

Silviculture



Wildlife



Water Quality



Cooperative Forestry Research Unit *2001 Annual Report*

MAFES Miscellaneous Report 428

ABOUT THE CFRU

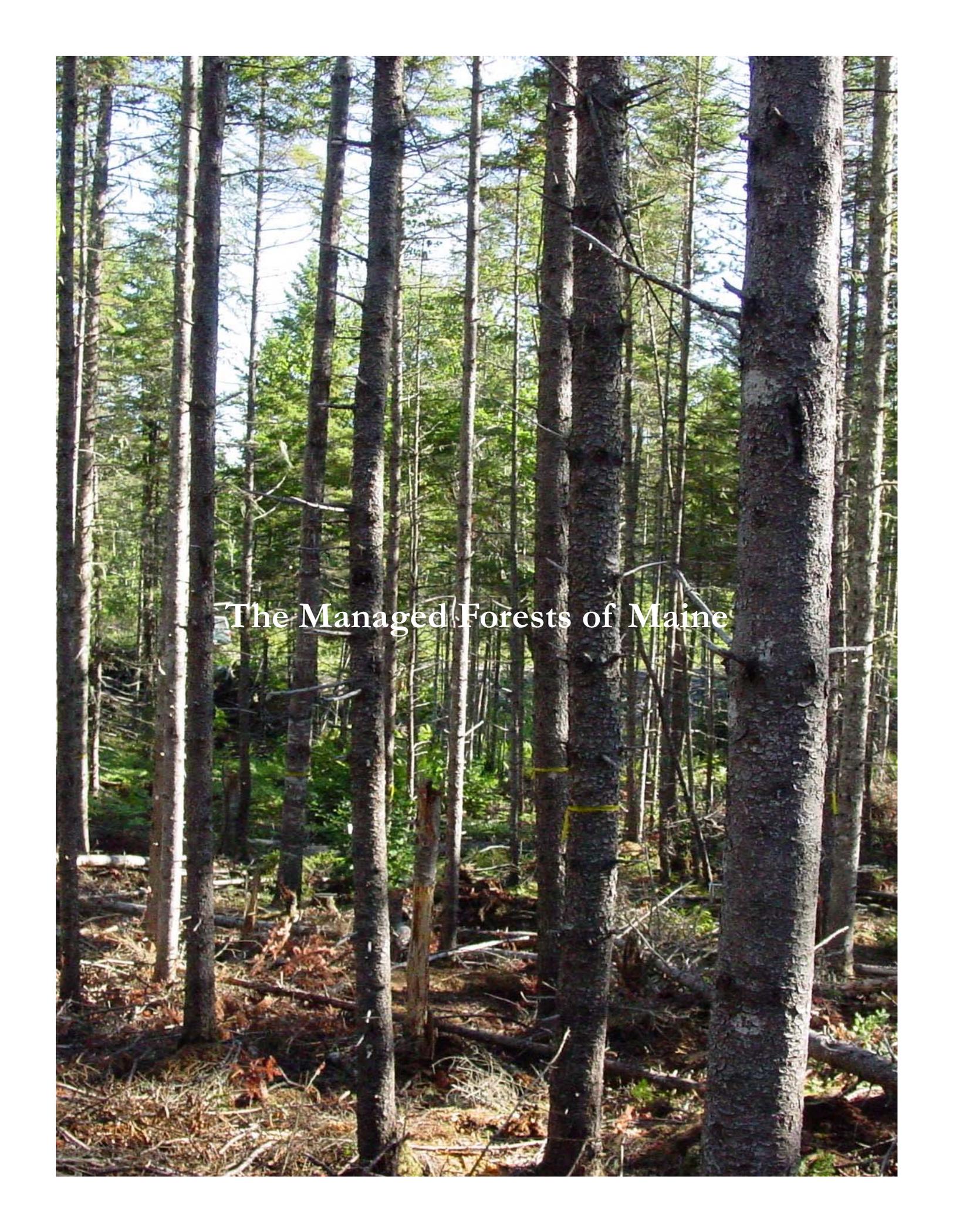
Founded in 1975, the CFRU is one of the oldest industry / university forest research cooperatives in the United States. We are composed of 26 member organizations including private industrial, private non-industrial, and public forest landowners, plus other private contributors. Research by the CFRU seeks to solve the most important problems facing the managers of Maine's forests.

CFRU COMMUNICATIONS
*5755 Nutting Hall, Rm 235
Orono, ME 04469-5755
<http://www.umaine.edu/cfru>*

TABLE OF CONTENTS

	<i>Page</i>
Highlights 2000-2001	10
Chair's Report	11
Deans' Report	12
Director's Report	13
Introduction	14
Organization Accomplishments	15
<i>Financial Report</i>	16
<i>Advisory Committee</i>	18
<i>Field and Data Report</i>	19
<i>Communications Report</i>	20
Research	22
<i>Silviculture</i>	22
<i>Commercial Thinning Research Network - Robert G. Wagner and Robert S. Seymour, and Daniel J. McConville</i>	23
<i>Condition and Development of Root Systems of Balsam Fir and Red Spruce in Precommercially Thinned and Unthinned Stands - Suzhong Tian and William D. Ostrofsky</i>	36
<i>Long-Term Effects of Herbicide and Precommercial Thinning Treatments on Young Spruce-Fir Stands: The Austin Pond Study - Howard Daggett and Robert G. Wagner</i>	37
<i>Assessing Silviculture Research Priorities for Maine Using a Wood Supply Analysis - Robert G. Wagner, Robert S. Seymour, and Ernest H. Bowling</i>	39
<i>Juvenility and Rooting Potential of Basal Stem Sprouts from Heavily Pruned Hybrid Larch Trees - Carl L. Haag</i>	42
<i>Wildlife and Biodiversity</i>	44
<i>Marten as a Tool for Landscape-Scale Habitat Planning in Northern Maine -Jeffery A. Hepinstall and Daniel J. Harrison</i>	45
<i>Effect of Precommercial Thinning on Selected Wildlife Species With Special Emphasis on Snowshoe Hare - Jessica A. Homyack, Daniel J. Harrison and William B. Krohn</i>	49
<i>Can Patch Retention Maintain Biodiversity in Clearcuts and Partially Harvested Forest? - John M. Hagan and Andrew A. Whitman</i>	54

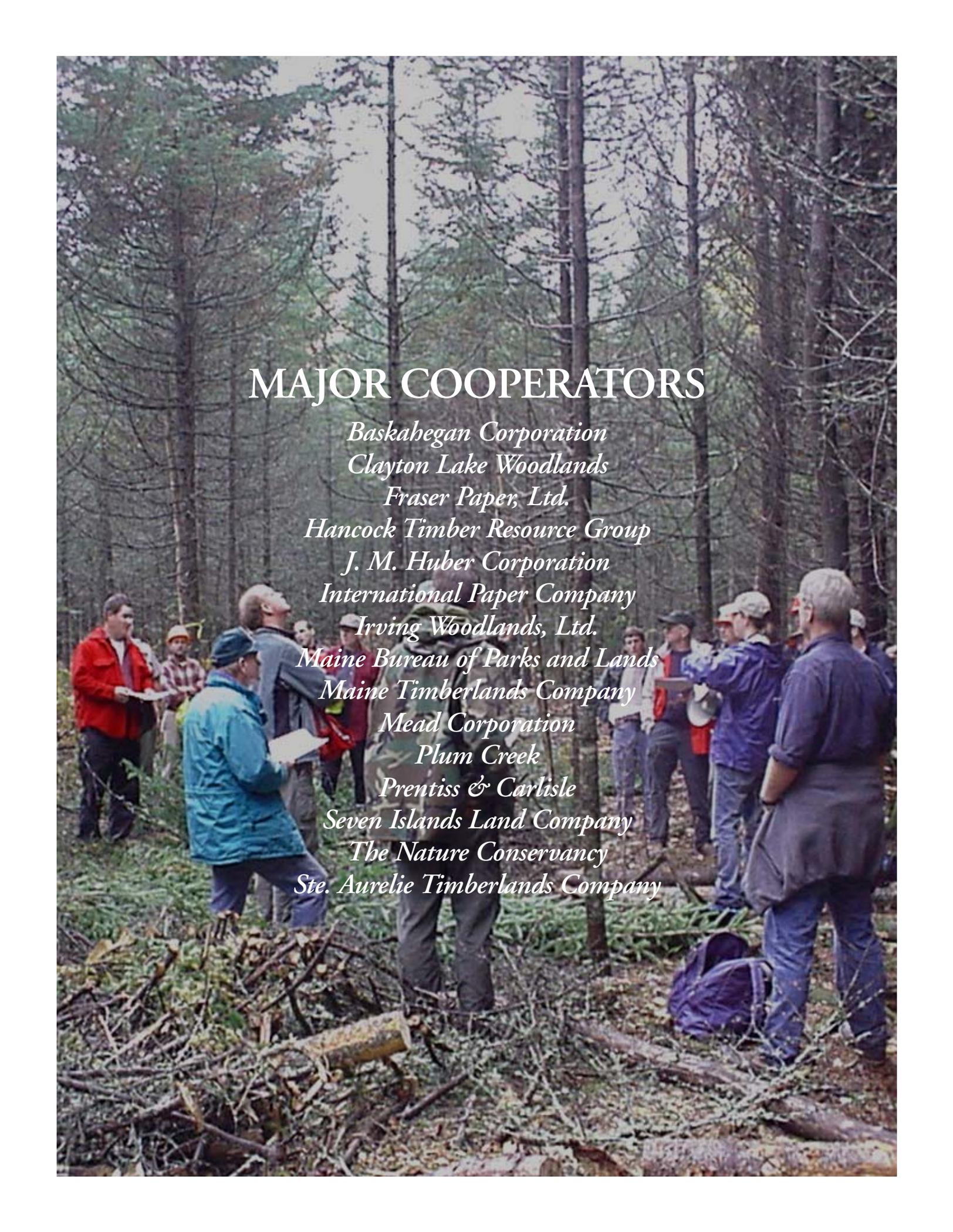
	<i>Page</i>
<i>Water Quality</i>	60
<i>The Effectiveness of Different Buffer Widths for Protecting Riparian Values</i> - John M. Hagan and Darlene Siegel	61
Technology Transfer	66
<i>Journal Publications</i>	66
<i>Articles</i>	66
<i>Research Reports</i>	66
<i>Conference Proceedings</i>	66
<i>Computer Software</i>	67
<i>Theses</i>	67
<i>Presentations</i>	67
Appendices	71
<i>List of Scientific Names</i>	71
<i>List of Contacts</i>	72



The Managed Forests of Maine

FOREWARD

The forest land owners, managers and scientists that make up the CFRU aspire to make a profound difference in the forests of Maine. Millions of people will benefit from the research and products that are created from the cooperative effort between the University of Maine and Maine's forest managers. In this year's annual report, we provide an overview of how our combined efforts have improved our understanding about how to better manage the forests of our state.



MAJOR COOPERATORS

Baskahegan Corporation

Clayton Lake Woodlands

Fraser Paper, Ltd.

