupon complete metadata are described and hyperlinks allow the user to open associated documents directly from the PDB. This information can be used by CFRU Scientists, Cooperators, and the public seeking information regarding past CFRU research, or as a primer for using past research results to address new research questions.

Now that a system is in place for managing project information, the CFRU PDB can be easily updated as new projects progress and new research results emerge. With input from principal investigators, metadata will be entered and appropriate documents linked to the project of interest. The CFRU PDB, in its current MS Access format, works in harmony with other database management systems, commonly-used spreadsheet programs, and statistical analysis programs. With regard to evolving technologies, the database will remain in pace with current software standards used by researchers and cooperators in order to ensure a product that can be effectively used.

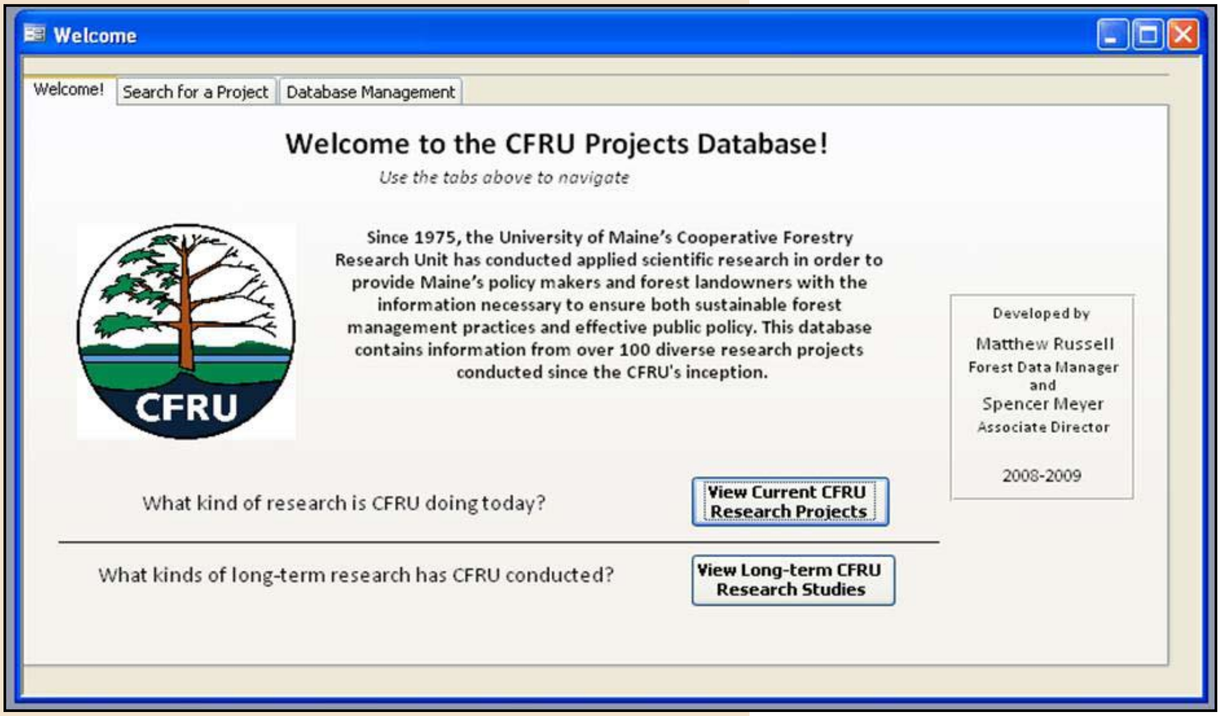

Figure 20. The CFRU Projects Database serves as a clearinghouse for all historical CFRU project information in addition to a tool for retrieving desired information.

CONCLUSIONS

Information gathered throughout the *30 Years* project makes available a historical account of CFRU research, while additionally providing value-added research. Serving as the primary record of baseline information, data collected from past projects can be revisited to address future scientific inquiries, which will reduce the cost and labor associated with collecting new data. Datasets that were previously collected and analyzed have numerous future opportunities, such as forecasting the trends of Maine's forests and for use in modeling efforts to predict forest growth and yield.

Identifying projects and compiling and archiving data establishes the structure for a long-term system for accessing past and current CFRU information. A foundation is in place for which future systems, such as web-based user interfaces, can be developed for retrieving CFRU data and records.

A database containing metadata (project-level) and measurement data (experiment-level) increases the accessibility of CFRU research. CFRU Scientists can utilize the database for investigating past data collected, while Cooperators and the general public may utilize the database for searching for past CFRU research results. In order to continue to address the research questions asked from Maine's forests, this centralized database provides a tool that brings to the forefront the lasting research of the CFRU.

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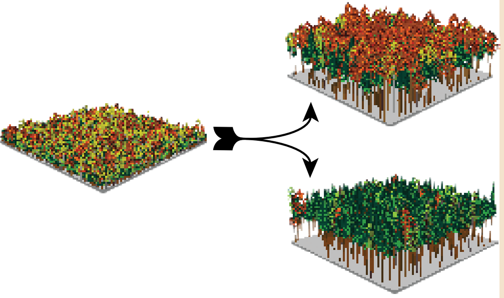
For more information about this project, please contact Spencer Meyer.



Refinement of the Forest Vegetation Simulator, Northeastern Variant Growth and Yield Model

Phase 1

Authors

Aaron R. Weiskittel
Robert G. Wagner
Robert S. Seymour

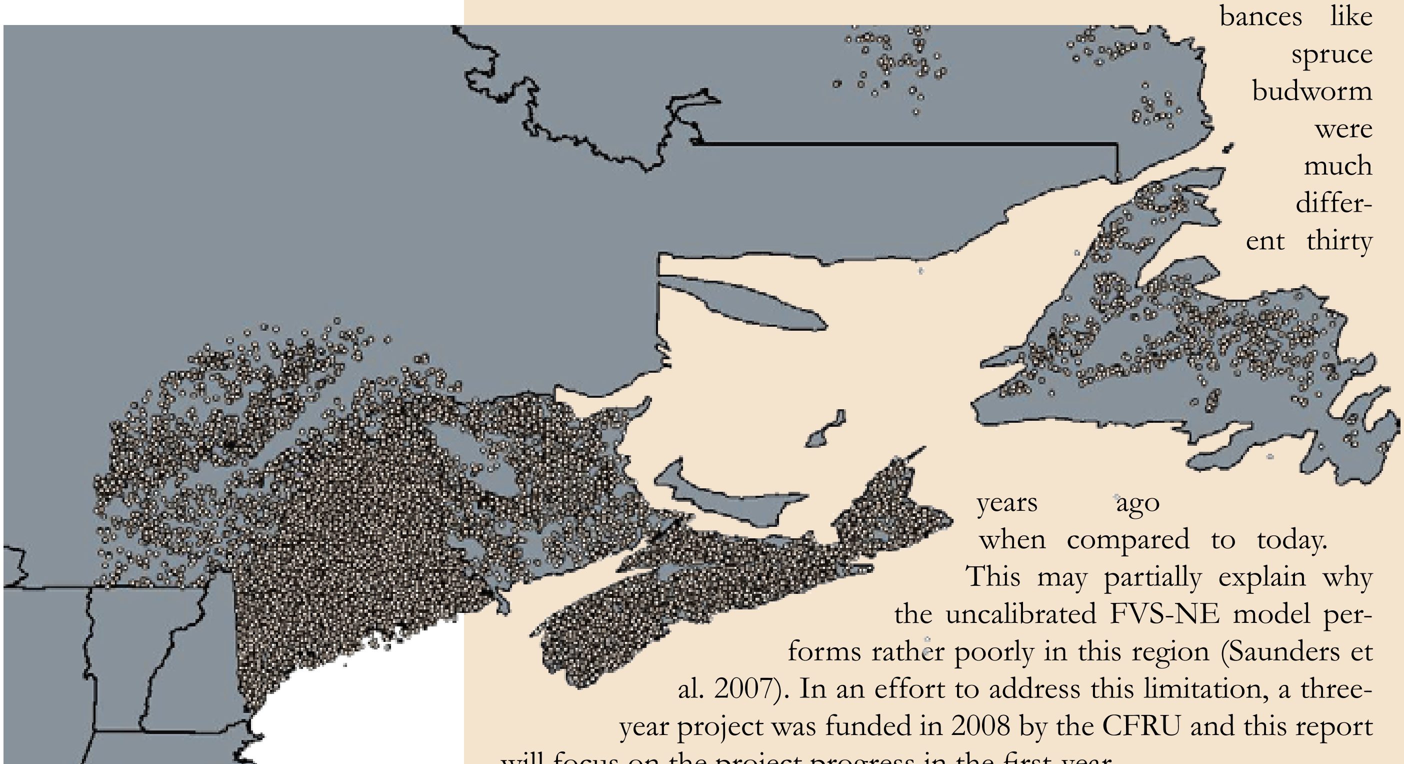
Center for Advanced Forestry Systems

This CFRU project represents the first of many exciting projects spearheaded under a new partnership between the University of Maine and other research universities across the United States. This partnership, the National Science Foudnation sponsored, Center for Advanced Forestry Systems (CAFS) brings together industry representatives and researchers with interests in all aspects of applied forest management to solve some of the toughest problems facing forest managers around the coutnry. Read more about this exciting new program in the CAFS overview section on page 14.

INTRODUCTION

The accuracy of regional empirical growth and yield models like the Forest Vegetation Simulator (FVS) relies on the quality and extent of the data used to parameterized them. The Northeastern variant (NE) of FVS covers a broad geographic area and was parameterized with a historical dataset consisting primarily of US Forest Service Forest and Inventory Analysis (FIA) plots measured between 1960 and 1980 (Teck and Hilt, 1991). Although FIA data from Maine comprised a significant portion of the original dataset, management practices and the role of disturbances like spruce budworm were much different thirty years ago when compared to today. This may partially explain why the uncalibrated FVS-NE model performs rather poorly in this region (Saunders et al. 2007). In an effort to address this limitation, a three-year project was funded in 2008 by the CFRU and this report will focus on the project progress in the first-year.

Figure 21. Location of plots in the database.



Source	Owner	Number of Observa-tions	Years of Measure-ments	Geographic Region	% of Observa-tions With Height Measurements	# of Remeasure-ments
Acadian Forest Ecosystem Research Program	University of Maine	31850	1995-2007	Central Maine	0	8
Austin Pond	CFRU	10267	1999	Central Maine	26	0
Bartlett Experimental Forest	US Forest Service	34876	1964-2000	Central New Hampshire	9	11
Commercial Thinning Research Network	CFRU	85388	2000-2007	Northern Maine	46	8
Fiber	US Forest Service	250712	1955-1985	Maine & New Hampshire	0	3 to 6
Forest Inventory and Analysis	US Forest Service	303150	1958-2005	Maine	56	2 to 6
Holt Experimental Forest	University of Maine	2912	1984-2005	Southern Maine	100	2
Maine Forest Service	Maine Forest Service	13898	2001-2003	Maine	99	1
McCormack Thinning Study	CFRU	1773	1978-1994	Northern Maine	100	6
New Brunswick Permanent Sample Points	New Bruswick Department of Natural Resources	502847	1985-2005	New Brunswick	72	3 to 6
Newfoundland Permanent Sample Points	Newfoundland Department of Natural Resources	502847	1985-2008	Newfoundland	75	3 to 6
Nova Scotia Permanent Sample Points	Nova Scotia Department of Natural Resources	369302	1965-2006	Nova Scotia	81	3 to 6
Penobscot Experimental Forest	US Forest Service	171313	1974-2006	Central Maine	8	4
Québec Permanent Sample Points	Québec Minsitry of Forests	323821	1970-2008	Québec	19	4 to 8
Spruce Budworm Growth Impact Study	CFRU	73056	1975-1985	Northern Maine	100	10

Table 10. Attributes of the datasets obtained.

Species	DBH (inches)					HT (feet)				
	N	Mean	StDev	Min	Max	N	Mean	StDev	Min	Max
Balsam fir	958162	4.4	2.5	0.8	37.0	518947	28.60	13.97	0.33	95.12
Black spruce	339278	4.2	2.3	0.2	39.0	224090	25.63	13.32	0.33	99.97
Red spruce	303937	6.2	3.1	1.1	46.7	213586	38.64	13.13	1.97	115.97
Red maple	259252	5.8	3.2	1.1	32.3	149397	42.10	12.55	0.33	99.06
Paper birch	161343	5.1	3.0	0.2	28.3	84504	36.89	15.87	0.33	99.06
Sugar maple	118852	6.6	3.8	1.3	41.8	55153	47.28	12.72	1.80	111.22
White spruce	102486	6.3	3.1	6.0	27.1	74184	35.03	13.80	1.97	98.97
Northern white cedar	99653	6.6	3.3	11.0	39.3	36999	35.82	9.55	4.00	96.98
Yellow birch	76809	6.7	4.2	2.2	38.6	37609	42.74	12.69	3.28	103.32
Eastern hemlock	70420	6.9	4.7	0.5	34.9	21932	40.69	13.78	4.89	102.34
American beech	65334	6.4	3.4	0.1	26.3	27133	40.48	13.47	4.00	103.39
White pine	48054	8.2	5.3	5.4	43.6	25638	45.65	17.67	1.97	127.97
Quaking aspen	26214	6.7	3.3	2.1	26.6	9642	47.71	17.74	1.97	111.19

Table 11. Individual tree attributes for the top 15 species in the database.