Hancock Timber Resource Group

J. M. Huber Corporation

International Paper Company

Irving Woodlands, Ltd.

Maine Bureau of Parks and Lands

Maine Timberlands Company

Mead Corporation

Plum Creek

Prentiss & Carlisle

Seven Islands Land Company

The Nature Conservancy

Ste. Aurelie Timberlands Company



OTHER COOPERATORS

Bethel Furniture Stock, Inc.

H. O. Bouchard, Inc.

Field Timberlands

Finestkind Tree Farms

H. C. Haynes, Inc.

Landvest

F. A. Madden, Inc.

Peavey Manufacturing Company

Pride Manufacturing Company

Robbins Lumber Company

Western Maine Nurseries



CFRU STAFF

DIRECTOR

Robert G. Wagner

Associate Professor of Forest Ecosystem Science

PROFESSIONAL STAFF

H. E. "Chip" Griffin

Communications and Financial Coordinator

Daniel J. McConville

Field and Data Coordinator

KaDonna Randolph

Research Associate

COOPERATING SCIENTISTS

Michael S. Greenwood

Professor of Forest Ecosystem Science

Daniel J. Harrison

Professor of Wildlife Ecology

John M. Hagan

Manomet Center for Conservation Sciences

Robert S. Seymour

Professor of Forest Ecosystem Science

PROJECT SCIENTISTS

William D. Ostrofsky

Associate Professor of Forest Management

Andrew A. Whitman

Manomet Center for Conservation Sciences

Highlights 2000-2001

ORGANIZATIONAL

- The support of the landowners for CFRU has been reaffirmed with an overwhelming vote to increase the dues to \$.055/acre after almost 12 years of no increases.
- Clayton Lake Woodlands joined the CFRU.
- NCASI(National Council of Air and Stream Improvement) became a non-voting member of the CFRU.
- Bob Seymour and John Hagan completed their first year as Cooperating Scientists.
- A strong group of project scientists, research technicians, and graduate students continue to be associated with new and ongoing CFRU projects.
- Organization productivity and deliverables have been increased by 300% over the last two fiscal years.
- The CFRU website has provided a new focus and popular approach for communications with cooperators, as well as reduced costs.

RESEARCH

Silviculture

- The Commercial Thinning Research Network, led by Bob Wagner and Bob Seymour, is addressing one of the CFRU cooperators biggest concerns--finding improved strategies for commercial thinning.
- KaDonna Randolph completed the ThinME modeling effort for the commercial thinning study.
- The Hardwood Silviculture Research Advisory Committee issued its first RFPs for work to improve the management of the hardwood resource.
- Suzhong Tian and Bill Ostrofsky completed a project examining the effects of precommercial thinning on rooting characteristics of spruce and fir in Maine. In general, balsam fir root characteristics were affected more by precommercial thinning treatments than were roots of red spruce.
- The Austin Pond Study continues to provide one of the best opportunities to document the long-term effects of herbicide treatments and pre-commercial thinning (PCT) on spruce-fir stands in the region.

- A wood supply analysis of Maine forests suggested that understanding the yield consequences from tree planting, PCT, and herbicide application remained more important for calculating sustainable harvest levels than a better understanding about stand responses to commercial thinning.

Wildlife

- Examination of marten populations as a means of evaluating landscape effects of forest harvesting and as a coarse filter to assist in long-term forest planning at the scale of townships or larger landscapes is making excellent progress.
- Recent concerns about the Canada lynx and the effect of precommercial thinning in Maine's forests has stimulated a two studies by Dan Harrison.
- Jessica Homyack and Dan Harrison are currently investigating the effects of PCT, at different intervals since thinning, on hare, small mammals, and forest structure in the industrial forests of northern Maine
- John Hagan and Andy Whitman are comparing forest structure, vascular plants, lichens, mosses, microclimate, and ground beetles in retention patches, clearcuts, and mature forests to evaluate to the long term ability of patch retention to retain ecological features in western and northern Maine.
- Ecological features scores suggest mixedwood retention patches buffers > 100m wide are ecologically similar to mature stands.

Water Quality

- Hagan and Whitman completed pre-harvest data collection on a variety of ecological parameters along 15 small headwater streams in western Maine. Different buffer widths were created with harvesting over the past winter. Headwater stream turbidity of undisturbed streams normally have very low sustainability. However, a significant rain event can increase turbidity even when extensive mature intact forest flanks the stream.

Chair's Report

The year 2001 has been a very productive one for the CFRU. Accomplishments for the year include:

New Cooperating Scientists

As described in the revised CFRU Prospectus, Cooperating scientists are selected based on their specific expertise and are responsible for providing leadership and guidance in helping achieve the CFRU's research objectives as well as delivering approved research projects in their field of expertise. It was decided by the advisory committee that four cooperating scientists would be a full compliment. Two scientists, **Mike Greenwood** and **Dan Harrison**, were approved in 1999. **Bob Seymour** and **John Hagan** were nominated and approved for the remaining two positions early in 2001.

New Member

At the fall meeting of 2000 it was moved by two of our members that our bylaws be amended to accept a member of NCASI(National Council of Air and Stream Improvement) as a non-voting member of the CFRU. The motion was approved and NCASI became a non-voting member early in 2001.

Hardwood Silviculture Research Sub-Committee

Late in 2000 a meeting was held to develop a proposal for the establishment of a committee to address hardwood research concerns. The proposal was to outline objectives, terms of reference, research priorities and membership. The proposal was presented and accepted at the October, 2000 meeting. Early in 2001 nominations for membership were made and the committee was complete by May. Membership includes the director of the CFRU, one member from the executive committee, four members from the advisory committee, the Henry Saunders Chair, a member from the Maine Hardwood Association, a member from the USFS and at present, three hardwood researchers.

The committee met for the first time in June to appoint a chair and get some projects underway. One of the first projects was to organize a hardwood workshop/field tour which was held in late September in Woodstock, N.B. It was well attended and well received by forestry personnel from both sides of the border.

A request for research proposals has been prepared and disseminated by Bob Wagner. Hopefully some pertinent hardwood research projects will result.

Revised Dues Structure

In recent years the dues base of the CFRU has eroded somewhat due to much forest land in Maine changing hands and in some cases the new owners/managers not joining the CFRU. This coupled with a need for increased funding in order to maintain the level of research desired by the membership necessitated a revision of the dues structure. Spending was in excess of revenue and the reserve account was quickly being drawn down. A sub-committee was struck to address this situation. Members met twice in June and prepared a recommendation for a revised dues structure. The recommendation was presented at the July 31 advisory committee meeting. It was agreed that the dues be raised to \$0.055 per acre in 2002 and to maintain a reserve equal to 30% of annual dues by 2005.

Fall Field Meeting

A fall field tour was conducted over two days in October. The first portion of the fall field tour was conducted in the Kibby and Skinner study areas featuring the CFRU/NCASI Buffer Strip and Patch Retention Projects. Day two of the tour highlighted projects in the Greenville area. Thanks to those involved in the organization, coordination and hosting of the event.

Research

The various research projects that have been completed and those that are ongoing in 2001 are described in detail in this report. As you will see a great deal is being accomplished in the fields of silviculture, habitat protection and management, growth and yield, riparian zone management and other important fields.

All in all, I would rate 2001 as a successful year for the CFRU. On behalf of the Advisory Committee I would like to thank **Bruce Wiersma** for his participation and the University's continued support of the unit; **Bob Wagner** and the CFRU staff for the excellent work they have done in running the unit; and the cooperating and project scientists for the timely and pertinent research they are carrying out in working toward achieving the goals and objectives of the unit.



Brian Higgs
Chair, CFRU Advisory Committee

Dean's Report

The Cooperative Forestry Research Unit (CFRU) has completed another successful year. The core of this success rests with the cooperators themselves, their active participation in the research efforts, the key faculty and scientists who are actually carrying out the work and, most assuredly, the very able leadership provided by the CFRU director and capable staff.

It has been a good year. The support of the landowners for CFRU has been reaffirmed with an overwhelming vote to increase the dues to \$.055/acre after almost 12 years of no increases. We also saw a new cooperator in Clayton Lake and two new "virtual" faculty in **Bob Seymour** and **John Hagan**.

I want to take this opportunity to thank **Peter Triandafilou** for his dedication and leadership over the last six years. Peter helped guide the CFRU through major changes and did so while carrying out his own very demanding job with Huber Corporation. We are deeply indebted to Peter for all he has done. I also want to thank **Brian Higgs** for his very able leadership during the last two years and welcome **Doug Denico** as our new Chair.

I believe the future of the CFRU is bright. The research needs remain. The appreciation of the forest landowner community of the need for research and what the research

process entails is sophisticated and focused. We at times in the academic community may take this level of sophistication by our cooperators for granted since we have become used to it over the years, but it is unusual, and should be valued. Research is a long-term process with, by nature, uncertain results. For cooperators, who operate in a much different world, to have as profound understanding of both the opportunities as well as the limitations of the research process can, in no small way, be attributed to CFRU. I offer my compliments to our cooperators as well as my thanks.

We still face challenges in the future including shifting land bases and ownership, continued political dissent on the forest and increasing demands of all types on the forest resources. The CFRU is needed now more than ever. It has my complete support and I look forward to working with the faculty, staff and cooperators in the coming year.



Bruce Wiersma
Dean, College NSFA

Director's Report

I am happy to report that the new CFRU continues to develop and build on the successful restructuring that occurred two years ago. The research projects developed to date reflect the cooperator's highest research priorities identified in our five-year plan. The CFRU's research effort is currently balanced between 1) *Silviculture* - principally the commercial thinning network; 2) *Wildlife* - focused currently on Marten habitat supply and lynx/hare research; and 3) *Riparian and patch retention* - examining buffer strip width effects and the ecological value of patch retention. Our success in this regard has come from attracting some excellent Cooperating Scientists to the unit. **Dan Harrison** continues to lead our productive wildlife research effort. **Mike Greenwood** is winding down his CFRU research in genetics and developing new proposals around seed production and regeneration issues associated with the new commercial thinning installations. The Advisory Committee elected **Bob Seymour and John Hagan** as Cooperating Scientists this year. Bob Seymour returns to the unit with his nationally recognized silviculture expertise and has been invaluable in helping to establish our commercial thinning efforts. CFRU's new partnership with **John Hagan** of **Manomet Conservation Sciences** adds a new dimension to the word "Cooperative" in CFRU by establishing a formal relationship outside of the university with his well-known forest research effort in Maine.

Member support for these new research directions and associations with new researchers was reflected this year when the CFRU Advisory Committee voted the first dues increase since the late 1980s. At our July meeting, the Advisory Committee voted nearly unanimously to raise dues from \$0.05/A to \$0.055/A. This decision was made during one of the worst wood products markets in a number of years, reflecting the importance of the CFRU to its members and the importance of maintaining the long-term financial viability of the unit. I wish to thank the **Executive Committee (Brian Higgs, Peter Etheridge, and Peter Triandafillou)** and the Financial Restructuring Committee for their hard work during several long summer meetings. Although several challenges remain, particularly how our current dues structure affects our largest members, we will continually strive to adapt the CFRU to the changing needs and expectations of its members.

Toward that end, efforts this year have sought to stimulate new research in the area of hardwood silviculture. With

the help of several members, a **Hardwood Silviculture Research Subcommittee** was initiated. The first meeting was held in June, a CFRU co-sponsored hardwood silviculture meeting held in September, and a request for research pre-proposals sent out across the region. I look forward to new research projects derived from this effort helping CFRU members to address this important research priority over the next several years.

Rapidly changing patterns of forestland ownership continues to be a major challenge for the unit. Conversion of forestland from owners focused on longer-term stewardship to those focused on shorter-term financial returns continues to erode acres represented in the unit. As lands are sold, we are continually seeking new members that share a long-term commitment to Maine's forests. In this regard, we are very happy to welcome **Clayton Lake Woodlands** as a new CFRU Cooperator this year. The addition of Clayton Lake brings the total acres represented by the CFRU to about 7.5 million.

Two personnel changes occurred this year that deserve special mention. **KaDonna Randolph** left the CFRU this summer to pursue further graduate education. She spent a very productive year developing the ThinME model that was released this year. Bob Seymour and I thank her for a truly excellent effort. **Carl Haag** left Plum Creek this year. I want to personally thank Carl for his energy, vision, and leadership during the CFRU transition over the past several years. Many of the ideas for the re-structuring, for new research projects, and for the new partnerships the CFRU has developed originated from Carl's strong commitment to the mission of the CFRU.

I look forward to another productive year, working closely with **Chip Griffin, Dan McConville**, our Cooperating Scientists, and our member organizations to keep the CFRU moving forward.



Robert G. Wagner
CFRU Director

To:

Our Fellow COOPERATORS.

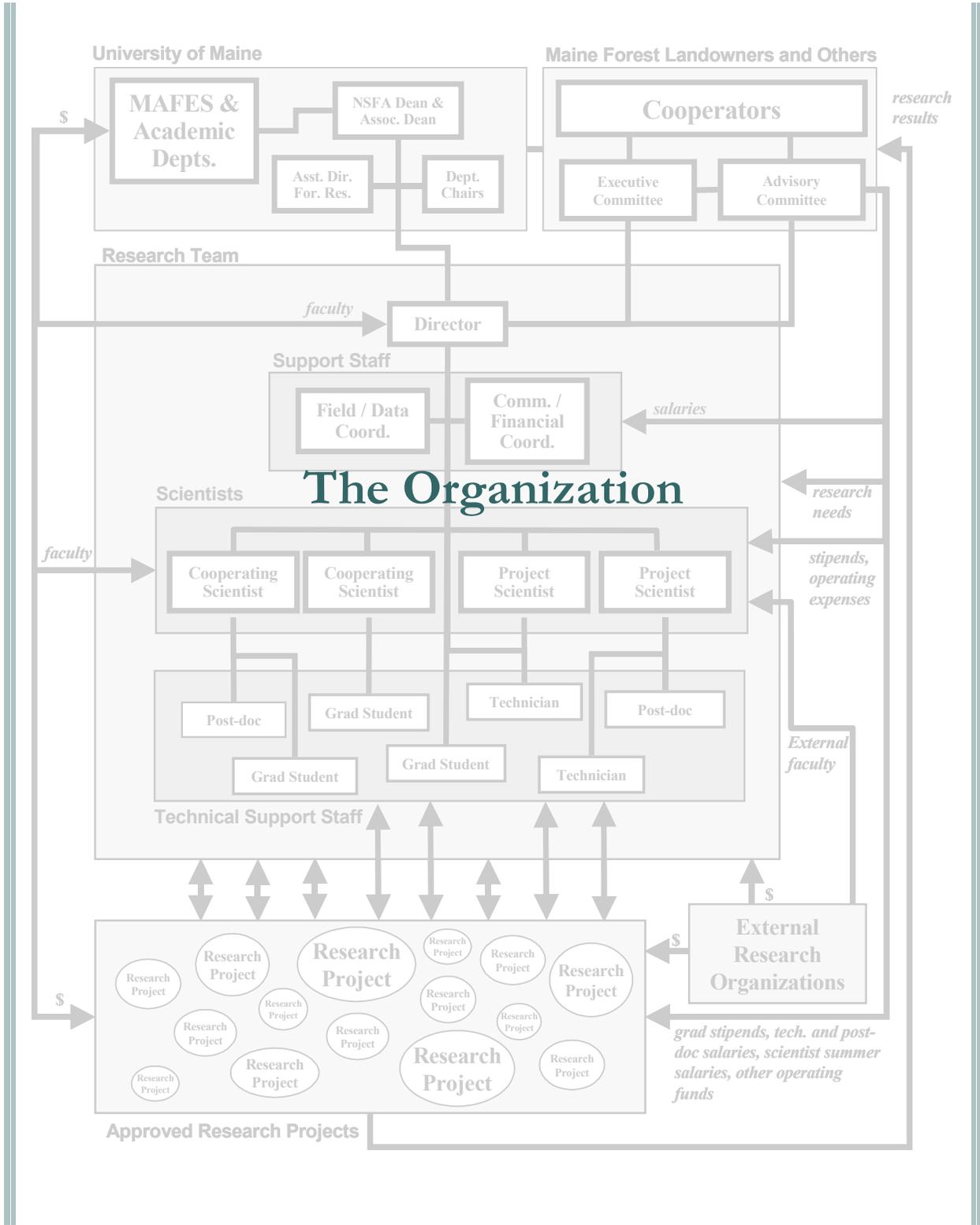
The CFRU is one of the oldest industry / university forest research cooperatives in the United States. Funding for this organization comes from private industrial and non-industrial organizations, public agencies, and individual contributors who want to solve specific forestry problems or generally want to advance forest management in the state of Maine through scientific research.

Over the last 27 years, we have seen dynamic changes to forestry in the state of Maine. During this time, the CFRU served forest managers and landowners in the state by conducting research that addressed their most pressing problems. These projects resulted in the publication of over 500 CFRU sponsored publications. Several long-term research sites (e.g., Weymouth Point and Austin Pond) were also established and continue to be maintained.

We have entered into a new century, and our mission continues to be *to conduct applied scientific research that contributes to the sustainable management of Maine's forests for desired products, services, and conditions.* With current support from our 26 member organizations across the state of Maine, CFRU research is focused on a variety of problems facing the state's forest managers and landowners. Commercial thinning, buffer-strip management in riparian zones, snowshoe hare and marten habitat issues, the long-term effect of herbicides and precommercial thinning, precommercial thinning influences on roots, and the ecological value of patch retention in harvested stands are currently being pursued by our researchers.

Regular quarterly meetings, workshops, and conferences continue to be sponsored by the CFRU and are described in this report. Technical advice and recommendations to cooperators continues to be a benefit of membership and has been a hallmark of our organization since its earliest days. Additionally, our research results are rapidly communicated to our members via regular presentations, field tours, conferences, research reports, annual reports, web site, and articles in scientific journals. This annual report documents progress made by the CFRU during fiscal year 2000-2001.

Cooperative Forestry Research Unit



Financial Report

CHIP GRIFFIN, *University of Maine*

Sound fiscal management by all the project scientists and CFRU staff has resulted in returning \$21,053 or 5% of its FY2001 budget to the general fund at year end. The new organization structure continues to control the amount of fixed salary dollars and increases funds available for discretionary spending on research projects. This action allows the unit to more easily respond to changing research priorities and changes in the land base. Scientists, who come from both inside and outside the University of Maine, continue to submit proposals for Advisory Committee approval, based on established research priorities.

Loss of acreage continues to be a concern for the CFRU even with the addition of our new cooperator Clayton Lake Woodlands. Potential research funds continue to be at risk from land sales and continued financially ambitious spending levels. In FY2001, the organization spent 136% of its 2000 contributions, and has committed 101% of its 2001 contributions.

The monetary reserve of the CFRU is at a historic low. As a result, the Advisory Committee appointed a Financial Subcommittee in the summer of 2001 to examine a financial restructuring. Subcommittee members and staff examined several scenarios, and developed a suite of financial solutions. The following recommendations were approved by the Advisory Committee as a result of meetings in summer 2001:

- Raise cooperator dues per acre to \$.055/acre in FY 2002
- Future budgets must be linked to dues income
- Maintain a reserve equal to 30% of the previous year's dues

This policy is intended to provide a financial plan that can be used to develop annual budgets and better plan for future levels of research activity. Annual budgets and dues rates will continue to be approved annually by the CFRU Advisory Committee.

Table 1. FY 2001 Expense Report by Project

Balance on Hand	\$ 155,087.00
Investments	\$ 33,452.00
Contributions FY01	\$ 432,059.00
Vehicle Sale	\$ 4,800.00
Unspent FY00 Budget Returned to Control	\$ 61,945.00
FY 2002	\$ (436,989.00)
Unspent FY01 Budget Returned to Control	\$ 21,053.00
Unallocated Balance on Hand 09/30/01	\$ 271,407.00

Cooperative Forestry Research Unit

Table 2. FY 01 Dues by acre and payments received

Cooperator	Acreage	2001 Dues	2000 Dues	FY Total
Baskahegan Lands	101,629	\$ 5,081		\$ 5,081
Bethel Furniture Stock	2,500	\$ 125		\$ 125
Bouchard, H. O., Inc.	4,000	\$ 200		\$ 200
Clayton Lake Woodlands	245,000	\$ 12,250		\$ 12,250
Field Timberlands	2,000	\$ 100		\$ 100
Finestkind Tree Farms	2,000	\$ 100		\$ 100
Fraser Papers	238,880	\$ 11,944		\$ 11,944
Maine Timberlands Company/GNP	326,915	\$ 16,346		\$ 16,346
Hancock Timber Resource Group	301,295	\$ 15,065		\$ 15,065
Haynes, H. C., Inc.	4,000	\$ 200		\$ 200
Huber, J. M. Corporation	320,000	\$ 16,000		\$ 16,000
International Paper Company	1,380,267	\$ 69,013		\$ 69,013
Irving, J. D. Ltd.	1,550,000	\$ 77,500	\$ 38,750	\$ 116,250
Landvest	4,000	\$ 200		\$ 200
Madden, F. A., Inc.	4,000	\$ 200		\$ 200
Maine Bureau of Parks and Lands	349,414	\$ 17,471		\$ 17,471
Mead Corporation	549,081	\$ 27,454	\$ 13,755	\$ 41,209
Peavey Corporation	170	\$ 137		\$ 137
Plum Creek Timberlands	863,000	\$ 43,150		\$ 43,150
Prentiss and Carlisle	81,500	\$ 4,075		\$ 4,075
Pride Manufacturing	no forest	\$ 468		\$ 468
Robbins Lumber Company	30,000	\$ 1,500		\$ 1,500
Ste. Aurelie Timberlands	60,000	\$ 3,000		\$ 3,000
Seven Islands Land Company	880,000	\$ 44,000		\$ 44,000
The Nature Conservancy	185,000	\$ 9,250	\$ 4,625	\$ 13,875
Western Maine Nurseries, Inc.	2,000	\$ 100		\$ 100
TOTAL	7,488,651	\$ 374,929	\$ 57,130	\$ 432,059

Advisory Committee

CHIP GRIFFIN, *University of Maine*

The Advisory Committee governs all the affairs of the CFRU and helps ensure that ongoing research efforts continue and new research ideas are developed and implemented.