The primary objectives of the project's first-year were to: (1) obtain regional long-term growth and yield datasets; (2) compile datasets into a unified relational database; (3) clean the data; and (4) begin preliminary analysis.

METHODS

Permanent growth and yield datasets were obtained from a variety of sources (Table 10). The primary sources included the CFRU, several Canadian provincial government agencies, the Maine Forest Service, and the US Forest Service. The data were converted to metric, species designated with standard FIA numeric codes, and compiled into a Microsoft Access 2007 database. Plot coordinates and physiographic information (slope, aspect, elevation) was obtained when available. Three relational tables were constructed, namely tree-, plot-, and stand-level data. The tree-level data consisted of species diameter at breast height (DBH), total tree height (HT), height to crown base (HCB), and an expansion factor. Plot-level data were estimated from the tree-level data and included stem density, total basal area, quadratic mean diameter, stand density index, and average breast-height age (when available). Stand-level data consisted of latitude, longitude, elevation, slope, aspect, and soils information (when available). Climactic data for each plot was obtained from the US Forest Service Rocky Mountain Research Station (http://forest.moscowfsl.wsu.edu/climate/).

Species	Root mean square error (m)		% bias		Parameter Estimates		
	FVS-NE	This Study	FVS-NE	This Study	a_0	a_1	a_2
American beech	3.54	3.52	28.00	27.68	16.233	0.084	0.982
Balsam Fir	3.18	2.52	31.28	24.79	13.205	0.105	1.555
Black spruce	2.46	1.85	24.87	18.71	14.997	0.068	1.192
Eastern hemlock	3.60	2.73	27.43	20.74	18.909	0.048	1.097
Gray birch	2.29	2.20	21.71	20.82	12.056	0.141	1.192
Paper birch	3.33	2.52	25.90	19.55	16.269	0.079	0.943
Red maple	3.25	2.88	24.63	21.86	17.553	0.079	1.037
Red oak	4.54	3.82	32.15	27.01	16.233	0.083	0.982
Red spruce	2.68	2.15	22.70	18.28	17.618	0.053	1.127
Sugar maple	2.80	2.44	19.05	16.65	19.259	0.066	0.954
White pine	4.04	3.11	28.02	21.57	18.942	0.046	1.087
White spruce	3.35	2.23	30.20	20.09	15.581	0.066	1.326
Yellow birch	4.29	2.94	31.85	21.85	17.016	0.080	1.032

Table 12. Bias and parameter estimates for the Forest Vegetation Simulator Northeastern Variant (FVS-NE) and Chapman-Richards total tree height to diameter at breast height equation for the primary species in the database.

Preliminary analysis consisted of fitting regional individual tree HT-DBH allometric equations by species. FVS-NE biases were computed and compared to several model forms. The final model form selected was a Chapman-Richards equation:

$$[1] \qquad HT = 1.37 + a_0[1 - \exp(-a_1 DBH)]^{a2}$$

where HT is in m, DBH is in cm, and a_0, a_1, and a_2 are species-specific parameters estimated from the data.

RESULTS

The plots covered a broad geographic distribution (Figure 21). The database contains data for 66 different species. Over 2.9 and nearly 1.6 million observations of DBH and HT were obtained with over 33% of the data being balsam fir (Table 11). The plots covered a range a range of stand conditions as the quadratic mean diameter ranged from 0.04 to 23.6 inches. Over 75% of the data did not have a measure of age.

Preliminary analysis of the FVS-NE equations revealed a significant bias in its HT-DBH equations as the percent bias ranged from 32 to 19% (Table 12). The Chapman-Richards equation fit well for most species and provided much better predictions as the root mean square was reduced by 19%, on average, when compared to the FVS-NE equation.

DISCUSSION

An extensive and well-documented relational individual tree growth and yield database was successfully constructed in the first-year of this project. The database covers the vast range of conditions that are characteristic of the Acadian Region and should provide a solid foundation for constructing a state of the art individual tree growth and yield model for the region. Most importantly, the database covers the extremes in the region, which ensures the development of robust model forms that can extrapolate reasonably well. The database also contains a range of long-term silvicultural experiments that will prove invaluable for assessing the model's performance in predicting response to management activities.

However, the database is not without some important limitations. Although not surprising, the most critical limitation is the relative lack of stand age information. This will limit the analysis to alternative measures of site productivity as site index estimates will not be available. Some measures that will be evaluated include mean climatic information, depth to the water table, and various transformations of the physiographic variables. The drawback to this approach is that the plot location information is often relatively coarse or intentionally fuzzed, which may limit the strength of the relationships.

Allometric equations like HT-DBH are important to growth and yield models as they are used to fill in missing tree heights and sometimes estimate height growth. Preliminary analysis of the data indicated significant biases in the FVS-NE predictions of HT. Furthermore, the model forms used by FVS-NE were inferior to the Chapman-Richards formulations utilized in this analysis, particularly at the upper end of predicted HT. This might explain why Saunders et al. (2007) was unable to correct the FVS-NE predictions of dominant height.

The next phase of the project will focus on the continued development of allometric and growth equations. The HT-DBH equations will be finalized by incorporating additional stand-level information and obtaining parameter estimates for minor species. Equations to predict tree-level height to crown base will also be developed for each species. Once missing heights and height to crown bases can be predicted, individual tree diameter and height increment equations will be constructed for each species. The final phase of the project will consist of evaluating the performance of the equations over a range of silvicultural treatments and developing appropriate equations to adjust their behavior as necessary.

For more information about this project, please contact Aaron Weiskittel.

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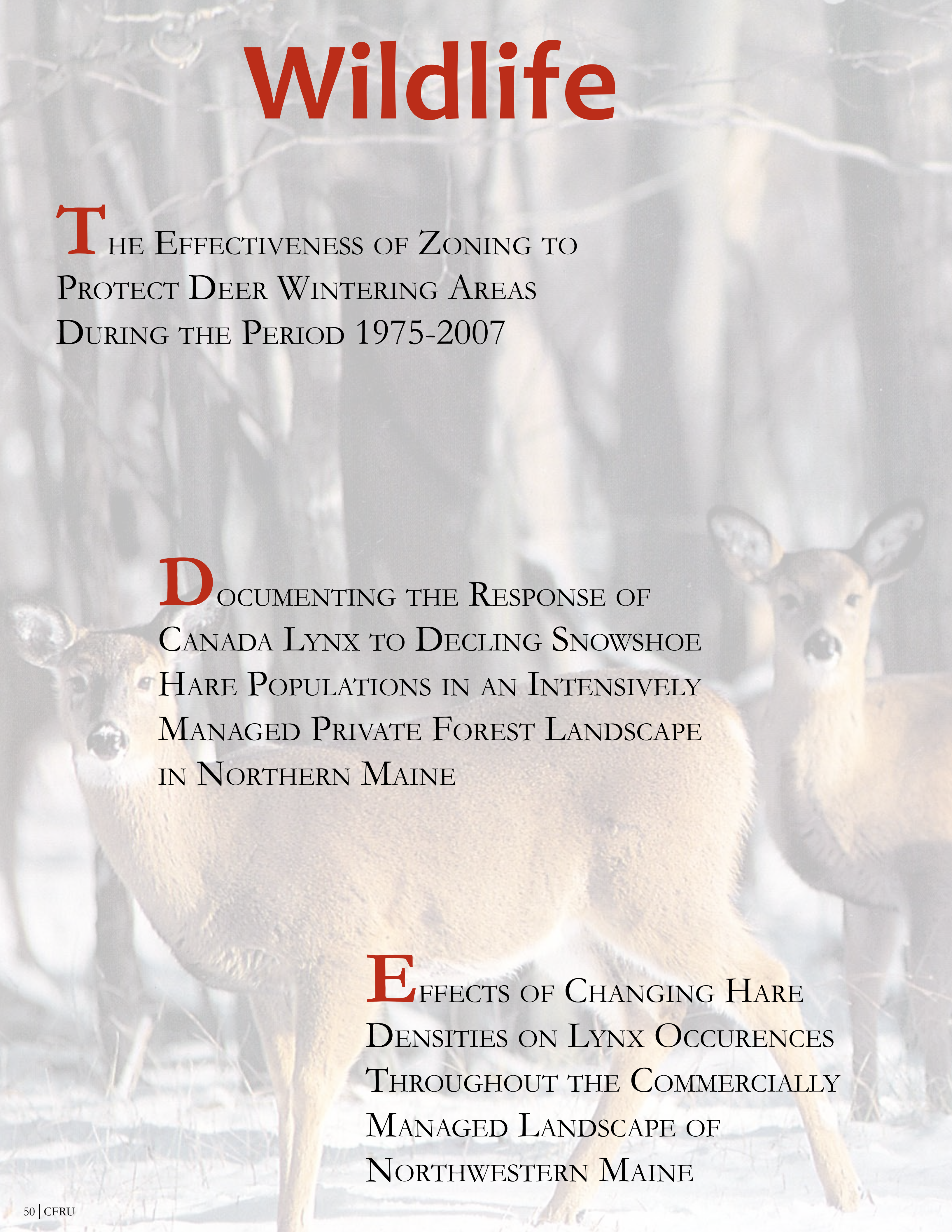
CFRU



Wildlife

The Effectiveness of Zoning to Protect Deer Wintering Areas During the Period 1975-2007

Documenting the Response of Canada Lynx to Decling Snowshoe Hare Populations in an Intensively Managed Private Forest Landscape in Northern Maine

Effects of Changing Hare Densities on Lynx Occurences Throughout the Commercially Managed Landscape of Northwestern Maine

The Effectiveness of Zoning to Protect Deer Wintering Areas During the Period 1975-2007

Does Compromising Forest Productivity to Protect Deer Habitat Achieve Desired Ecological Objectives?

Authors

Erin Simons
Daniel J. Harrison
Kasey Legaard
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INTRODUCTION

Deer Wintering Areas (DWAs) provide an important component of habitat quality for white-tailed deer near the northern extent of the species' geographic range and a unique challenge for habitat management. White-tailed deer require wintering habitat when snow conditions restrict mobility (Parker et al. 1984) and access to preferred forage (Dumont et al. 1998, Dumont 2005). For white-tailed deer populations in the northeastern U.S. and Canada, stands of mature conifer forest are a key component of deer wintering habitat, providing critical shelter from wind and snow (Verme 1973, Moen 1976, Potvin and Huot 1983, Lishawa et al. 2007). Loss of quality deer wintering habitat has been identified as the major limiting factor preventing efforts to increase the size of the deer herd in northern and eastern Maine. The Maine Department of Inland Fisheries and Wildlife (MDIFW) has estimated that quality deer wintering habitat in these areas has declined from approximately 10% to <5% since the early 1970s. Factors contributing to this decline include reduction in conifer forests after the most recent spruce budworm epidemic, increased harvesting of softwood forests, and senescence of balsam fir stands (MDIFW 2007). To ensure sufficient wintering habitat to support desired populations goals for deer management in northern and western Maine, MDIFW has proposed to substantially increase zoning for DWAs. Such changes could have a substantial influence on the productivity of Maine's forest via reduced harvests of fiber from mature softwood stands.

Application of existing laws has resulted in the past zoning of approximately 70,000 acres of DWAs on commercial forestlands through the Land Use Regulation Commission (LURC) process of defining wildlife protection subdistricts (P-FW, Dept. of Conservation, Maine LURC 1997, LURC statute TITLE 12, M.R.S.A., Chapter 206-A LAND USE REGULATION, Chapter 10 Land Use Districts and Standards defines Fish and Wildlife Protection Subdistricts). MDIFW has a long-term objective to increase zoning for white-tailed deer management to 8-10% of the land base in northern and western Maine (by 2030 or sooner) (MDIFW 2007). The potential economic impacts of additional acreage in DWAs include loss in market value of timberland, reduction in annual stumpage income to landowners, and a reduction in the number

"Harvesting was widespread 1975-1991, with 60% of DWAs receiving a heavy harvest by 1991, which was coincident with much of the salvage harvesting that occurred in response to the spruce budworm outbreak of the 1970s and 1980s."