We thank the officers, **Brian Higgs** (Baskahegan) - Chair, **Peter Etheridge** (JD Irving) - Vice Chair, **Peter Triandafillou** (Huber) - Financial Officer for their hard work and dedication to the CFRU.

The Advisory Committee met four times in FY2001 (October 3, 2000; January 22, 2001; May 3, 2001, and July 31, 2001). A highlight of the year was the annual CFRU field tour conducted on October 3-4, 2000. The field tour was conducted over two days from the Grand Summit Hotel at Sugarloaf, USA. The first portion of the fall field tour was conducted in the Kibby and Skinner study areas featuring the CFRU/NCASI Buffer Strip and Patch Retention Projects. Hagan, Whitman, and Haag lead this portion of the tour. Day two of the tour highlighted projects in the Greenville area. The PCT and Snowshoe Hare Effect project discussion was lead by Harrison and Homyack. Wagner, Seymour, McConville, and Randolph discussed the Commercial Thinning

Project, and Bob Shepard discussed his Wood Quality Project.

ADVISORY COMMITTEE 2001

Si Balch, Mead Corporation
John Brissette, USFS NE Forestry Experiment Station
John Cashwell, Seven Islands Land Company
Doug Denico, Plum Creek Maine Timberlands, LLC
Peter Etheridge, J. D. Irving, Limited
Anthony Filauro, Maine Timberlands/GNP
Chuck Gadzik, Irving Woodlands LLC
Brian Higgs, Baskahegan Company
Phil Malerba, International Paper Company
Bill Miller, Prentiss and Carlisle
Jacques Morin, Ste. Aurelie Timberlands Company
Thomas A. Morrison, Maine Bureau of Parks & Lands
Nancy Sferra, The Nature Conservancy
Bill Sylvester, Clayton Lake Woodlands
Peter Triandafillou, Huber Cooperation
Kevin Topolniski, Fraser Papers Inc.
Paul C. Van Deusen, NCASI
Henry Whittemore, Hancock Timber Resource Group
G. Bruce Wiersma, Dean, College of NSFA



Figure 1. Cooperators, scientists, staff, and guests attending CFRU field tour.

Field and Data Report

DANIEL J. McCONVILLE, *University of Maine*

FIELD COORDINATION

Field coordination efforts focused on the continuation of the Commercial Thinning Research Network (see pages 23-35). The winter of 2000-2001 was spent writing thinning prescriptions, marking the trees for harvest, and overseeing harvest operations. Over the winter, the first 5 research sites were thinned. During the summer 2001 the final 5 commercial thinning sites were installed and measured. In addition, the thinned sites were re-measured after the harvest.

As the workload with the Commercial Thinning project declines a greater effort will be placed on providing support for other CFRU projects. Much of the support will be targeted towards monumenting CFRU study sites on the ground and with GPS. In addition, historic CFRU study sites such as Weymouth Point and Austin Pond will be re-marked with more permanent plot markers. GPS

will also be utilized to establish coordinates for important study features.

DATA COORDINATION

One of my primary goals is to develop and implement a data management system to ensure that all CFRU data is warehoused in a safe, well-organized manner. This past year was spent researching data management systems that would be appropriate for the CFRU. Several data management systems were evaluated and two were chosen that fit our needs. One is a directory system for organizing data files; the other is a relational database system that would be accessible through the internet. These systems will be tested in the coming year using the Commercial Thinning and Weymouth Point data. Evaluations will be made on cost, ease of use, and ability to scale to large projects.



Figure 2 Dan McConville marking trees in thinning research plots on Mead lands

Communications Report

CHIP GRIFFIN, *University of Maine*

The objective of the new CFRU communications plan is to provide cooperators with a regular output of research results from CFRU projects in a form that cooperators find most useful. The cooperators in this program “bear” from the unit on a regular basis, and scientists in the unit are regularly encouraged to turn out interim products from their work.

Development of a “pull” communications system with a strong web presence has served as the center of the new communications system. Cooperators agreed to no future paper printing and mailings, which resulted in considerable cost savings to the program. In the first year of the new approach, Cooperators have voiced their approval of the new web access idea. Completion of the web page, a publications schedule, and maintenance of a complete email list for each member company has been achieved.

The CFRU switched exclusively to web delivery in 2000. Where appropriate, traditional and other methods of the delivery of results continue to be used. Printed and web based publications have been standardized and updated to reflect a more contemporary look. An emphasis is placed on publications that are more user friendly and image conscious. Below is an overview of communications activities by subject area:

WEB PAGE. The new CFRU web became not only a site showcasing research and educational material; it also became a vehicle to better serve the requirements of the cooperators. Annual reports, research notes, research reports, and other research results are now available exclusively on-line.

The web page continues to be a work in process, and has been modified several times since its launch. Additional password protection has been added, as well as new sections for more in depth current research update information.

Efforts are underway to enter a more comprehensive list of abstracts of past CFRU publications for website access. This body of information will be used in an on-line database to be completed this summer.

The use of limited access pages has allowed both front-line foresters and Advisory Committee members 24 hour access to publications and meeting materials. This move alone revealed efficiencies by means of reduced printing costs, postage costs, and faster publication cycles. Information distribution lists utilizing email, mail, and fax lists are used to notify cooperators when new postings are available on the web. The following products provide the core of CFRU communication activities in addition to the website.

CD ROMs. Any documents on the web that are requested by specific cooperators throughout the year are available on CD ROM.

RESEARCH NOTES SERIES. In August, CFRU scientists began providing cooperators with 1-4 page research notes of ongoing and new research projects. These research notes provide quick updates by researchers and in a more readable form for cooperators. This ongoing series is in web format only.

- Partial Harvesting Guidelines for Maintenance of Marten and their Primary Prey, October 2000
- Monitoring of Stream and Soil Solution Element Concentrations at Weymouth Point, November 2000
- Literature Synthesis of the Effects of Forest Management Activities on Riparian Biota of Northeastern North America, April 2001
- Arsenal Herbicide Reduces Height Growth in Red Spruce and Balsam Fir, September 2001

RESEARCH REPORTS. The CFRU has a tradition of providing detailed project reports to cooperators and the public at the completion of research projects. CFRU Research Reports, like all other publications, have been standardized and updated to reflect a more consistent and contemporary look, and are in web format only. Most of these publications will continue to carry MAFES publication numbers for university referencing.

- Hardwood Site Classification Field Guide for Maine, December 2000

- Literature Synthesis of the Effects of Forest Management Activities on Riparian and In-stream Biota of New England, May 2001

QUARTERLY ADVISORY COMMITTEE

MEETING. Quarterly CFRU Advisory Committee meetings have been and will continue to be the most important form of communications about CFRU research. The detailed minutes from these meetings (available online) provide an organizational history of the unit and an update of current research results. Meetings were held:

- October 3-4, 2000 Field Tour
- January 24, 2001
- May 3, 2001
- July 31, 2001

ANNUAL FIELD TOUR. A fall field tour was conducted over two days from the Grand Summit Hotel at Sugarloaf, USA. The first portion of the fall field tour was conducted in the Kibby and Skinner study areas featuring the CFRU/NCASI Buffer Strip and Patch Retention Projects. Hagan, Whitman, and Haag lead this portion of the tour. Day two of the tour highlighted projects in the Greenville area. The PCT and Snowshoe Hare Effect project discussion was lead by Harrison and Homyack. Wagner, Seymour, McConville, and Randolph discussed the Commercial Thinning Project, and Shepard discussed the Wood Quality Project.

ANNUAL REPORT. The annual report will continue to provide a summary of the research conducted each year by the CFRU. Financials, technology transfer, and other administrative reports will also be highlighted. CFRU Annual Reports, like all other publications, have been standardized and updated to reflect a more user

friendly, consistent and contemporary look on the web.

CONFERENCES AND WORKSHOPS. Provide a valuable means of focused communication among cooperators, scientists, and others about topics of common interest. This year the CFRU cosponsored "Forestry and the Riparian Zone" on October 26, 2000 at Wells Conference Center in Orono, Maine.

POSTERS/PORTABLE EXHIBITS. A portable display highlighting the research unit's past, ongoing and planned research was designed and updated for use at university events, conferences, and workshops. A soft copy of the poster has also been used in the past year. Current posters were featured at:

- Nutting Hall CFRU display April 2001
- Forestry and the Riparian Zone, October 2000
- SAF National Meeting, November 2000
- NESAF Meeting March 2001
- Irving Science Forum, April 2001

LITERATURE REQUESTS. Literature requests deliver past and present non-web based CFRU products. Most of these requests are for past reports. Some have been delivered via CD ROM and as email PDF. attachments. Cooperators and outside requestors accounted for over 230 transactions.

PROGRAM BROCHURE. Completed and published in April 2001 for use as a web and hard copy, the brochure is a full-color four fold document.

EXTERNAL PLACEMENT. The Bangor Daily News Forest Products Week section featured an Austin Pond article in October 2000.



SILVICULTURE

The art of cultivating a forest...

Commercial Thinning Research Network

ROBERT G. WAGNER, ROBERT S. SEYMOUR, AND DANIEL J. McCONVILLE *University of Maine*

CFRU members identified a better understanding about commercial thinning strategies and growth and yield responses following commercial thinning as top research priorities in 1999. As a result, the CFRU Commercial Thinning Network was established in 2000. This major CFRU project is divided into two phases, each accomplishing separate objectives: *Phase I*—develop a set of interim guidelines for commercial thinning that can be used by CFRU members and *Phase II*—establish a statewide network of research sites on cooperator lands that can be used to test and refine the interim guidelines. This year marked the second year of activity for the network.

Substantial progress was made in both phases of the network this year. This progress was made possible by advice and guidance provided by our Commercial Thinning Subcommittee (names listed in 2000 CFRU Annual Report). The following describes the accomplishments of Phase I and II for this year.

PHASE I

Interim Guidelines for Commercial Thinning in Spruce-fir Stands. CFRU Research Associate, KaDonna Randolph, led this effort over the past year and a half, working tirelessly to complete the first product developed from Phase I. The product is called ThinME (short for “Thin Maine”). ThinME is a graphical analytical tool for making commercial thinning prescriptions in Maine’s spruce-fir stands.

After completing the first version of ThinME, KaDonna left the CFRU in July to return to graduate school at the University of Tennessee. The ThinME CD (Figure 3) was released to CFRU Cooperators at the July 31 Advisory Committee meeting. The release of ThinME completes Phase I of the project as proposed last year. We thank members of the Commercial Thinning Subcommittee who worked with KaDonna to review and refine early drafts of ThinME before the final release.

The significance of ThinME was revealed this year when KaDonna was asked to present ThinME as a featured keynote presentation at an international conference on thinning that was held in Quebec City in September. A paper

about ThinME was delivered and published in the conference proceedings (Randolph et al. 2001).