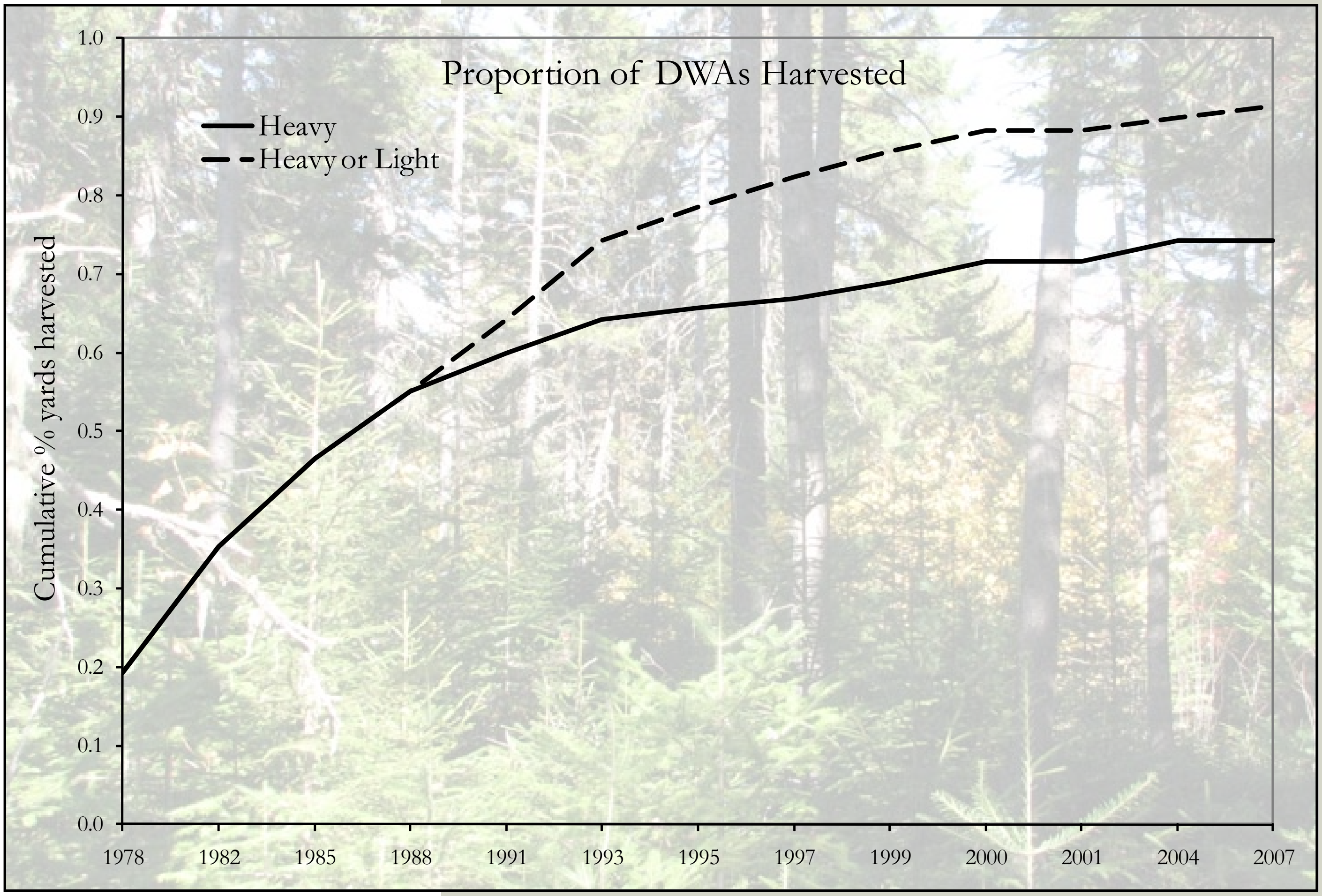

Figure 22. Cumulative proportion of deeryards that received a timber harvest, 1978-2007, for 187 zoned deeryards on managed forestland in northern and western Maine. Trends are shown for heavy harvests (unbroken line) and heavy and light harvests combined (dashed line). *(Spencer Meyer photo)*

of jobs statewide. With the potential for significant economic losses to landowners associated with expanded zoning and the apparent failure of past zoning to prevent population declines in northern and eastern Maine, a comprehensive evaluation of the current condition of existing zoned DWAs was needed to evaluate if past compromises in softwood productivity from Maine's forests have achieved ecological objectives for deer management and to determine if increased zoning is a cost-effective and ecologically viable option for managing deer populations into the future.

Ecological objectives associated with DWAs should also extend beyond deer management and be based on how well DWAs function as a coarse-scale biodiversity tool. Landscape conservation planning requires that the habitat needs of all wildlife species are accommodated to avoid species loss and to maintain a viable distribution of organisms. The *umbrella species* concept has been proposed as a tool for simplifying biodiversity conservation by focusing on protecting the minimum habitat requirements of species that represent numerous co-occurring species in the region (Murphy and Wilcox 1986, Noss 1990). This coarse-filter approach can account for habitat requisites needed to maintain viable population sizes of other forest-dependent species. Umbrella species are typically chosen based on a narrow habitat association (e.g., late successional specialist), sensitivity to habitat area (Caro and O'Doherty 1999, Roberge and Angelstam 2004), or sensitivity to landscape composition and configuration. The spatial scale at which deer wintering yards function exceeds that of ongoing approaches to landscape planning in Maine using umbrella species (e.gl, American marten and Canada lynx). Further, protection by LURC zoning is limited to the area within a

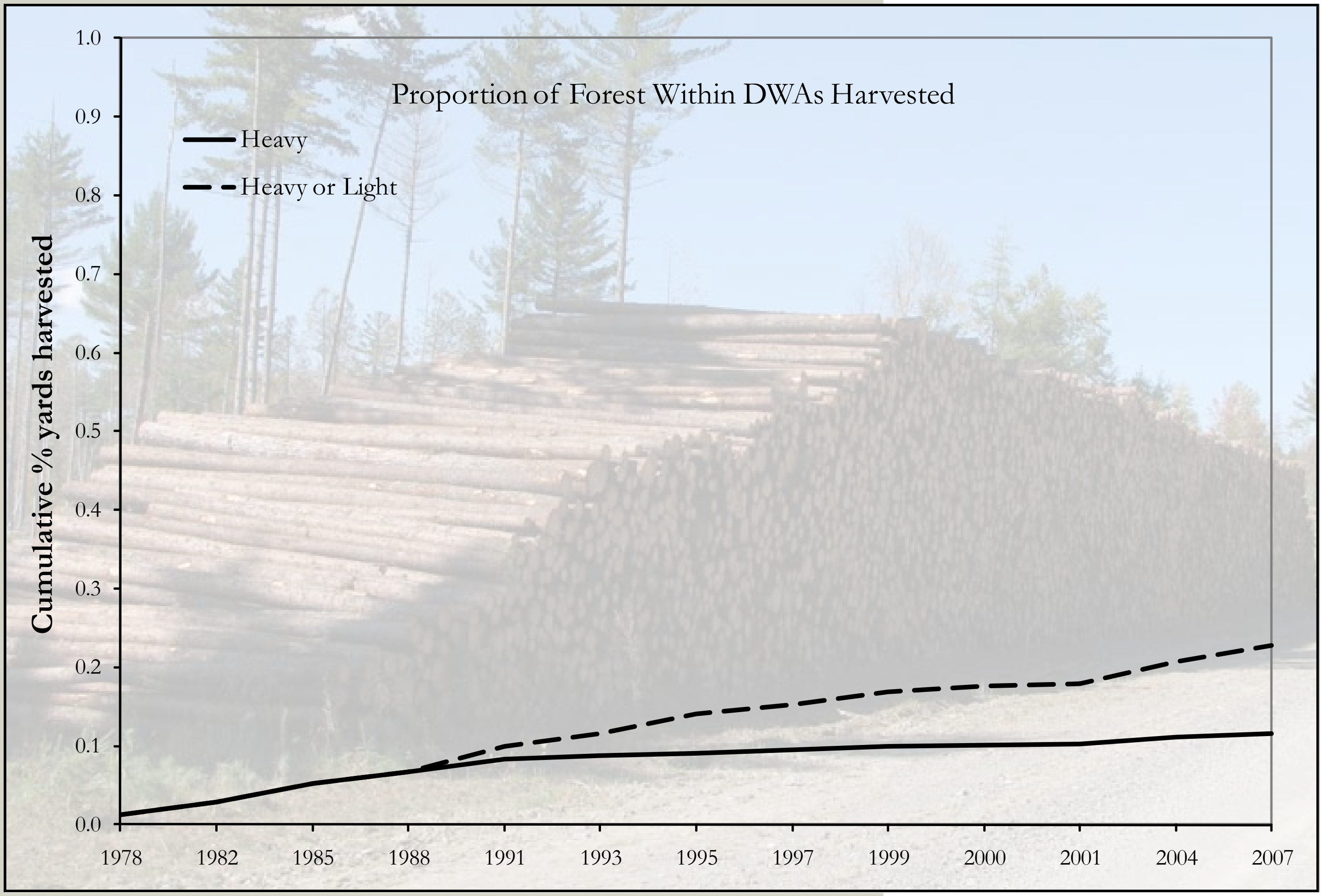

Figure 23. Cumulative proportion of forest within deeryards affected by timber harvesting, 1978-2007, for 187 zoned deeryards on managed forestland in northern and western Maine. Trends are shown for heavy harvests (unbroken line) and heavy and light harvests combined (dashed line). *(Spencer Meyer photo)*

DWA currently providing critical shelter where deer use can be readily documented. Thus, most zoned DWAs are likely smaller than the actual area used by deer in winter and preliminary indications suggest that the size, shape and configuration of existing zoned DWAs could cause them to function poorly for other mature forest associated species and thus, DWAs could be ineffective for conserving other forest-dependent wildlife.

An analysis of habitat change and degree of fragmentation of deer wintering habitats is critical to evaluating the effectiveness of zoned DWAs. Habitat loss and fragmentation are often considered the primary threats to biological diversity (Wilcox and Murphy 1985, Fahrig 1997) as these processes can lead to reductions in population size, increased isolation of populations, and decreased colonization (Lawton 1995). The goal of our project is to evaluate how well 58,560 ac (25,245 ha) of previously zoned DWAs on commercial forestlands have functioned in protecting deer wintering habitat during the period 1975-2007. Understanding the extent and scale at which habitat changes have influenced DWAs is informative, but also can enable and focus future research to better understand current patterns in use and nonuse among yards. The objectives of this project are to:

1) Document the extent and rate of habitat change within LURC-zoned Deer Wintering Areas (DWAs) during the period 1975-2007.

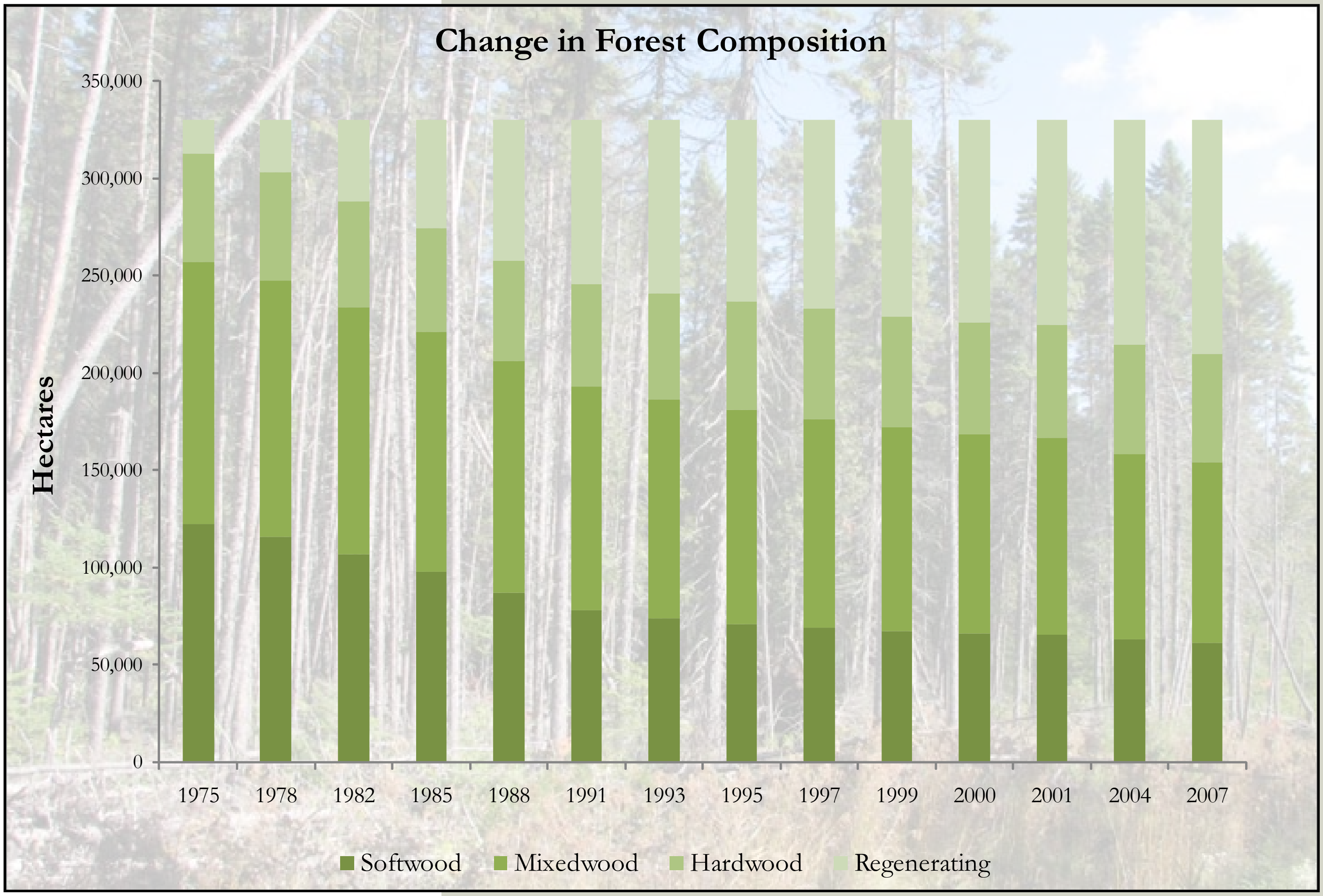

Figure 24. Change in composition of forested area, 1975-2007, within 187 zoned deeryards on managed forestland in northern and western Maine, including mature forest types (softwood, mixed, hardwood) and regenerating forest. *(Spencer Meyer photo)*

2) Evaluate changes in landscape composition, connectivity, and fragmentation within buffers around DWAs to inform current policy and future research.

3) Simulate the effects of increased zoning restrictions to meet the MDIFW objective of 8-10% of the land base in zoned yards and evaluate potential losses in forest productivity.

4) Evaluate how well DWAs function as a coarse-filter for biodiversity conservation.

SUMMARY OF PROGRESS IN YEAR 1

In the first year we documented the extent and rate of change in 58,560 ac of LURC-zoned DWAs in northern Maine. To identify habitat changes we used a previously developed harvest detection time series (Legaard et al., Maine Image Analysis Laboratory, University of Maine, *In preparation*) that captures forest change (1975-2007) at 1-4 year intervals across ~4 million acres of commercial forestland in northern Maine. Timber harvests within this area were identified and mapped using established change detection methods based on Landsat satellite imagery (e.g., Sader and Winne 1992, Sader et al. 2003). With these data we were able to evaluate the magnitude and temporal pattern of biomass loss caused by timber harvesting activities. We also quantified the effects of timber harvesting on the proportion of mature forest (conifer, deciduous, and mixed-wood) and regenerating forest within DWAs and the change in composition of forest within DWAs during the period 1975-2007. We have documented the extent and rate of habitat change within zoned deer yards, which we are using to assess the effectiveness of DWAs for ensuring continued use by deer and to evaluate whether past tradeoffs in forest harvests have resulted in the maintenance of quality deer wintering habitat.

PRELIMINARY RESULTS

Our analysis included a total of 187 LURC-zoned DWAs. Zoned DWAs within our study area ranged in size from 0.03 km^2 (7.4 ac) to 16.3 km^2 (4027.8 ac), with the majority (185/187) less than 0.07 km^2 (17 ac). Harvesting was widespread 1975-1991, with 60% of DWAs receiving a heavy harvest by 1991 (Figure 22), which was coincident with much of the salvage harvesting that occurred in response to the spruce budworm outbreak of the 1970s and 1980s. Almost all DWAs (91%; Figure 22) received some form of harvest 1975-2007; however, only 23% of the forest area was affected (Figure 23). The effect of harvesting within DWAs on forest composition was not insignificant (Figure 24). Regenerating forest within DWAs increased a dramatic 455% 1975-2007, while mature softwood and mature mixed-wood declined by 15% and 8% respectively. Mature hardwood forest increased 2% 1975-2007.

PLANS FOR 2010

In Year 2 we will document the extent and rate of change within buffers around the zoned DWAs to evaluate the potential influences of habitat loss and fragmentation on deer wintering habitat in the larger landscape. Deer often select areas of high use based on the characteristics of surrounding stands; therefore habitat decisions are not based solely on the characteristics of the stand (Morrison et al. 2002). Thus, spatial arrangement of stands around deer yards is particularly important to their effectiveness in promoting and maintaining use by wintering deer. We will also calculate landscape metrics that allow us to capture biologically meaningful changes in the mature softwood patches that comprise a critical component of deer wintering habitat. We will also simulate the effects of increased zoning restrictions to meet the MDIFW objective of 8-10% of the land base in zoned yards and estimate potential losses in volume of fiber harvested. Finally, we will evaluate how well DWAs function as a coarse filter for biodiversity conservation by evaluating the percent of vertebrate species in Maine whose habitat needs are met by using DWA habitat. This analysis will be based on vertebrate species distributions from the Maine GAP Analysis Project (Boone and Krohn 1998ab) for 1) forest generalist species, 2) forest deciduous specialist species, and 3) forest conifer specialist species and will allow us to identify those species that would be disproproportionately or proportionately benefited by application of conservation planning based on habitat for white-tailed deer.

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For more information about this project, please contact Dan Harrison.

Documenting the Response of Canada Lynx to Declining Snowshoe Hare Populations in an Intensively Managed Private Forest Landscape in Northern Maine

Authors

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Angela Fuller
David Mallett
Scott McLellan
Walter Jakubas
John Organ

Photographs in this project report are compliments of Maine Inland Fisheries and Wildlife.

SUMMARY OF PROGRESS

The goal of this study is to document lynx spatial ecology, habitat preferences, and population demography during a period of low snowshoe hare abundance for comparisons to similar data collected when snowshoe hares were more abundant. In 2008, we transitioned from a study that monitored lynx using VHF telemetry collars to a study using GPS collars. Our activities in 2009 were focused on recovering data from 13 (nine males and four females) GPS collars deployed on lynx in 2008 and maintaining a sample of lynx equipped with GPS collars. Scott McLellan led a 70-day winter field effort and Lisa Bates led a 63-day fall field effort that involved a 6- and 4-person field crew, respectively. In 2009, we captured 14 new lynx (seven males and seven females) and equipped 10 lynx (five males and five females) with GPS collars and four (two males and twp females) with satellite collars. In addition, three previously collared lynx had their VHF or satellite collars replaced with GPS collars and a female lynx that was no longer wearing a collar was recaptured and equipped with a new GPS collar. Throughout 2009, we monitored 35 different lynx including 27 lynx with GPS collars. Maine Warden Service pilots monitored each radio-collared lynx to document mortality (i.e., when an animal is inactive the radio signal pulse rate changes). During this report period, five adult males and three adult females died; five were killed by predators, one died of starvation, and two died of unknown causes. During the winter of 2009, we tracked four radio-collared adult female lynx to determine if they had kittens (i.e., observed tracks of kittens with the adult female in the snow); none were observed with kittens. In the spring, we monitored radio-collared adult female lynx and determined that none initiated denning behavior. At the end of October, we were monitoring 25 lynx (14 males and 11 females) including 19 lynx equipped with GPS collars, although one GPS collar is not emitting a signal. This past winter and fall, we recovered data from 13 GPS collars.

PROJECT OVERVIEW

In 2000, Canada lynx (*Lynx canadensis*) were listed as federally threatened species in 14 conterminous United States including four eastern states (Maine, New Hampshire, Vermont, and New York). Maine has the only documented lynx population in the east. The United States

"It is imperative that lynx population demographics and associated habitat use be studied at both high and low hare densities to establish realistic recovery objectives and effective management efforts for lynx in the northeast. "

Field biologists assess the health of an adult lynx in northern Maine.

Endangered Species Act requires that critical habitat be designated and a recovery plan be established to facilitate conservation efforts and ultimate recovery of a listed species. With the recent designation of critical habitat for lynx, including 10,000 square miles in Maine, the United States Fish and Wildlife Service (USFWS) will finalize a recovery plan for lynx. This plan will identify the management actions needed to recover the lynx population, criteria for measuring the recovery rate, and warrants to remove lynx from the federal list of threatened species.

Current information on lynx habitat use and requirements in Maine is based on a radio telemetry study conducted during a period of high snowshoe hare and lynx abundance (Vashon et al. 2008 a and b, Fuller et al. 2007). Recently, lynx reproductive rates and snowshoe hare densities have declined on our study sites in Maine. Current models indicate that a 20% change in hare densities can have a dramatic impact on the long-term viability of some lynx populations (Steury and Murray 2003). The decline in hare densities in northern Maine provides an opportunity to study how hare densities influence lynx population demographics and population viability in the northeast. Specifically, will lynx persist at lower hare densities or are higher hare densities needed to sustain lynx in Maine? It is imperative that lynx population demographics and associated habitat use be studied at both high and low hare densities to establish realistic recovery objectives and effective management efforts for lynx in the northeast.

In 2007, the University of Maine (UMaine), Maine Department of Inland Fisheries and Wildlife (MDIFW), and the USFWS initiated a cooperative study to assess the variability in lynx population demographics and possible threshold densities of hares needed to support lynx in Maine. This study continues the ongoing lynx telemetry efforts in northern Maine, but with the benefit of using GPS technology. Support from the Cooperative Forest Research Unit and its members provided the matching funds that leveraged an additional $90,000 in federal grants for our field efforts in 2009.

PRIMARY ACTIVITIES IN 2009

In 2009, our capture efforts were initiated to increase our sample to 20 lynx monitored with GPS collars, download data from previously deployed GPS collars, recapture a female lynx whose GPS collar deployed prematurely, and perform maintenance on previously deployed collars. From January 21st to April 1st, a 6-person field crew set cage traps to capture lynx and conducted track surveys to document the presence of kittens in the Musquacook study area. Beginning on August 19th, a 4-person field crew set foot-hold traps for lynx and counted snowshoe hare fecal pellets on the study area. We equipped lynx captured in traps with GPS or satellite collars that were programmed to obtain between one (Lotek GPS collars) and four locations (Sirtrack GPS collars) per day or a location every other day (satellite collars) to document lynx movements, home-range size, and habitat use patterns. In addition, each collar was equipped with a mortality sensor. Warden pilots monitored the collar for a mortality signal once a week during the winter, once a month during the spring and summer, and twice a month during the fall. We investigated each mortality site and performed necropsies to determine the cause of death. During the winter, we documented the presence of kittens by tracking, on foot, each radio-collared adult female and counting the number of kitten tracks. Beginning in May, all radio-collared female lynx were located at least twice per week to document den initiation and the production of kittens.

PRELIMINARY RESULTS

Capture Effort

In 2009, we captured 23 different lynx (14 males, nine females) 58 times, including 14 new lynx (seven males and seven females). Six new lynx (five males and one female) and nine previously collared lynx (eight males, one female) were captured during the winter, eight new lynx (two males and six females) and three previously collared male lynx were captured during the fall, and two previously collared female lynx were captured during a one week spring trapping effort. We also released a male lynx with a GPS collar in January after he had fully recovered from a broken leg (see 2008 Annual Report). We replaced VHF (n=1) and satellite (n=2) collars on previously collared lynx that were recaptured during 2009 field efforts. We also recaptured a female lynx that was no longer wearing a GPS collar and equipped her with a new GPS collar. During winter, spring, and fall capture efforts, we equipped 15 lynx with GPS collars (10 new captures and five previous captures) and four new lynx with satellite collars. Because satellite collars collect less accurate data than GPS collars, we only equipped adult lynx with satellite collars after all functioning GPS collars have been deployed. In 2009, we recovered data from 13 GPS collars including 10 during the winter and three during the fall.

Telemetry Monitoring

When we initiated our capture efforts in 2009, 15 radio-collared lynx (12 males and three females) were being monitored, including 12 lynx equipped with GPS collars. Throughout 2009, we monitored 35 radio-collared lynx (21 males and 14 females) including 27 lynx wearing GPS collars. Two GPS collars released prematurely and eight lynx died. By November 1, 2009, we were monitoring 25 lynx (14 males and 11 females) including 19 equipped with a GPS collar (10 males, nine females), five lynx equipped with a satellite collar (three male and two females), and one male equipped with a VHF collar (outside the study area).

During the summer and fall of 2009 David Mallett, the UM graduate research assistant for this study, started field efforts to determine locational error and fix success of GPS collars in different habitats. This effort will determine whether GPS collars can accurately assess lynx habitat use.

Snow Track Surveys and Hare Monitoring

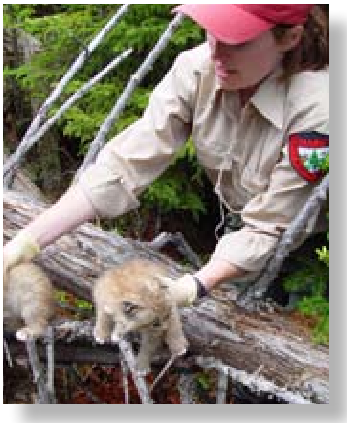
During the winter of 2009, we backtracked four radio-collared female lynx; none were observed with kittens including two females caught for the first time this winter. Snowshoe hare fecal pellets were counted in May and September at 16 sites. These counts will be used to document trends in snowshoe hare abundance in our study area.

Den Site Visits

By the spring of 2009, we had monitored 17 lynx, including four adult females. Despite a small sample size, this year marked the fourth year of low production and second year when none of the females produced a litter.

Plans for 2010

Throughout the year, we will continue to monitor radio-collared lynx to document mortalities. During the winter, we will continue our capture efforts to recover GPS locational data from 19 GPS collars and maintain a sample of collared females to document reproductive rates in the spring. This winter, we will also track radio-collared female lynx (currently 11 females are being monitored) and any female lynx captured this winter to determine if they are traveling with kittens. In the spring, we will count snowshoe hare fecal pellets at 16 sites and monitor radio-collared female lynx to document reproduction.



For more information about this project, please contact Jennifer Vashon.

David Mallett will continue with his course work at the University of Maine, count snowshoe hare pellet on the University of Maine long-term study plots, and assist with the winter lynx trapping efforts, as well as, backtracking of females to determine presence of kittens during the winter of 2010. He will also test location error and fix success of GPS collars during the leaf off season (late fall and winter 2009/2010). This summer and fall, he will analyze data and prepare his thesis.

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Effects of Changing Hare Densities on Lynx Occurences Throughout the Commercially Managed Landscape of Northwestern Maine

Authors

Shonene Scott
Dan Harrison
William Krohn

INTRODUCTION

Canada lynx are morphologically adapted for hunting snowshoe hares and rely primarily on hares for food throughout the year and across years of variable hare abundance. Thus, lynx in Maine have been documented to exhibit strong selection for habitats where snowshoe hares are abundant (Fuller et al. 2007, Vashon et al. 2008b). Additionally, previous worked funded by the CFRU has documented that density of hares is the most important factor explaining the spatial occurrence patterns of resident lynx in northern Maine (Robinson 2006, Simons 2009). Snowshoe hare populations exhibit predictable cycles of abundance in the northern boreal forest; however, ongoing surveys conducted by CFRU scientists during this study have documented that since 2001 hares in northern Maine have exhibited a 6-yr period of high abundance (2001-2006; average density 2.1 hares/ha), followed by a 3-yr period of lower abundance (2007-2009; 1.0 hares/ha). These results suggest that hares in northern Maine may fluctuate with reduced amplitude relative to populations within northern boreal forest (Figure 25). In fact, two more years of population trend data will be collected as part of the study described here with the support of CFRU and the U.S. Fish and Wildlife Service.