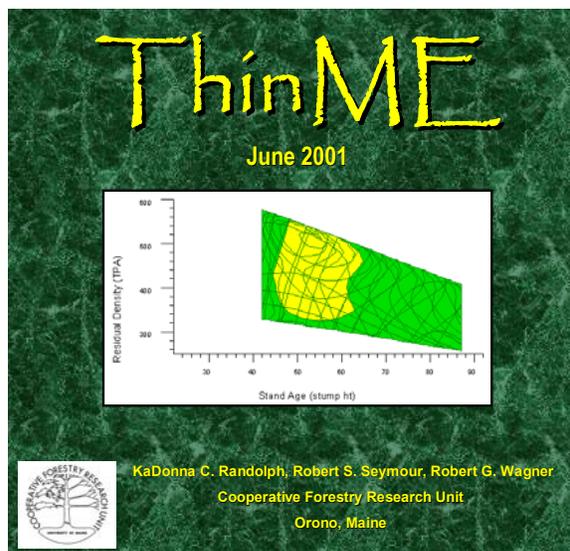


Figure 3. Cover of the ThinME CD.

ThinME Overview. The conceptual basis of ThinME was reviewed extensively in the 2000 CFRU Annual Report. In general, ThinME is an interactive, graphical way for users to digest a comprehensive array of stand growth simulations for a particular set of initial conditions (Figure 4). Based on an initial stand structure or tree list, a set of simulations involving a complete range of residual stand density, timing, and method of commercial thinning, is made to create a database of five performance indicators:

- Mean annual increment
- Average piece size in the final harvest
- Final harvest cost
- Total wood costs
- Net present value

ArcView is then used to interpolate within this database and produce contour “maps” or *nomograms* of these five variables based on *thinning intensity* (residual density or percent removal, depending on stand history) and *final harvest age* (the two major axes of the nomogram). For

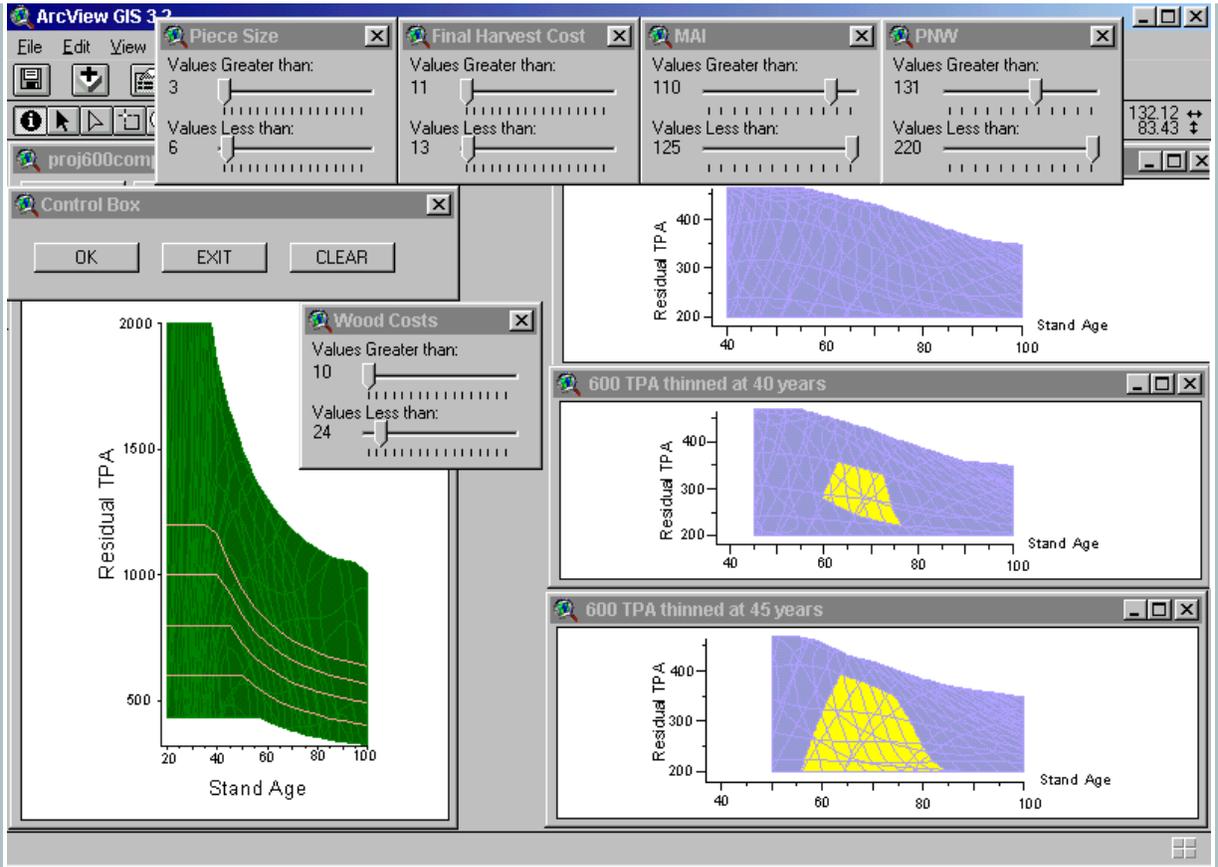


Figure 4. Example of ThinME ArcView interface with nomograms.

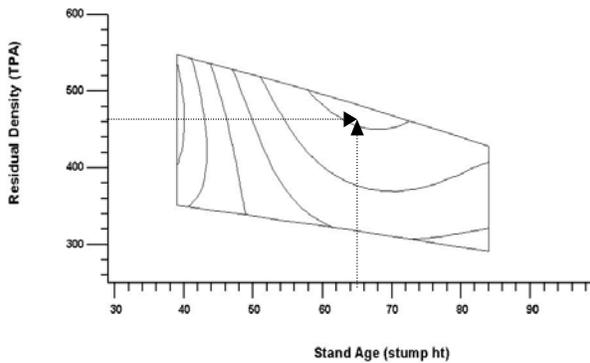


Figure 5. Example nomogram for mean annual increment.

example, the nomogram shown in Figure 5 shows a rising pattern of mean annual increment that peaks at a density of about 520 trees per acre, at a final harvest age of about 65 years.

ThinME allows users to overlay any combination of these nomograms for a given set of initial conditions, define the boundary between an acceptable and unacceptable outcome for each, and create a final “decision space” that represents the region on overlapping nomograms that satisfies all objectives simultaneously. The example in Figure 6 (from the ThinME Users Manual) illustrates a simple case with only two variables (MAI and final harvest cost).

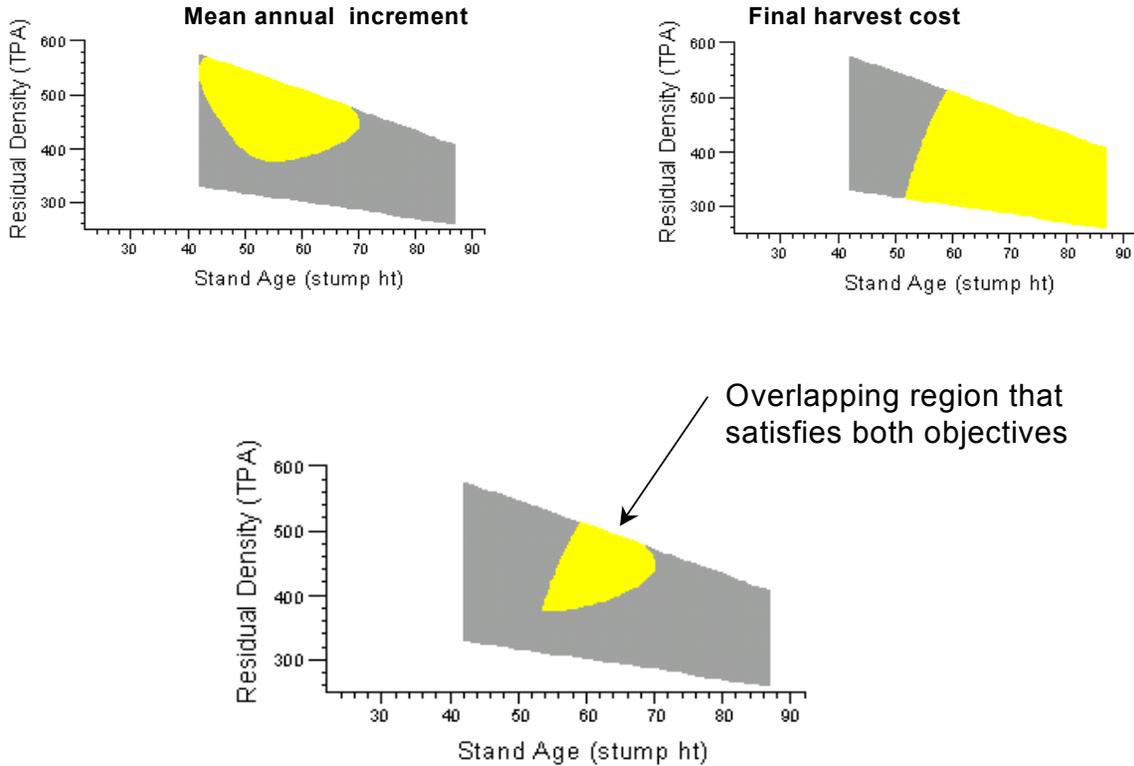


Figure 6. Overlapping nomograms illustrating a simple case with only two variables (MAI and final harvest cost).

Simulation Model Comparisons. Early in the conceptual development of ThinMe, activities focused on developing and testing the interface using the data derived from the Nova Scotia Softwood Growth and Yield Model (GNY) yield table generator (NSDNR 1993) as the growth simulator on hypothetical starting conditions. In recognition of GNY's inherent limitations for handling a diverse array of stand conditions, we evaluated two other

models currently in use throughout the region: FIBER, a stand table projection model (Solomon et al. 1995) and the Forest Vegetation Simulator (FVS) (Bush 1995) which uses NE-TWIGS, an individual-tree growth simulator. Biological and practical criteria were used to evaluate the models' suitability for creating the commercial thinning guide (Table 3).

Table 3. List of biological and practical criteria used to evaluate suitability of three growth and yield models for ThinME devel-

Biological	Practical
Reasonable height growth	Variety of thinning methods
Reasonable diameter growth	Expandable for including new options in guide
Ability to handle saplings	Ways to study diameter distributions
Capability to match actual stands	Ways to examine species composition
Self-thinning behavior	Technical support
Capacity to include mixed species stands	User interface efficiency
	Data input requirement

Table 4. Evaluation scores for FIBER, FVS, and GNY models based on biological and practical criteria.

	Model		
	FIBER	FVS	GNY
Unweighted Total	51	59.2	39
Weighted Total	119	141.3	95
Percent attained of weighted total	76.8%	91.2%	61.3%

To gain experience with all models under a comparable framework, we attempted to apply them to two typical stands, one with PCT and the other without. After weeks of trials, FVS ranked as the most suitable model for creating ThinME (Table 4). The simplicity of the GNY ranked it high in user interface efficiency and data input requirement, but low in other attributes considered necessary for this particular task. FIBER fell short in its ability to handle saplings and produce reasonable height growth, two important factors. FVS had no obvious weaknesses and was selected for use in creating the database used in ThinME.