The largest population of the U.S. federally threatened Canada lynx in the conterminous U.S., and the only eastern population, occurs in northern Maine where 24,587 km^2 of critical habitat was designated by the U.S. Department of the Interior in 2009. The occupied geographic range of lynx in Maine is characterized by areas of high annual snowfall (Hoving et al. 2005), and within Maine their occurrence is associated with areas of advanced (i.e., older and more developed) conifer-dominated regenerating forest (Hoving et al. 2004) and higher average hare density (Robinson 2006, Simons 2009). Further, home range placement (Vashon et al. 2008b), stand-scale habitat selection (Fuller et al. 2007, Vashon et al. 2008b) and foraging activity by lynx in Maine (Fuller 2006) were focused on areas with high amounts of regenerating conifer forest and relatively high hare densities. Preferred areas of regenerating forest (19-33 yr post harvest) have supported winter hare densities of 2.1-2.4 hares/ha (Robinson 2006, Vashon et al. 2008b, Scott 2009); however, recent data suggests a 50% decline in over-winter densities of hares within regenerating conifer stands, from a period of higher hare densities in 2001-2006 to a period of lower densities in 2007-2009 (Figure 25).

"Our results suggest that regular fluctuations in hare densities will be an important consideration in future landscape and demographic planning for lynx conservation."

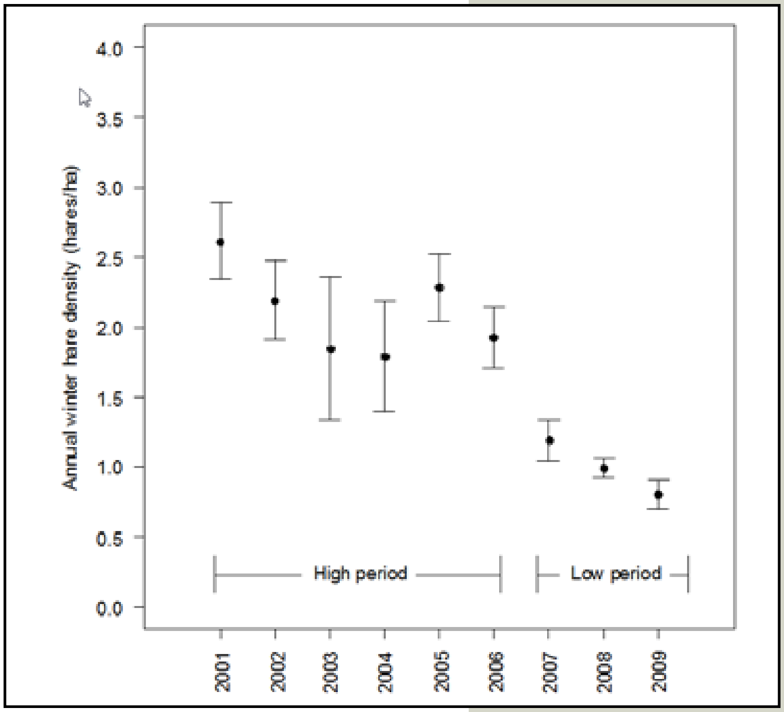

Figure 25. The mean and standard error (whiskers) of estimates for mean over-winter hare densities in 15 regenerating conifer stands in northern Maine, 2001-2009. Results of analyses indicate that hare populations fluctuated from a period of relatively high density (2001-2006; average 2.1 hares/ha) to relatively low density (2007-2009; average 1.0 hares/ha).

The minimum snowshoe hare density necessary to sustain a lynx has yet to be empirically determined, but researchers in the western U.S. have hypothesized that 0.5 hares/ha within lynx home ranges are required for lynx persistence in southern areas. This is consistent with the documented breakdown of lynx territorial social structure in the Yukon below 0.5 hares/ha within home ranges, suggesting that lynx may be unable to meet energetic requirements below that density. Population viability analyses showed that stand-scale hare densities greater than 1.5 hares/ha in optimal habitats were required to sustain a reintroduced population; whereas, a lynx occurrence model for Maine suggested that hare density requirements across the entire landscape could be lower than 1.5 hares/ha (Simons 2009). Given the strong relationship between lynx demography, occurrence, and hare density, the observed decline in stand-scale hare densities in northern Maine after 2006 may warrant concern for the future sustainability of this federally threatened lynx population.

Previous work funded by the CFRU (Simons 2009) resulted in the development of a model for predicting lynx occurrence patterns in Maine based on landscape-scale hare densities, the proportion of mature conifer forest within simulated lynx home range areas based on systematic snow track surveys in northern Maine. Models were developed for occupied and unoccupied areas ranging in hare density from 0.38-1.21 hares/ha (Simons 2009), providing a robust tool for projecting the effects of observed changes in stand-scale hare densities, across a range of forest types, on lynx in the same landscape for which the model was developed. Thus, the primary objectives of our study during 2010 were:

1) To utilize the hare density data collected by CFRU scientists during 2001-2009 to estimate changes in landscape-scale density of snowshoe hares for a period of higher density from 2001-2006 and for a period of lower density from 2007-2009 and

2) To apply our predictive occurrence model for lynx to evaluate the effects of changing hare densities on patterns of predicted habitat occupancy by lynx throughout the commercially managed forests of northern Maine.

RESULTS

Hare densities were documented in 15 regenerating conifer stands and in 12 partially harvested stands during fall 2008 and spring 2009 using established protocols based on hare pellet density x pellet density regression equations. Within our 15 benchmark "high quality" stands (i.e., regenerating conifer clearcuts with past herbicide treatment), hare densities declined by 0.19 hares/ha during the leaf-off season to an

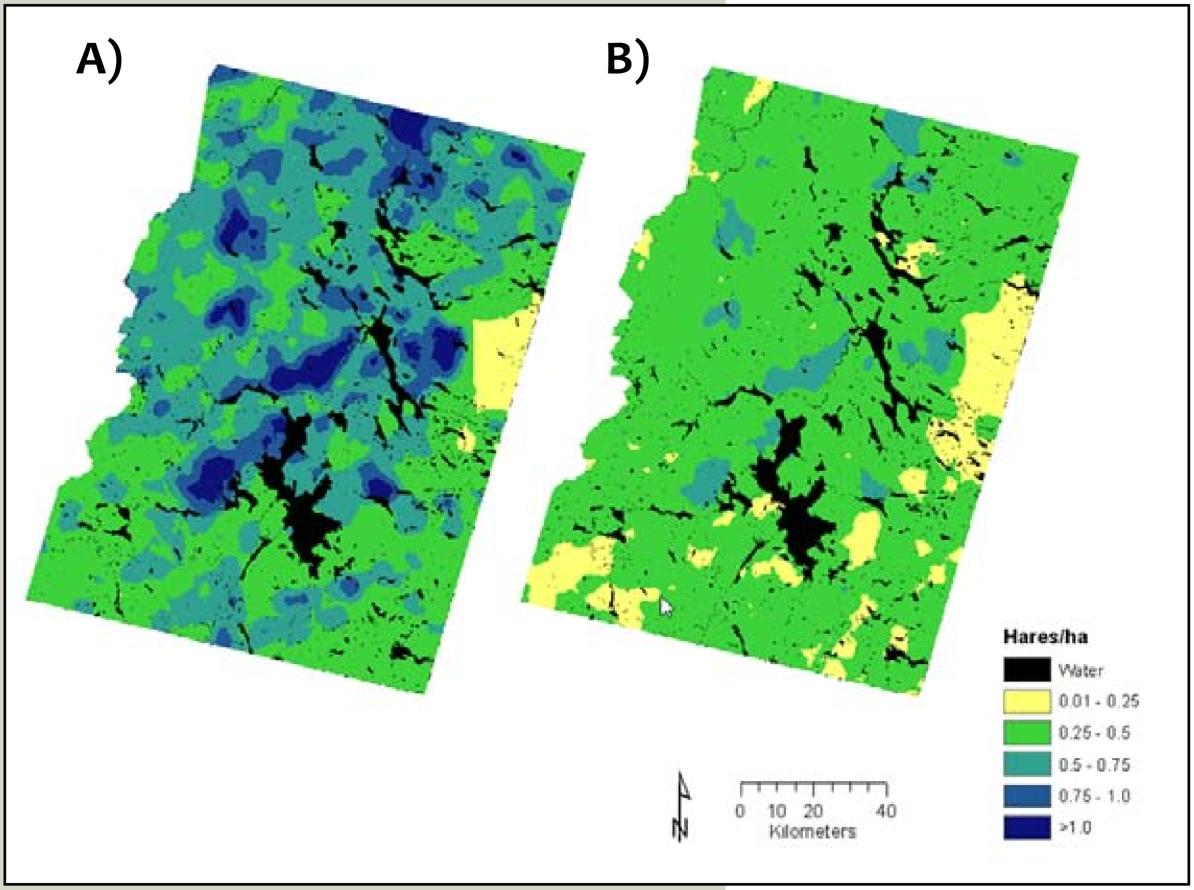

Figure 26. Mean hare density at the lynx home-range scale across a 1.6 million ha study area in northern Maine for A) a higher hare density period, 2001-2006; and B) a lower hare density period, 2007-2009. Darker colors indicate higher hare densities. Forest cover was held static at the 2004 condition for both periods to remove the confounding influence of plant succession.

average over-winter density of 0.80 hares/ha (Figure 25). This density was not significantly different from over-winter hare densities observed in 2007 (1.19 hares/ha) or 2008 (0.99 hares/ha), but was 62% lower than the average hare density observed during the high density period from 2001-2009 (average across years = 2.1 hares/ha).

Estimated hare density across the landscape declined drastically from the high density period (2001-2006) to the low density period (2007–2009) (Figure 26). During the high density period 14.7% of potential lynx home range areas had an average hare density exceeding 0.75 hares/ha,. During the low hare density period, however, none of the potential lynx home ranges had estimated hare densities exceeding 0.75 hares/ha. Furthermore, less than 5% of the landscape had predicted hare density exceeding 0.5 hares/ha during the low density period.

Estimated probabilities of lynx occurrences across the landscape declined precipitously from the high to the lower hare density period (Figure 27). During the high period, 22.1% of the landscape was comprised of forestland with an estimated probability of lynx occurrence of greater than 80%. Strikingly, less than 1% of forestland had a probability of lynx occurrence greater than 80% after hare densities declined. Thus, our results suggest that regular fluctuations in hare densities will be an important consideration in future landscape and demographic planning for lynx conservation.

FUTURE PLANS

We will continue to monitor hare densities and will be evaluating responses of radio-collared lynx to changes in hare densities during 2010. Additionally, we will be preparing reports and manuscripts on the ef-

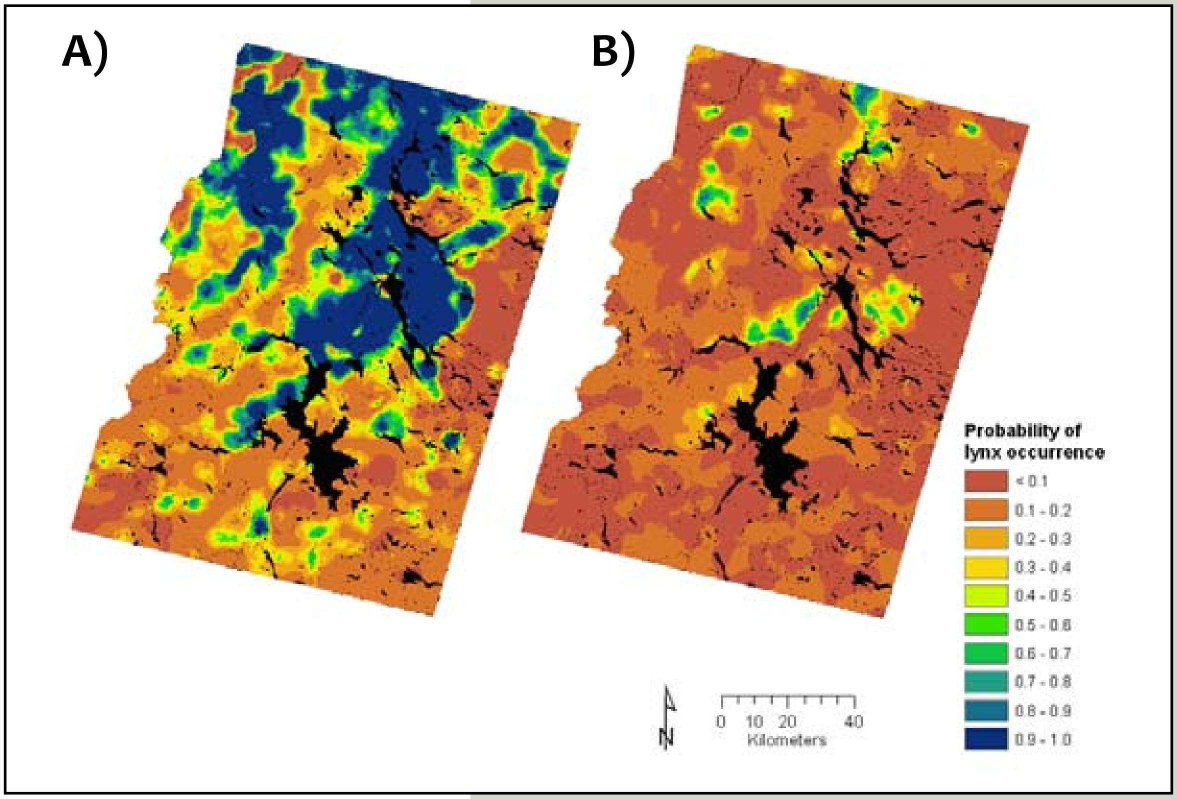

Figure 27. Mean hare density at the lynx home-range scale across a 1.6 million ha study area in northern Maine for A) a higher hare density period, 2001-2006; and B) a lower hare density period, 2007-2009. Darker colors indicate higher hare densities. Forest cover was held static at the 2004 condition for both periods to remove the confounding influence of plant succession.

fects of partial harvesting and within-stand forest succession on hare populations. We anticipate two journal manuscripts and a graduate thesis on the hare-lynx relationships work to be completed by December 2010.

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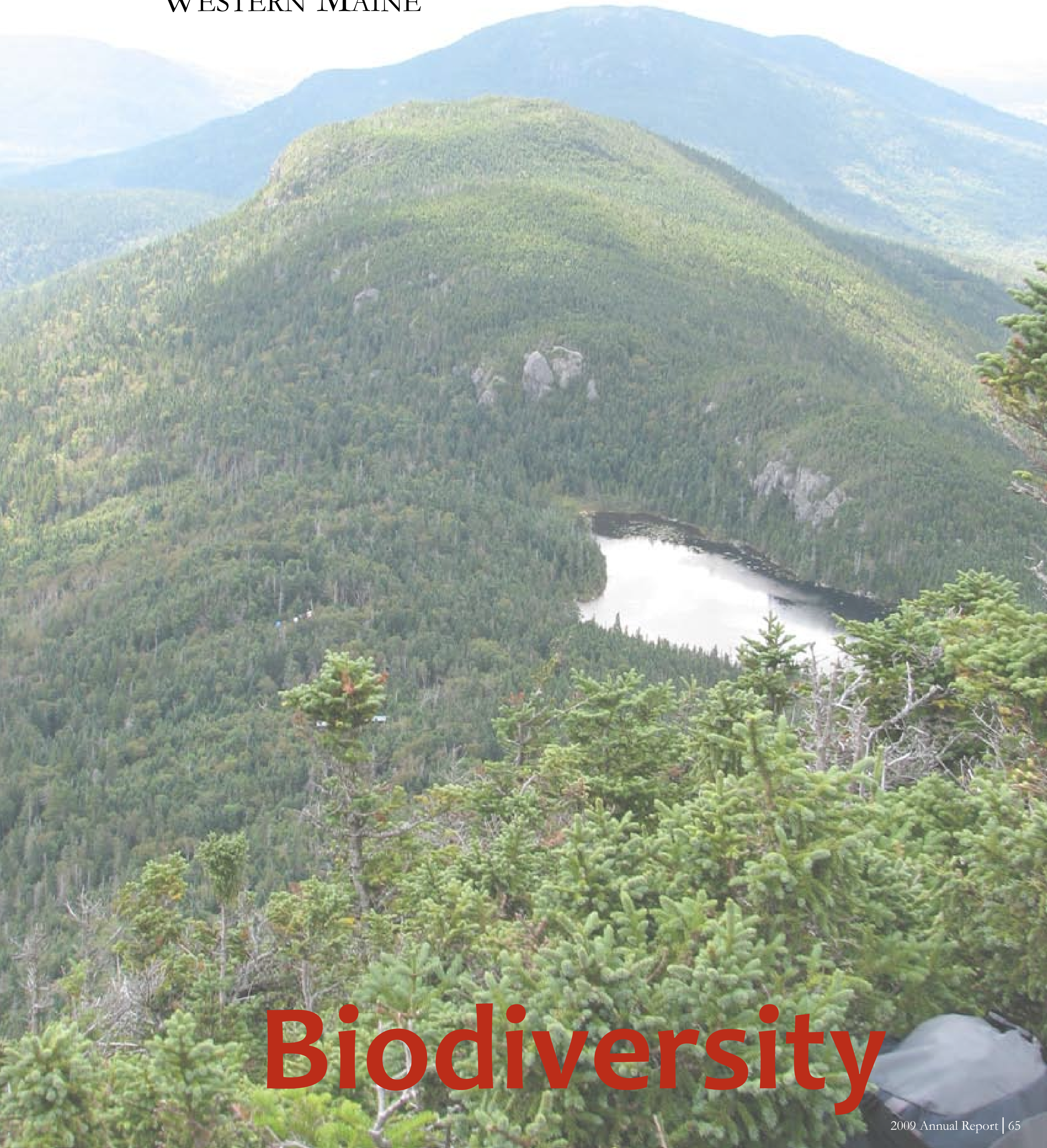
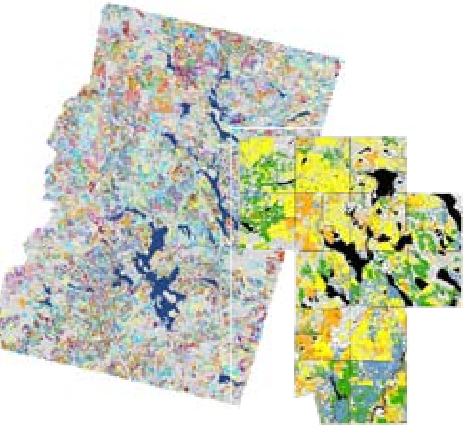
For more information about this project, please contact Dan Harrison.

Quantifying Biodiversity Values Across Managed Landscapes in Northern and Western Maine



Biodiversity



Quantifying Biodiversity Values Across Managed Landscapes in Northern and Western Maine

Authors

Erin Simons
Daniel Harrison
Andrew Whitman
Jeremy Wilson

"It is important for forest and wildlife managers to expect all condition indicators to decline over the next 25 years if current management strategies dependent on partial harvesting persist."

PROJECT OVERVIEW

Sustainable forestry certification programs require forest managers to monitor and manage the environmental impacts of management activities in order to maintain biodiversity. Managers often look to current regulations that are aimed at protecting specific landscape features (e.g., bald eagle nesting areas, deer wintering areas, or shoreland zones) as a starting point, but these regulations do not provide the necessary tools for protecting biodiversity at large. Supplemental management guidelines and tools are needed to ensure that, for example, the habitat requirements of early-successional, area-sensitive, and riparian species are also incorporated into long-term forest management planning. Previous research funded through CFRU and others have generated the tools necessary for quantifying a number of important biodiversity values, positioning Maine to be a leader in biodiversity conservation on managed forestlands. Specifically, the CFRU has funded a number of projects that have resulted in development of condition indicators for managed forests in Maine (Hagan and Whitman 2006), which have been designed to quantify the condition of elements of biodiversity. Typical indicators of sustainable forestry certification programs only describe landowners' policies, practices, and institutional capacity to protect biodiversity. While important, these policy response indicators provide no information about the actual status of biodiversity (Hagan and Whitman 2006). In addition to providing valuable information about the current status of biodiversity on Maine's managed forestlands, the condition indicators can also be integrated into a conservation planning, biodiversity management, and performance scoring framework, which may serve to simplify and standardize landowner efforts to conserve biodiversity.

Condition indicators for managed forestlands in Maine have been developed at two spatial scales; stand and landscape. Stand-scale indicators were designed to facilitate identification of structural characteristics associated with important elements of biodiversity. Late-successional (LS) forest, for example, provides important structure (e.g., large trees, large snags, and large logs) associated with many species of lichens, mosses and liverworts in the Northeast (Selva 1994, Cleavitt 2009). Whitman and Hagan (2007) tested a suite of potential LS indicators for northern hardwood and spruce-fir forest in Maine and concluded that foresters could use large tree density (≥ 16 in DBH) as an indicator of the degree to which a stand is in LS condition for both forest types. Landscape-scale condition indicators were developed using predictive models for

Scale	Indicator	Definition
Stand		
	1a. ES shrub bird habitat	Percent of forestland with Basal Area (BA) <6 ft^2/ac
	1b. ES sapling bird habitat	Percent of forestland with BA <59 ft^2/ac
	1c. Snowshoe hare habitat	Percent of forestland with conifer or mixed, even-aged regenerating forest (15-35 years post harvest)
	2a. Marten habitat	Percent of forestland in patches ≥6.7 ac with BA ≥80 ft^2/ac and mean stand height ≥30 ft (for trees ≥3 in (7.6 cm) DBH) and with canopy closure >30%
	2b. LS northern hardwood	Percent of Hardwood-dominated forestland ≥100 years old with stand size class 4 and canopy closure >60%
	2c. LS spruce-fir	Percent of Softwood-dominated forestland ≥100 years old with stand size class 4 and canopy closure >60%
Landscape		
	3a. Male marten occurrence	Percent of forestland with ≥60% probability of occurrence for male martens
	3b. Female marten occurrence	Percent of forestland with ≥60% probability of occurrence for female martens
	4a. Lynx occurrence	Percent of forestland with ≥60% probability of occurrence for lynx

Table 13. Condition indicators of biodiversity for managed forestlands in northern Maine. Stand-scale indicators included are early-successional (ES) shrub bird habitat, ES sapling bird habitat, snowshoe hare habitat, marten habitat, late-successional (LS) northern hardwood forest, and LS spruce-fir forest. Landscape-scale indicators included are male and female marten occurrence and lynx occurrence.

two important umbrella species in Maine, Canada lynx and American martens, to promote large-scale conservation planning targeted at maintaining connectivity and availability of habitat for area-sensitive species. Lynx and martens represent a range of ecological conditions (i.e., early-successional forest and mid- to late-successional forest, respectively) and previous research has demonstrated that habitat conservation for these two species will encompass the broad-scale habitat requirements for >85% of the forest-generalist, deciduous-forest specialist, and coniferous-forest specialist vertebrate species (n = 111) occurring in northern Maine (Hepinstall and Harrison, in preparation).

Landowners have traditionally applied existing planning tools independently; therefore, no framework previously existed for the evaluating the need for and potential outcomes that might arise from applying biodiversity conservation across multiple landowners in commercially managed landscapes. Further, existing tools are limited in their utility for evaluating the future effects of forest management activities on multiple biodiversity values. Thus, we proposed to apply a set of condition indicators developed for managed forests in Maine across a set of unorganized townships that are representative of the variety of forest management legacies and current landowner types present in northern Maine. The goals of this project were to provide a better understanding of indicator performance across a diverse set of owners, owner types and forest management regimes in northern Maine, and identify current and future biodiversity challenges. The objectives were to:

1) Map and quantify biodiversity values for the condition indicators and assess the range of variability across a diverse set of owners, owner types and forest management regimes in northern Maine. Evaluate the time and information needs required to apply the indicators.

2) Evaluate the scalability and performance of each of the condition indicators to determine which of those inferred biodiversity values accrue from the parcel to multi-township scale.

3) Forecast and quantify change in the condition indicators based on alternative forest management scenarios. Use results to evaluate the costs and benefits of biodiversity conservation at scales of 1-14 townships.

4) Quantify changes in sustainable harvest volume associated with biodiversity planning and alternatively, the changes in future biodiversity of proceeding with a maximum sustainable harvest strategy without associated biodiversity planning.

Late succesional (LS) forest is home to many species of lichens (seen here), mosses and liverworts.
(Manomet photo)

SUMMARY OF PROGRESS DURING YEAR 3

In the final year of this project we completed our analysis of the current status and likely future trends (2007-2032) of a set of biodiversity indicators across 14 townships in north-central Maine that are representative of the variety of forest management legacies that have been created since the 1970s spruce budworm outbreak. Townships in our study area formed a contiguous area (344,034 acres) in north-central Maine composed of 23 parcels representing a mix of ownership types, including a non-governmental organization, several large and small commercial landowners (with and without conservation easements), and state-owned and managed lands. Stand-level data for these parcels were based on a common classification scheme developed in Years 1 and 2 using satellite-derived forest harvest and composition information (Legaard et al., Maine Image Analysis Laboratory, University of Maine, in preparation), coupled with Forest Inventory and Analysis (FIA) plot data.

We analyzed nine indicators (Table 13), which were derived based on previous UM and Manomet research conducted in northern Maine and supported by the CFRU and others. Indicators that could be evaluated using information typically available in existing GIS databases and supporting timber inventories were chosen. Because stand-level structural characteristics (e.g., basal area) had to be approximated in our study, results should considered representative of the patterns present on managed forestlands in northern Maine, but exact values should be viewed with caution. We included six stand-scale indicators to assess the overall composition of parcels with respect to forest structure. Additionally, we included three landscape-scale indicators derived from spatially-explicit models developed for lynx (Simons 2009) and martens (Hepinstall et al., in preparation) to better understand the effects of forest composition and configuration on area-sensitive wildlife. See final project report for additional details about the indicators.