Initial Model Applications. Based on extensive feedback from the Commercial Thinning Subcommittee, we decided to develop nomograms for the following conditions:

- Stand History: stands with and without a pre-commercial thinning
- Site Index: 40, 50, 60, 70, and 80 if pre-commercially thinned; 40, 50 and 60 otherwise
- Initial Density, if pre-commercially thinned: 500, 750, and 1000 trees per acre
- Thinning Method, if without pre-commercial thinning: Crown and Low

The stand structure and composition data used to initialize the growth model came directly from Phase II research plots established last year. International Paper’s Alder Stream site was used to represent the 500 trees per acre PCT stand; Plum Creek’s Ronco Cove site represented the 750 and 1000 densities. Seven Island’s Sarah’s Road site was used to represent stands without a prior history of precommercial thinning (PCT).

Preliminary Conclusions. ThinME offers a new analytical approach for CFRU cooperators to evaluate the suitability of a wide array of commercial thinning prescriptions for spruce-fir stands. This flexibility, however, makes the tool relatively complex, and therefore will require some period of use by cooperators until the strengths and weaknesses of ThinME (version 1.0) are fully evaluated. We have requested feedback from Cooperators as they gain experience with ThinME. We will use this feedback as we develop plans for developing future versions of the program.

From a research perspective, ThinME offers an opportunity to examine a variety of commercial thinning scenarios and observe general patterns of behavior that can be used to draw general conclusions about stand responses to commercial thinning. Observations to date offer some preliminary patterns:

- In PCT stands, delaying commercial thinning until ten years after the stand reaches 40 ft in height provides the most favorable values for all variables.
- In the natural stands, delaying a low thinning until ten or fifteen years after the stand reaches 50 ft tall produces the lowest final harvest costs and fewest trees per cord. Highest NPVs are achieved by implementing the low thinning five or ten years after the stand reaches 50 ft tall. Delaying a crown thinning until ten or fifteen years after the stand reaches 50 ft produces the lowest final harvest costs and fewest trees per cord. Highest NPVs and MAIs are achieved when the crown thinning is implemented within five years of the stand reaching 50 ft.

- Total wood costs are more affected by commercial thinning intensity than final harvest age and tend to decrease with high levels of removal at commercial thinning.
- NPV, piece size, and final harvest costs are more affected by final harvest age than by commercial thinning intensity. Long rotation lengths produce the fewest trees per cord and lowest final harvest costs. NPVs are highest with short or moderate rotation lengths.
- MAI is more affected by final harvest age than by commercial thinning intensity in the natural stands. In PCT stands the reverse is true, as MAI is more affected by commercial thinning intensity than by final harvest age. MAIs are highest with moderate levels of removal in natural stand crown thinnings and highest with light levels of removal in the PCT stands. MAI is unaffected by the intensity of removal in the natural stand low thinnings.
- In the natural stands, the highest MAIs and NPVs are attained by crown thinning rather than by low thinning. Lowest final harvest costs result from low thinning. Total wood costs are comparably low for both the crown and low thinnings. The best type of thinning for piece size depends upon the timing of commercial thinning and site index.
- PCT stands outperform natural stands for piece size only. Final harvest costs are comparable, but NPV, total wood cost, and MAI are all superior in the natural stands for a given site index. Only site indexes 60, 50, and 40 ft (18.4, 15.2, and 12.2 m) (50-year base) were compared.

User's Guide. The ThinME CD includes a complete User's Guide describing how to use the program. In addition, a number of supporting technical documents are provided as Appendices to help users better understand the technical foundations on which the program was built. Documents include on the ThinME CD include:

- A 25 page User's Guide;
- A 16-page tutorial that illustrates how to use the model for stands both with and without prior PCT;
- A 43-page Appendix with graphs that show

the simple one-dimensional responses of all variables incorporated in ThinME, over the range tested;

- An Appendix that describes in detail the assumptions and model used to compute harvesting costs based on piece size and other factors;
- All the ArcView files needed to conduct multi-dimensional analyses.

Copies of ThinME are available to all CFRU members by calling **Chip Griffin** at 207-581-2893 or emailing chip_griffin@umenfa.maine.edu.

PHASE II

Establishment of Commercial Thinning Research Plots in Spruce-Fir Stands. One of the most significant accomplishments of the Commercial Thinning Research Network has been establishing a network of research plots on CFRU cooperator lands across the state. As Boris Zeide indicated this year in an article describing the state of knowledge about forest thinning, all of our quantitative knowledge about thinning and growth in forest stands since 1860 has come from permanent plots (Zeide 2001). Zeide believes that once such permanent plots are established, they "deserve to be treasured as living national monuments."

Few permanent plots addressing questions about commercial thinning exist in Maine or the Northeast. To help fill this gap, CFRU continued to establish a set of long-term research installations at twelve locations across the state. The objective was to establish six study sites in each of two separate experiments. The questions being addressed in these experiments include: (1) For spruce-fir stands that have not received PCT, what is the influence of method of thinning and residual density on overall stand responses? and (2) For spruce-fir stands that have received PCT, what is the influence of timing of first commercial thinning entry and residual density on stand responses? Data obtained from these experiments also are intended help test and refine future versions of the ThinME model, as well as address other silvicultural and ecological questions of interest.

Details about this year's accomplishments on these two experiments are described below. A paper describing the design and accomplishments of Phase 2 also was presented at the international thinning conference held in Quebec City in September (Wagner et al. 2001).

Table 5. Attributes and conditions sought for study sites in Phase II, Experiment #1.

Attribute	Conditions sought
Site quality	Good to excellent (Briggs site class 1, 2, or 2/3)
Species composition	Dominated by balsam fir or spruce species
Stand age	Ready for first commercial harvest
Stand history	Naturally regenerated from stand-replacing disturbance, received PCT treatment (generally 15-20 years ago), received a herbicide release treatment prior to and/or following PCT
Stand structure and initial density	Well-stocked, single-cohort, with relative density > 0.25 (Wilson et. al 1998)

Experiment #1: Influence of timing of entry and residual density in previously PCT'd spruce-fir stands

Site selection and establishment. The objective for this experiment during the 2000 and 2001 field seasons was to establish 6 study sites on CFRU cooperator lands across the state of Maine. With substantial help from cooperators, we were able to successfully establish three sites during the 2000 field season and the remaining three were established this year. Thanks to all cooperators for their terrific assistance with this phase of the study.

Initial conditions sought for each site are shown in Table 5. Ages of the sites selected range from 23 to 42 yrs and initial relative density ranged from 0.29 to 0.36 (Table 6). All sites are dominated by balsam fir and had pre-treatment volumes ranging from 21.2 to 28.5 cords/A. Locations of all Commercial Thinning Network sites now established are shown in Figure 7.

Thinning treatments. The seven treatments being examined consist of a 3 X 2 factorial combination of timing of entry (0, 5, and 10 yrs from present) and amount of density reduction (33% and 50% reduction in relative density) plus an untreated control. All thinning is being done using single-grip processors and conventional harvesting methods (Figure 8).

Each thinning prescription was developed and individual trees marked for removal based on an analysis of pre-treatment data from each plot. Relative density was calculated for each plot according to Wilson et. al (1999). Although great care was taken to ensure that all plots were similar to one another on each site, some variation in initial plot conditions was inevitable. To ensure that the 33 and 50% removals did not create thinned plots of similar condition due to these initial differences, we ranked each plot based on initial relative density. Treatment assignments were then made based on this ranking. Plots with the 1st and 5th highest pre-treatment

Table 6. Description of PCT study sites.

Site Name	Ronco Cove	Macwahoc	Alder Stream	Lazy Tom	Weeks Brook Rd.	Comp. 23A
Landowner	Plum Creek	IP	IP	Plum Creek	JDI	USFS
Township	Days Academy	T2, R4	Squaretown	T1, R13	T7, R6	Bradley
Age (yrs)	23	42	33	31	30	40
PCT Year	1985	1983	1984	1984	1985	1983
TPA	736	656	539	758	811	607
DBH (in)	5.3	5.9	6.1	5.4	5.3	5.5
Basal area (ft ² /A)	113	125	109	122	124	101
Height (ft)	31	39	33	34	35	35
Volume (cords/A)	21.2	28.5	23	25.4	26.7	21.8
Relative density	0.292	0.364	0.295	0.34	0.359	0.288

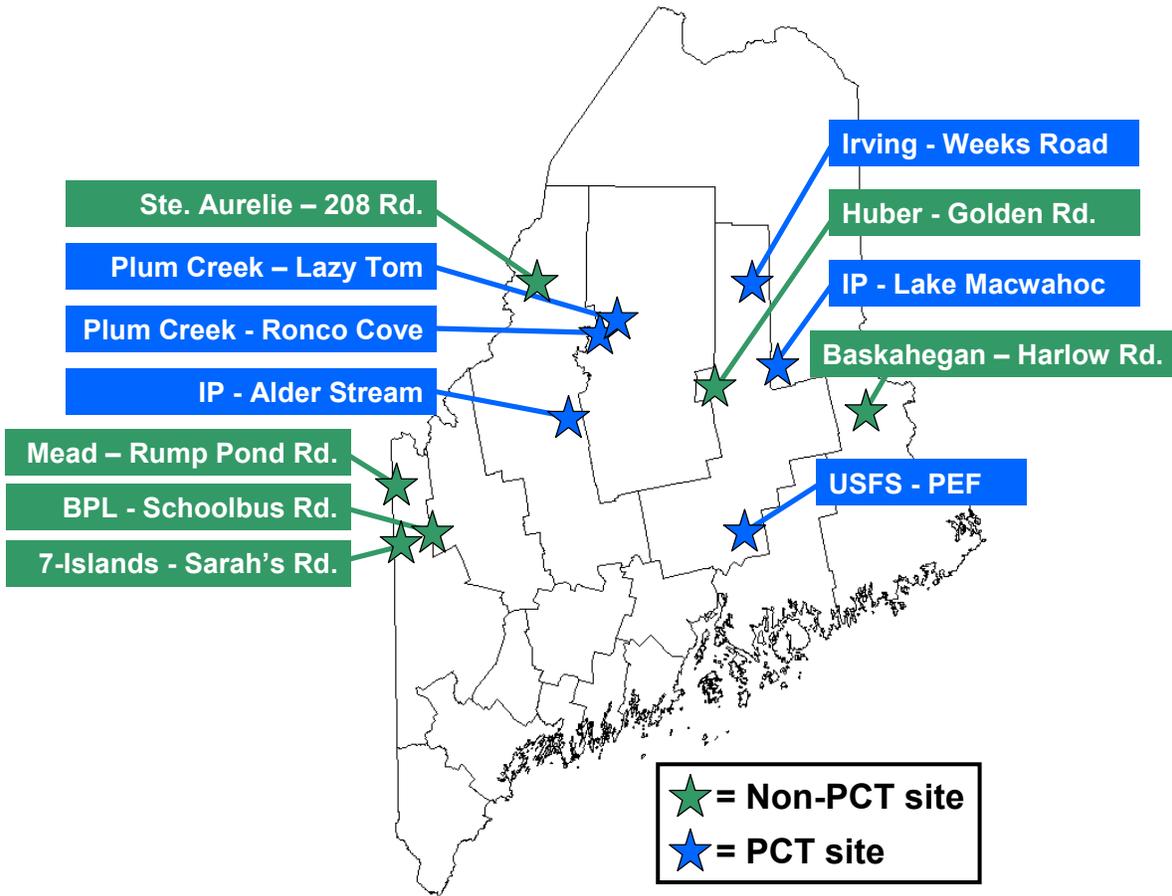


Figure 7. Locations of CFRU Commercial Thinning Network study sites.