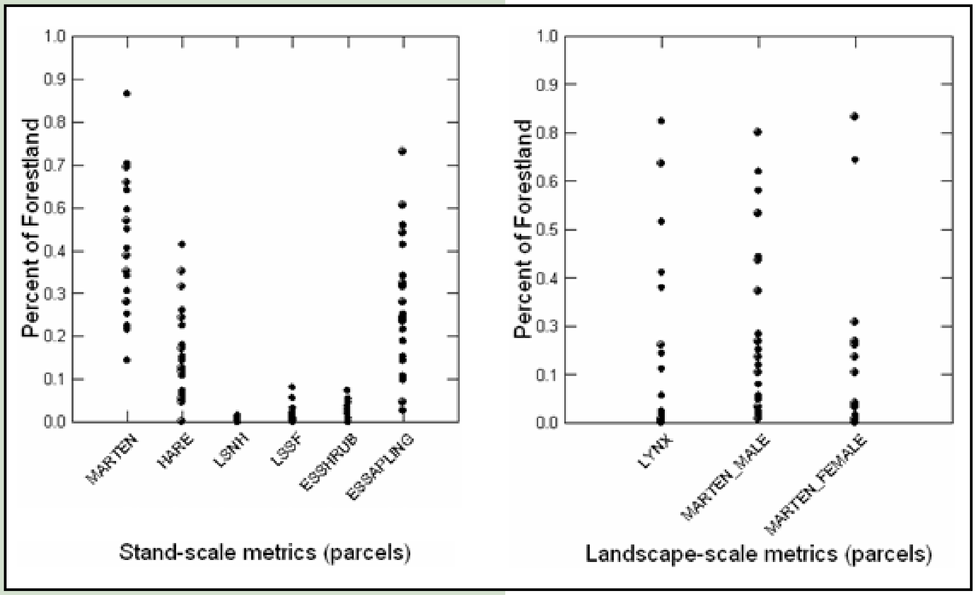


Figure 28. Distribution of stand- and landscape-scale metrics ca. 2007 across 23 parcels in northern Maine. Stand-scale indicators included percent of forestland providing marten habitat (MARTEN), hare habitat (HARE), late-successional northern hardwood habitat (LS NH), late-successional spruce-fir habitat (LS SF), early-successional shrub habitat (ESSHRUB), or early-successional sapling habitat (ESSAPLING). Landscape-scale indicators included percent of forestland providing >60% probability of occurrence for lynx, male martens, or female martens.

KEY FINDINGS

At the parcel level we calculated the percent of forestland estimated to have the conditions associated with each of the nine indicators (Table 13). The distribution of indicator values ca. 2007 varied widely across the 23 parcels included in our study area. At the stand-scale, early-successional shrub bird habitat (ES Shrub) and late-successional northern hardwood (LS NH) and spruce-fir (LS SF) forest all had particularly narrow distributions (Figure 28), suggesting that these forest types are limited on the landscape and are not generally being managed for under the current regulations and predominant forest practices of northern Maine. The other stand-scale ES indicator, hare habitat, was relatively well represented (Figure 28) as was landscape-scale lynx occurrence (Figure 28), which is strongly associated with snowshoe hare density (Robinson 2006, Fuller et al. 2007, Simons 2009). Marten habitat was also well represented at the stand-scale (Figure 28), as was landscape-scale marten occurrence (Figure 28).

We combined the parcel-level data across parcel and township boundaries to evaluate the scalability of the indicators at three scales (parcel, township, 4-township block) to determine if any of the indicators accrued as scale increased. Results indicated that scale was a more important consideration for our landscape-scale indicators. Landscape-scale indicators were more sensitive to the location of a 4-township block (Figure 29) and the size of the contiguous area with >60% probability of occurrence it provided. Thus, the parcel-level may be sufficient when managing forest to meet the conditions associated with a stand-scale indicator, but owners should consider 4 townships as the minimum scale when managing for the occurrence of area-sensitive species such as lynx and martens. Lynx in particular require large home ranges relative to the size of parcels in northern Maine (53.6 and 25.7 km2, respectively, for males and females; Vashon et al. 2008). Only six out of

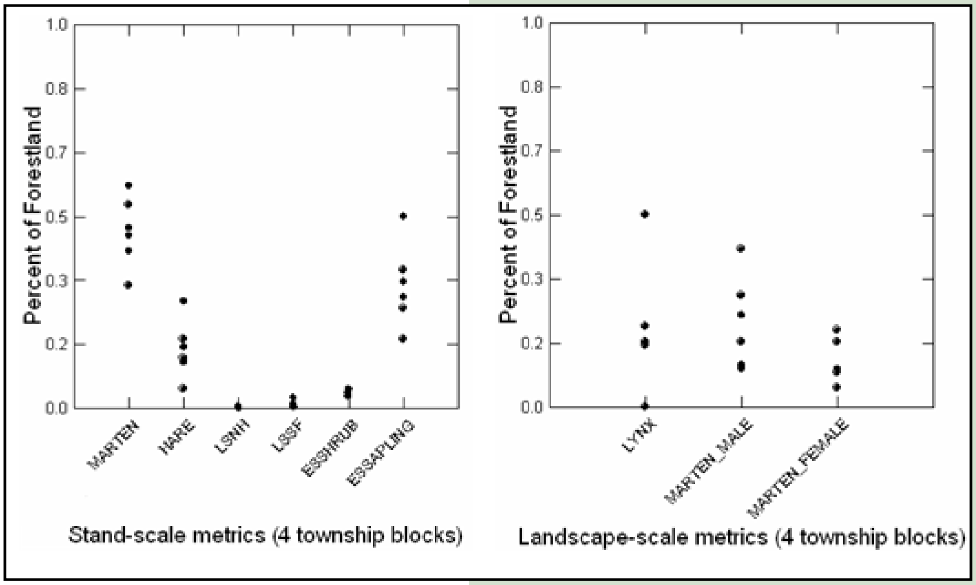


Figure 29. Distribution of stand- and landscape-scale metrics ca. 2007 for 23 parcels in northern Maine aggregated by 4-township blocks. Stand-scale indicators included percent of forestland providing marten habitat (MARTEN), hare habitat (HARE), late-successional northern hardwood habitat (LS NH), late-successional Spruce-Fir habitat (LS SF), early-successional shrub habitat (ESSHRUB), or early-successional sapling habitat (ESSAPLING). Landscape-scale indicators included percent of forestland providing >60% probability of occurrence for lynx, male martens, or female martens.

the 23 parcels included in our study area had sufficient forestland area with >60% probability of lynx occurrence to support even a single resident male lynx.

When evaluating the representation of stand-scale indicators across the ownerships included in our study area (n=9), results were strongly influenced by the past forest management history on an ownership. The ES indicators were highly correlated and were well represented on ownerships with a history of salvage logging during the spruce budworm outbreak of the 1970s and 1980s. Marten habitat, however, not well represented on these ownerships; rather, marten habitat occurred where forest management has generally occurred as partial harvesting. LS northern hardwood condition had a strong positive correlation with marten habitat but correlations between LS spruce-fir condition and the other indicators were weak, suggesting that maintenance of LS spruce-fir condition will be largely independent of other forest types. Consequently, because of negative and/or weak correlations between indicators, forest and wildlife managers will face significant challenges to managing for all habitat types on a single ownership.

To provide a better understanding of future biodiversity challenges we used the Remsoft Spatial Planning System to project the trend in each of the indicators, 2007-2032, under three alternative forest management scenarios 1) natural succession; 2) continuing recent forest management trends for included ownerships; and 3) maximize sustainable harvest. Results indicated that 8 of the 9 indicators with the exception of stands-scale marten habitat will decline if current harvesting rates and patterns persist. It is important to note, however, that these trends are dependent on the details of the growth models used during simulation (Simons 2009). If harvesting were to shift towards a strategy to maximize sustainable volume, all indicators would receive some benefit by 2032. Hare habitat and lynx occurrence are, however, still expected to decline as habitat created during the salvage logging period continues to age and snowshoe hare densities begin to decline (Simons 2009). If harvesting were to stop altogether, the LS indicators and marten indicators are projected to increase, and the area with probability of occurrence >60% for male and female martens would increase by a striking 259% and 325%, respectively. Not surprisingly, without additional harvesting all ES indicators, including lynx occurrence, are projected to decline. Additional details of scenario outcomes can be found in our final report.

MANAGEMENT RECOMMENDATIONS

Large trees, both living and on the forest floor, help maintain biodiversity values in stands.
(Spencer Meyer photo)

The distributions of the nine condition indicators were tied to past forest management legacy. ES habitats will generally be well represented on parcels with a history of salvage logging during the budworm outbreak of the 1970s and 1980s; thus, we recommend that in these areas stand-scale management for biodiversity should be directed at maintaining marten habitat and LS forest. LS forest in particular is currently very limited on the landscape and is projected to decline in the near future. Forest managers will also, however, need to plan to create a future supply of early-successional habitats, which are otherwise expected to decline as a result of broad-scale changes in forest management. Because of the strong relationship between snowshoe hare density and landscape-scale occurrence of lynx (Robinson 2006, Simons 2009), probability of occurrence for lynx will also be generally higher on the same parcels. It is, however, important when planning for lynx that forest and wildlife managers are particularly sensitive to scale. Because few individual parcels are likely to have sufficient area with >60% probability of occurrence for lynx, we recommend that landowners consider four townships as the minimum scale when managing for lynx. When managing for marten occurrence, it may also be necessary to look beyond a single parcel in order to meet habitat configuration requirements. Thus, we recommend that abutting forestland owners strategically identify groups of 4-8 townships that could be managed to benefit both lynx and martens.

Finally, it is important for forest and wildlife managers to expect all condition indicators to decline over the next 25 years if current management strategies dependent on partial harvesting persist. Alternative forest management strategies should be considered when biodiversity planning is a high priority. Specifically, our results suggest that forest and wildlife managers should consider strategies that integrate clearcutting in order to reduce the total acreage harvested. This type of strategy could provide a benefit to land owners in the form of increased volume, as well as provide an opportunity to increase the amount of LS and marten habitats in areas reserved from harvesting.


For more information about this project, please contact Dan Harrison.

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Appendices

Outreach

List of Figures

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Contact Information

The CFRU continually strives to communicate the results from our research with all our stakeholders, including our members, the scientific community, policy-makers and the concerned public. We publish articles in peer-reviewed journals, CFRU Research Reports, Results briefs, conference proceedings and in popular media.

In addition to published research, CFRU scientists and staff routinely present research findings to many audiences, including scientific conferences, field workshops for members and others, industry forums, stakeholder meetings and public forest awareness events.

OUTREACH

JOURNAL PUBLICATIONS

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Weiskittel, A.R., Kershaw, J.A., Hofmeyer, P.V., and Seymour, R.S. 2009. Species differences in total and vertical distribution of branch- and tree-level leaf area for the five primary conifer species in Maine, USA. Forest Ecology and Management 258: 1695-1703.

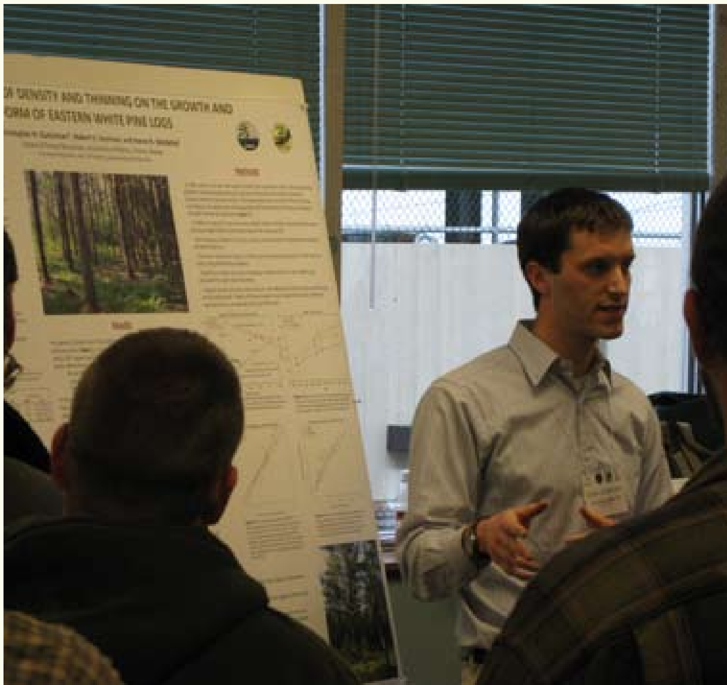
RESEARCH REPORTS

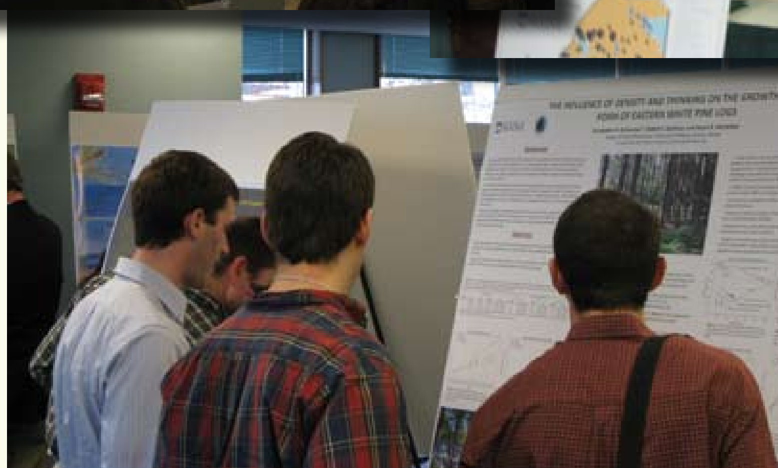
Gunn, J, J. Hagan, and A. Whitman. 2009. Forestry adaptation and mitigation in a changing climate: a forest resource manager's guide for the northeastern United States. Manomet center for Conservation Scineces, Brunswick, ME. Ecosystem Se rvices Resource Center Report, NCI-2009-1.