Figure 8. Thinning equipment used in CFRU commercial thinning studies.

Table 7. Treatment assignment procedure based on rank order of initial relative density among research plots on each site.

Plot relative density rank	1	2	3	4	5	6	7
Year 0	33 %	Leave	Leave	Control	50%	Leave	Leave
Year 5	Leave	33 %	Leave	Control	Leave	50%	Leave
Year 10	Leave	Leave	33 %	Control	Leave	Leave	50%

relative density are thinned in year 0 at 33 and 50 percent, respectively. The plot with the median relative density was chosen as the untreated control plot. Remaining plots are left unthinned during the first cutting cycle and the year 5 and 10 treatments assigned based on this initial ranking (Table 7).

After the treatment assignments were determined, the thinning prescription was calculated for the appropriate plot. The target post-treatment relative density was calculated by multiplying the pre-treatment relative density by 0.67 for the 33% removal and by 0.50 for the 50% removal. The prescriptions were then marked on each plot by selecting the best-spaced and most vigorous residual

stand possible while meeting the relative density targets. "Leave" tree selections generally sought to retain most spruce and remove all hardwoods, balsam fir > 8.5 in. dbh, and any poor quality trees. This target was achieved iteratively by selecting, measuring, and calculating the relative density of "leave" trees with a laptop computer until the target residual relative density was achieved within ± 1 percent. After the "leave" trees were selected, all remaining trees greater than 2.5 inches dbh were marked for removal. The prescription was calculated and marked without regard to the forwarder and ghost trails that would be created later during the harvesting operation.

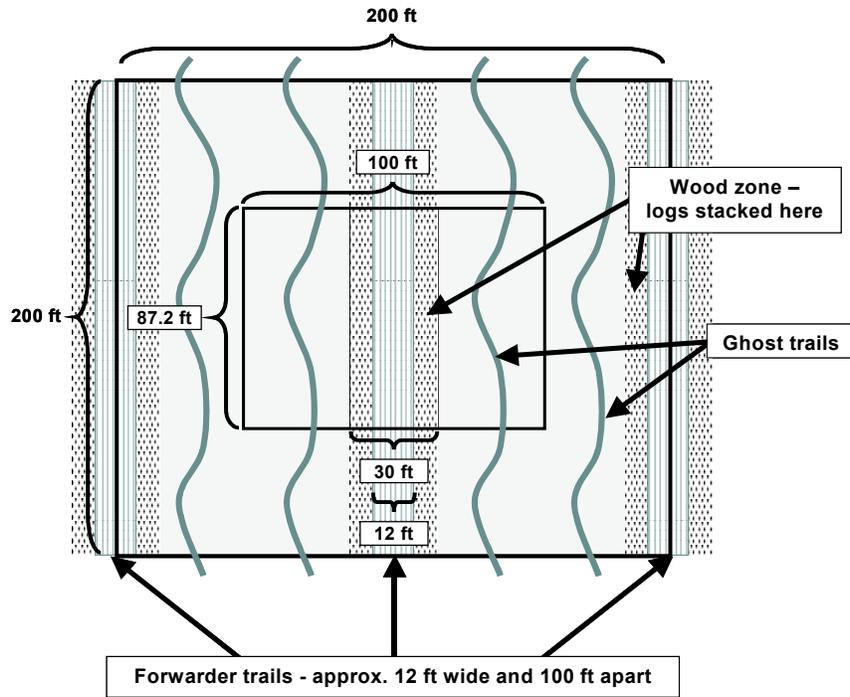


Figure 9. Layout for Commercial Thinning study plots.

Experimental design and measurements. On each site, seven 0.20-acre (87.2 x 100 ft.) plots were established and nested within a 0.9-acre (200 x 200 ft.) treatment area (Figure 9). Each 0.20-acre plot is subdivided into four 0.05-acre subplots. Before treatment, all trees taller than 4.5 feet and whose dbh was greater than 2.5 inches were tallied, and species and dbh were recorded on each plot. All tallied trees were measured for distance and azimuth to plot center. In addition, a sub-sample of trees was measured for total height and height to base of live crown. These data were used to predict heights of trees not measured. On each of the four subplot corners, an 8-foot radius sub-plot was established and each tree taller than 4.5 feet but smaller than 2.6 inches dbh was tallied by species and diameter class.

Sample plots are re-measured immediately following the thinning treatment. Each tree will be tagged and numbered, identified to tree species-level and measured for dbh, total height, crown height, and distance and azimuth to plot center. Plots will be re-measured every two years following the first post-treatment measurement to monitor growth responses. However, all plots will be monitored for blow down and maintained annually.

Accomplishments and future plans. Our goal of selecting, installing, and measuring six study sites was achieved by the end of the 2001 field season. Over 6,100 trees have been measured and mapped on these sites. Three study sites (Ronco Cove, Macwahoc, and Alder Stream) were installed and measured during the summer of 2000. A considerable effort was undertaken during the following winter and spring to find 3 more suitable sites. By the end of 2002, the remaining 3 sites (Lazy Tom, Weeks Brook, and Comp. 23A) were installed and measured. The first group of plots to be thinned was completed on Ronco, Macwahoc, and Lazy Tom during the summer of 2001, and all merchantable wood was measured immediately following the thinning operation.

Thinning treatments on the remaining 3 sites (Alder

Stream, Week Brook, Comp. 23A) are scheduled for completion by the spring of 2002. Merchantable logs are measured at each plot following the thinning operation. All 6 sites will receive their first post-treatment measurement during the summer of 2002. Beginning in 2004 each site will be re-measured every 2 years and on the 5th, 10th, and 15th year of the study.

Experiment #2: Influence of thinning method and residual density in unthinned spruce-fir stands.

Site selection and establishment. As with Experiment #1, our objective for this second experiment was to establish 6 study sites on CFRU cooperator lands during the 2000 and 2001 field seasons. Four sites were established during 2000. The remaining two sites were established this year.

Initial conditions sought for each site are shown in Table 8. Ages of the sites selected range from 34-70 yrs and initial relative densities ranged from 0.52 to 0.73 (Table 9). Site locations are shown in Figure 7.

Thinning treatments. As with Experiment #1 above, seven treatments also are being examined. In this experiment, the design consists of a 3 X 2 factorial combination of method of thinning (low, crown, dominant) and amount of density reduction (33% and 50% reduction in relative density) plus an untreated control. All thinning is being done using single-grip processors and conventional harvesting methods (Figure 8).

All treatments were randomly assigned to the plots regardless of initial conditions, except in a few cases where untreated control plots were selected based on operational ease. Each thinning prescription was developed and individual trees marked for removal based on an analysis of pre-treatment data from each plot. As with Experiment #1, relative density was calculated for each plot according to Wilson et. al (1999). The target post-treatment relative density was calculated by multiplying

Table 8. Attributes and conditions sought for study sites in Phase II, Experiment #2.

Attribute	Conditions sought
Site quality	Moderate to excellent (Briggs site class 1 to 3)
Species composition	Dominated by red spruce and/or balsam fir
Stand age	Mature stand ready for first commercial harvest
Stand history	Naturally regenerated from stand-replacing disturbance and no PCT
Stand structure and initial density	Well-stocked, single-cohort, with relative density > 0.50 (Wilson et. al 1998)

Table 9. Description of non-PCT study sites.

Site Name	Schoolbus Rd.	Golden Rd.	208 Rd.	Sarah's Rd.	Harlow Rd.	Rump Rd.
Landowner	Bureau of Public Land	Huber Resources	Ste. Aurelie Timberlands	7-Islands Land Company	Baskahegan Company	Mead Corporation
Township	Richardson	Grindstone	T7 R19	Magalloway	Danforth	Parmachenee
Age (yrs)	65	57	34	54	70	40
TPA	1405	1261	2319	1783	839	2362
DBH (in)	5.2	5	3.7	4.8	6.2	3.9
Basal area (ft ² /A)	206	169	170	210	175	200
Height (ft)	42	38	25	34	48	31
Volume (cords/A)	56.1	41.7	33.4	50.5	53.4	43.8
Relative density	0.728	0.557	0.517	0.692	0.637	0.648

the pre-treatment relative density by 0.67 for the 33% removal and by 0.50 for the 50% removal.

The three methods of thinning were applied to each plot as shown in Figure 10. Prescriptions were developed for the low thinning by sorting trees from lowest to highest crown class (overtopped to dominant) and then by dbh in ascending order. Trees were marked to cut from the top of the list downward until the target residual relative density was achieved. The dominant thinning was developed in the opposite manner.

Crown thinning prescriptions were more complicated. First, the spacing for residual crop trees was calculated based on achieving a 0.3 spacing to height ratio among dominant and co-dominant classes -- a ratio found favorable for growth in previous thinning research (Zeide 2001). The best quality crop trees were then selected from these dominant and co-dominant classes that achieved this spacing. Competing trees surrounding these crop trees, starting with the closest and most dominant, were then marked for removal. This process continued until the target residual relative density was achieved. The target residual stand is composed of the spaced crop trees and trees in the lower crown classes that were considered least competitive to the crop trees. All treatments were calculated and marked without regard to the forwarder and ghost trails that would be created later during the harvesting operation.

The resulting treatments produce plots with a wide range of residual stands conditions (Figure 11).

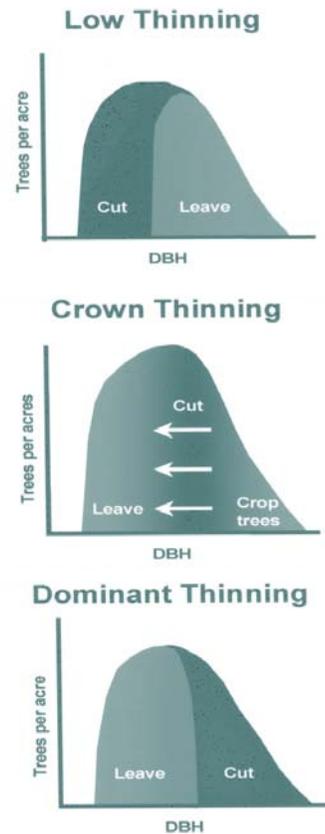


Figure 10. Hypothetical diameter distributions showing where each thinning method cuts and leaves trees.