Russell, M.B., S.R. Meyer, and R.G. Wagner. 2009. Capturing the value of 30 years of research: long-term data management and the Cooperative Forestry Research Unit. CFRU Res. Rep. RR-09-03. 32 pp.

Simons, E., D. Harrison, A. Whitman, J. Hagan and E. Wilkerson. Quantifying biodiversity values across managed landscapes in northern and western Maine. Pages 52-54 in Maine Cooperative Forestry Research Unit Annual Report, Maine Agricultural and Forest Experiment Station Miscellaneous Report 444, Orono, Maine.

Simons, E. K. Legaard, D. Harrison, S. Sader, J. Wilson, and W. Krohn. Predicting responses of forest landscape change on wildlife umbrella species. Pages 55-59 in Maine Cooperative Forestry Research Unit Annual Report, Maine Agricultural and Forest Experiment Station Miscellaneous Report 444, Orono, Maine.





CFRU scientists, staff and graduate students convey the latest results from their research to scientists, practitioners, and other audiences throughout the year. Peer reviewed journals, research reports, conference proceedings, posters, presentations, and many other outlets are used to help share what CFRU has learned about forests.

CONFERENCE PROCEEDINGS

Burke, A.M., I.J. Fernandez, A. Weiskittel, and R. Wagner. 2009. Modeling balsam fir nutrient uptake to address sustainability concerns in an age of bioenergy opportunity. Carbon in Northern Forests meeting. Traverse City, MI. June 9 – 12.

Fuller, A. K. D. J. Harrison, B. J. Hearn, and J. A. Hepinstall. 2009. Spatial responses to habitat loss in two populations of forest martens. Paper presented at 5th International Martes Symposium – Biology and Conservation of Martens: a New Synthesis, Seattle, Washington. September 10.

Gunn, J. and A. Whitman. 2009. Bioenergy and biodiversity. 2009 NE Society of American Foresters Annual Meeting, Portland, Maine. March 18th – 20th, 2009.

Harrison, D. J. 2009. Forests, forest mustelids, and forest fragmentation: what happens when mammals don't read? Invited presentation at Symposium on Behavioral Ecology of Mammals, W. M. Keck Center for Behavioral Ecology, North Carolina State University, September 4.

Harrison, D. J. and B. J. Hearn. 2009. Ecological comparisons of home-range characteristics of American martens in Newfoundland and Maine: why are home ranges of threatened Newfoundland martens so large? Paper presented at 5th International Martes Symposium – Biology and Conservation of Martens: a New Synthesis, Seattle, Washington. September 10.

Harrison, D. J. 2009. Forestry and Forest Wildlife, Chaired session at New England Society of American Foresters 89th Winter Meeting. Bio: Mass, Fuel, Products, Diversity - Resource Management in a Changing World. Portland, Maine. March 19.

Harrison, D. J., A. K. Fuller, J. A. Hepinstall, E. Simons, B. J. Hearn, and D. Payer. 2008. Forests, forestry, and forest martens: a landscape perspective. Invited presentation at conference titled: Pour une sylviculture adaptee a al feret irreguliere et sa faune, Faculty of Forestry, University of Laval, Baie Comeau, Quebec. October 8.

Krohn W. B., D. J. Harrison, S. A Scott, L. L. Robinson, C. L. Hoving, A. K. Fuller, and E. M. Simons. 2008. Variation in snowshoe hare densities as related to Canada lynx and forest management in eastern North America. Presentation at Eastern CANUSA Forest Science Conference, Orono, Maine. October 17.

Li, R. and Weiskittel, A.R. 2009. Evaluating model forms of bark thickness equations for seven conifers species using a mixed-effects model approach. 13th Annual Northeastern Mensurationists Meeting. November 2-3. Durham, NH.

Rijal, B. and Weiskittel, A.R.2009. Individual tree diameter and height allometric equations in the Acadian Forest. 13th Annual Northeastern Mensurationists Meeting. November 2-3. Durham, NH.

Russell, M. and Weiskittel, A.R. 2009. Development of a growth index for application in the mixed-species Acadian Forest. 13th Annual Northeastern Mensurationists Meeting. November 2-3. Durham, NH.

Scott, S. A, D.J. Harrison, and W. B. Krohn. 2009. The relative effects of forest practices and natural population processes on the temporal dynamics of hare populations in northern Maine. Invited Paper at New England Society of American Foresters 89th Winter Meeting, Portland, Maine. March 19.

Scott, S. A., D. J. Harrison, and W. B. Krohn. 2009. Spatio-temporal dynamics of snowshoe hares in northern Maine. Paper presented at Northeast Fish and Wildlife Conference, Lancaster, Pennsylvania. April 27.

Simons, E. M., D. J. Harrison, W. B. Krohn, K. R. Legaard, J. S. Wilson, and S. A. Sader. 2009. Past and future trends in habitat supply for martens and lynx across the landscapes of northern Maine, 1973-2032. . Invited Paper at New England Society of American Foresters 89th Winter Meeting, Portland, Maine. March 19.

Simons, E. M., D. J. Harrison, W. B. Krohn, K. R. Legaard, and S. A. Sader. 2008. Retrospective changes in habitat supply for Canada lynx and snowshoe hares resulting from timber harvesting: Implications for lynx recovery? Paper presented at The Wildlife Society 15th Annual Conference, Miami, Florida. November 9.

Wagner, R.G., R.S. Seymour, M.R. Saunders, D. McConville, and S.R. Meyer. 2009. Thinning responses of natural spruce-fir stands in the Acadian Forest of Maine, USA. Spruce in the context of global change: Ecology, silviculture, forest products, management risks and conservation practices, 31 Aug – 3 Sep 2009, Halmstad, Sweden (Invited keynote paper)

Zellers, C., R.S. Seymour, A.R. Weiskittel, J.G. Benjamin. 2009. Growth, Log Characteristics, and Financial Maturity of Isolated Archetypal Eastern White Pine (Pinus Strobus L.) Trees. New England Society of American Foresters 89th Annual Meeting. Bio: Mass, Fuel, Products, Diversity – Resource Management in a Changing World. Portland, ME. March 17-20.Presentations

THESES

Coup, Charles. 2009. A Case Study for Assessing Operational and Silvicultural Performance of Whole-Tree Biomass Harvesting in Maine. MS Thesis. School of Forest Resources.

Guiterman, Christopher H. (M.S. Fall 2009). The Influences of Conventional and Low-density Thinning on Leaf Area, Growth, and Growing Space Relationships of Eastern White Pine (Pinus strobus L.) 111 p.

Nelson, A.S. 2009. Spatial ecology and compositional management of American beech and sugar maple regeneration in Maine. M.S. thesis, University of Maine, Orono.

Noone M.D. 2009. Forest change and cover type monitoring and evaluation of disturbance influences in Maine: 2000 to 2007. M.S. Thesis, December 2009, University of Maine, Orono.

Simons, E.M. 2009. Influences of Past and Future Management on the Spatiotemporal Dynamics of Habitat Supply for Canada Lynx and American Martens in Northern Maine. Ph.D. Dissertation. May 2009. University of Maine, Orono. 271 p.

PRESENTATIONS, POSTERS, FIELD TOURS AND WORKSHOPS

Fuller, A. K., D. J. Harrison, and W. B. Krohn. 2009. Landscape planning on The Nature Conservancy lands in northern Maine. Invited presentation to executive director and staff of The Nature Conservancy, Brunswick, Maine. February 24.

Fuller, A. K., D. J. Harrison, and W. B. Krohn. 2008. Applications of lynx and marten models to operational forest management. Invited presentation at Lynx on the landscape: workshop and fall field tour, Cooperative Forestry Research Unit, Greenville, Maine. October 28.

Fuller, A. K., D. J. Harrison, B. K. Hearn, and J. A. Hepinstall. 2008. Spatial responses to habitat loss in 2 populations of forest martens. Paper presented at The Wildlife Society 15th Annual Conference, Miami, Florida. November 11.

Harrison, D. J. 2009. The growing need to fund additional scientists working on forest-wildlife interactions in Maine: a proposal. Presentation to Maine Cooperative Forestry Research Unit, Orono, Maine. February 26.

Harrison, D. J., and A. K. Fuller. 2009. Relative Densities, Patch Occupancy, and Population Performance of Spruce Grouse in Regenerating Conifer, Precommercially Thinned, Mature Conifer, and Conifer Wetlands Stands: a proposal. Presentation to Maine Cooperative Forestry Research Unit, Orono, Maine. April 15.

Harrison, D. J., E. M. Simons, and W. B. Krohn. 2009. Habitat changes for wildlife umbrella species: implications for landscape conservation strategies in northern Maine. Invited presentation to northern Appalachians landscape conservation committee, The Nature Conservancy, Brunswick, Maine. May 21.

Harrison, D. J., W. B. Krohn, and E. M. Simons. 2009. Past and future trends in habitat supply for forest carnivores in northern Maine: implications for forest policy. Invited presentation to leadership of Maine Forest Service, Maine Department of Inalnd Fisheries and Wildlife and Maine Natural Areas Program, Augusta, Maine. June 30.

Meyer, S.R. From the Lab to the Lands: Four Decades of CFRU Research. A presentation to School of Forest Resources. Orono, Maine. November 7, 2008.

Meyer, S.R. and M.B. Russell. 2009. Maine's Cooperative Forestry Research Unit. Poster presentation at New England Society of American Foresters 89th Winter Meeting. Mar 18-20, 2009.
Meyer, S.R. Working with Landowners Since 1975. A Presentation to the Milliken Family, Baskahegan Company Annual Meeting. Weston, Maine. July 1, 2009.

Meyer, S.R. and M.B. Russell. 2009. Maine's Cooperative Forestry Research Unit. Poster presentation at Wonder of Wood Expo. Sept 19, 2009.

Meyer, S.R. and M.B. Russell. 2009. Maine's Cooperative Forestry Research Unit. Poster presentation at U. Maine's Climate Change 21 Conference. Oct 23-24, 2009.
Patterson W. and A. K. Fuller. 2009. Silvicultural prescriptions for maintaining marten and lynx habitat requirements. Field tour of the Nature Conservancy St. John ownership for staff of The Nature Conservancy, U.S. Fish and Wildlife Service, and Huber Resources Group. May 4-6.

Scott, S.A., D.J. Harrison, and W.B. Krohn. 2009. Spatio-temporal dynamics of snowshoe hares in northern Maine. Presentation to Maine Cooperative Forestry Research Unit, Orono, Maine. April 15.

Simons, E. M., D. J. Harrison, W. B. Krohn, K. R. Legaard, J. S. Wilson, and S. A. Sader. 2009. Past and future trends in habitat supply for martens and lynx across the landscapes of northern Maine, 1973-2032. . Invited presentation to executive director and staff of The Nature Conservancy, Brunswick, Maine. February 24.

Simons, E. M. 2009. Influences of past and future forest management on the spatiotemporal dynamics of habitat supply for Canada lynx and American martens in northern Maine. Ph.D. defense seminar, The University of Maine, Orono. March 25.

Simons, E. M., J. S. Wilson, D. J. Harrison, W. B. Krohn. 2009. Future trends in habitat supply for martens and lynx across the landscapes of northern Maine under alternative forest management scenarios, 2007-2032. . Presentation to Maine Cooperative Forestry Research Unit, Orono, Maine. April 15.

Scott, S., D.J. Harrison, and W. B. Krohn. Partial harvests: contributing to foraging habitat? 2008. Presentation at Lynx on the Landscape Workshop, Maine Cooperative Forestry Research Unit , Workshop. Greenville, ME. October 28.

Simons, E. M., D. J. Harrison, W. B. Krohn, K. R. Legaard and S. A. Sader. 2008. Ecological factors associated with landscape-scale occurrences of Canada lynx in northern Maine. Invited Presentation at Lynx on the Landscape: What You Need to Know Workshop and Field Tour, Maine Cooperative Forestry Research Unit, Greenville, Maine. October 29.

Simons, E. M., K. R. Legaard (Co-Presenters), D. J. Harrison, W. B. Krohn, and S. Sader. 2008. Evaluating broad-scale changes in timber harvesting patterns, forest landscape structure, and wildlife habitat supply for umbrella species in northern Maine. Invited presentation at Friends of ForCAST, Center for Research on Sustainable Forests, Orono. November 20.

Wagner, R.W. 2009. Maine Forest Products Council Legislators Tour. Summary of CFRU research accomplishments in management of northern forest stands. Millinocket, ME. October, 2009.

Wagner, R.W. 2009. Organizer and Moderator, Latest Forest Biorefineries Technologies. New England Foresters Society of American, 89th Winter Meeting, Bio: Mass, Fuel, Products, Diversity Resource Management in a Changing World, March 17-20, 2009, Portland, Maine.

OTHER

Larouche, C., R. Wagner, S. Meyer, S. Wyatt. 2009. Promoting Communications Across the Border. The Forestry Chronicle. 85(1): 16.

CFRU data manager and graduate student Matt Russell talks with CRSF communications coordinator Summer Allen at U. Maine's Climate Change 21 conference. (Spencer Meyer photo)

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CFRU scientists, past, presemt amd future gather at the Austin Pond long-term experiment to discuss options for the next great idea on the site.

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