Unthinned control



Low thinning-33%



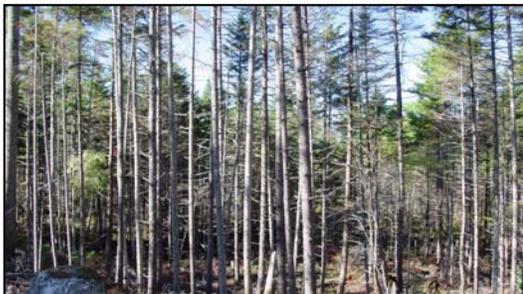
Low thinning-50%



Crown thinning-33%



Crown thinning-50%



Dominant thinning-33%



Dominant thinning-50%

Figure 11. Photos of seven thinning treatments on Huber Resources Golden Road site just after thinning

Experimental design and measurements. The same plot design was used for this experiment as with Experiment #1 (Figure 9). Before treatment, all trees taller than 4.5 feet were tallied, and species and dbh were recorded on each plot. A sub-sample of trees across the full range of diameter classes also was measured for total height and height to base of live crown. These data were used to predict the heights of trees not measured. On one of the four subplots each tree was measured for distance and azimuth to plot center and used to determine the spatial distribution of trees before treatment.

All thinned plots were measured the first summer after treatment. Each remaining tree was tagged and numbered, identified to tree species-level and measured for dbh, total height, crown height, and distance and azimuth to plot center.

Accomplishments and future plans. Four of the six study sites (School bus, Golden Rd., 208 Rd., and Sarah's Rd.) were installed and pre-treatment measurements taken during the summer of 2000. During the winter of 2001, prescriptions were developed and the sites were marked and thinned. In addition, all logs removed from the plots were measured at the time they were removed from the plots, allowing us to compare marked, cut, and merchantable volumes for all plots. Dan McConville and CFRU cooperator staff spent many hours in the field overseeing the thinning operation to assure a high quality and consistent job was done on all sites.

During the 2001 field season, Bob Wagner and Bob Seymour worked with cooperators to identify two more study sites (Harlow Road and Rump Road). CFRU field crews took pre-treatment measurements on these two new sites and conducted the post-thinning measurements on the first four sites. Plots on the two new sites will be marked and thinned during the winter or spring of 2002. Merchantable logs also will be measured immediately following the thinning. The establishment of this experiment has involved the measurement of over 15,000 trees.

Plans call for these new sites to receive their first post-treatment measurements during the summer of 2002. All plots will then be re-measured every few years to monitor growth responses. However, all plots will be monitored for blow down and maintained annually.

Predicted response of CFRU thinning plots to commercial thinning. Although the establishment of the above two experiments will make a substantial long-term contribution to our understanding about commercial

thinning in spruce-fir stands, the results will only come as fast as the plots are able to grow. As a result, it will be a number of years before we know how these plots will have responded to the thinning treatments.

However, because we have the initial and post-treatment plot conditions documented in such detail, it will be possible for us to use existing growth models to project the likely stand development outcomes of each study plot as a result of thinning. This is the basis of a new Master of Science thesis being conducted by CFRU graduate student Dawn Opland. Dawn has worked on the CFRU field crews establishing both experiments during the 2000 and 2001 field seasons. The focus of her thesis will be to use our existing and some additional data that she is collecting to accomplish several objectives:

- Predict how timing of entry and level of density reduction in previously precommercially thinned CFRU thinning plots, are likely to influence long-term stand development and financial returns.
- Predict how method of commercial thinning and level of density reduction in previously unthinned CFRU study plots are likely to influence long-term stand development and financial returns.
- Determine whether calibrating growth models using on ten-year radial growth rates will significantly alter long-term projections of stand development.
- Determine how method of thinning influences the growth efficiencies of residual stands and estimate how these differences are likely to influence long-term stand responses to commercial thinning.

The first two objectives will be accomplished by using the Forest Vegetation Simulator (FVS) with the NETWIGS individual-tree growth simulator (Bush 1995) to project the future development of each CFRU thinning plots that was established during the 2000 field season (3 sites from Experiment #1 and 4 sites from Experiment #2). Future stand table outputs from GNY will provide the basis for comparing the predicted outcomes for the thinning treatments in both experiments. These stand tables, combined with data about merchantable volumes removed and thinning costs, will provide the basis for a financial analysis of the treat-

ments in both experiments.

Part of her study involves taking additional measurements from a number of spruce trees on three of the sites in Experiment #2 to assess whether site-specific growth data derived from tree cores substantially alters stand projections made by FVS.

In addition, Dawn has collected detailed measurements of bark thickness, sapwood area, height, and live crowns on a number of the sample trees on three of the sites during fall 2001. These data will be used to calculate growth efficiencies of the residual stands that were created by the low, crown, and dominant thinning treatments. The question being addressed in this part of her study is whether the thinning methods used in the study significantly alter the mean growth efficiencies of the residual trees. And if so, whether it is likely to have an influence on how the residual stands respond to thinning. Having the growth efficiency documented on numbered trees at the time of thinning also will allow us to monitor how this variable changes as the stand continues to grow and develop.

Dawn's thesis will provide CFRU cooperators and researchers with an educated guess about how these treatments will affect long-term stand development and the likely economic returns from each treatment. These predictions can serve as a quantitative hypothesis about how the varied treatments in the CFRU thinning study are likely to influence the stands. Future departures between Dawn's model predictions and the actual plot data can provide a basis for identifying where these models need to be improved with regard to thinning predictions.

For more information about commercial thinning study, please contact **Bob Wagner** at 207-581-2903 or email bob_wagner@umenfa.maine.edu, **Bob Seymour** at 207-581-2860 or email seymour@umenfa.maine.edu, or **Dan McConville** at 207-581-2861, or email dan_mcconville@umenfa.maine.edu.

References

- Bush, Renate R. 1995. Northeastern TWIGS Variant of the Forest Vegetation Simulator. Available on the USDA Forest Service website at www.fs.fed.us/fmcs/fvs/fvs_variant_overviews.htm. Last checked July 5, 2001.
- Nova Scotia Department of Natural Resources (NSDNR). 1993. Nova Scotia softwood growth and yield model - version 1.0 user manual. For. Res. Section. Nova Scotia Dept. of Natural Resources For. Res. Rep. 43. 12 p.
- Randolph, K.C., R.S. Seymour, and R.G. Wagner. 2001. ThinME: Development of Commercial Thinning Guidelines for Maine Spruce-Fir Forests. In Proc. Thinnings: A Valuable Forest Management Tool – An International Conference. September 2001, Quebec City, Quebec. Forest Engineering Research Institute of Canada, Point-Claire, Quebec, Canada. Web: publications@mtl.feric.ca
- Solomon, D., Herman, D., Leak, W. 1995. FIBER 3.0: an ecological growth model for northeastern forest types. USDA For. Serv. Gen. Tech. Rep. NE-204. 24 p.
- Wagner, R.G., R.S. Seymour, and D.J. McConville. 2001. Maine's Commercial Thinning Research Plot Network. In Proc. Thinnings: A Valuable Forest Management Tool – An International Conference. September 2001, Quebec City, Quebec. Forest Engineering Research Institute of Canada, Point-Claire, Quebec, Canada. Web: publications@mtl.feric.ca
- Wilson, D.S.; Seymour, R.S.; and Maguire, D.A. 1999. Density management diagram for red spruce and balsam fir forests. North. J. Appl. For. 16(1): 48-56.
- Zeide, B. 2001. Thinning and Growth: A full turnaround. J. Forestry. 99(1): 20-21.

Condition and Development of Root Systems of Balsam Fir and Red Spruce in Precommercially Thinned and Unthinned Stands

SUZHONG TIAN AND WILLIAM D. OSTROFSKY, *University of Maine*

This project, initiated in 1998, was developed in response to an interest by cooperators to obtain better management information for young precommercially thinned spruce and fir stands that are approaching or are ready for the first commercial thinning. Although there has been significant research on the above-ground tree and stand responses to precommercial thinning treatments, there was relatively little information available about the below-ground responses. The primary objectives of this project were to compare root characteristics, windfirmness, and butt and root decay incidence in spruce and fir stands that had been precommercially thinned with stands which had been left unthinned.

Field work for this project was largely completed by October of 2000, with data analysis and final report preparation occurring during the past several months. The project is now complete, and a final report in the form of a PhD dissertation has been successfully defended. The study includes new information on balsam fir and red spruce root weight, length, size, and structure, an assessment of the incidence of root and butt decays, and an evaluation of windfirmness of both thinned and unthinned stands. Other data of significance includes estimates of below-ground biomass production and the effect of precommercial thinning on below-ground biomass production for both species.

Primary findings include the following:

- There was no significant difference in total (all species present) woody root density between stands that had been precommercially thinned 18 years ago with stands of the same age that had been left unthinned. The average root biomass was 1.2 kg/m² and the average root length was 65.6 m/m² for the combined data from the thinned and unthinned stands.
- Balsam fir was found to have significantly more root biomass and root length in precommercially thinned than in unthinned stands. However, this relationship was not found for red

spruce. A strong, positive relationship was found between tree DBH and below ground root biomass for balsam fir and red spruce.

- There was no significant difference in windfirmness for either balsam fir or red spruce, between the precommercially thinned and the unthinned stands tested. Windfirmness was determined by measurements of the direct force required to uproot a tree. Balsam fir was determined to be more windfirm than red spruce in commercial sized stands that had been precommercially thinned, even though red spruce had a larger proportion of large-sized roots than did balsam fir.
- Balsam fir was found to have a significantly higher (46 %) incidence of butt decay in commercial-sized trees than did red spruce (6%). Butt decay incidence was shown to be a reliable predictor of root decay incidence. Balsam fir crop trees of precommercial thinning size were found to have a higher incidence of butt decay than the balsam fir which were removed during the thinning. This difference apparently decreases over time. Within a species, there was no apparent effect of precommercial thinning on root and butt decay incidence in commercial-sized stands.

In general, it was found that balsam fir root characteristics were considerably more affected by precommercial thinning treatments than were red spruce root characteristics. This reflects the general trends already known for above-ground characteristics of these species, as well. This study indicates that it is apparently unrealistic to expect significant gains in windfirmness by precommercial thinning. Significant reduction of losses to root and butt decay of balsam fir could be realized if better methods were available for crop tree selection before precommercial thinning.

For more information on this study, contact **William D. Ostrofsky** at 207-581-2877 or email him at ostrofsk@umenfa.maine.edu.

Long-Term Effects of Herbicide and Precommercial Thinning Treatments on Young Spruce-Fir Stands: The Austin Pond Study

HOWARD DAGGETT AND ROBERT G. WAGNER, *University of Maine*

Steady progress was made this year toward the completion of Howard Daggett's M.S. thesis on Austin Pond. The objectives of this project are to:

- compare the effects of herbicide and PCT treatments (22 and 13 years after treatment, respectively) on overstory composition and wood volume in 29 year-old spruce-fir stands;
- project future stand development of all study plots (using FVS stand simulator) and evaluate potential long-term economic returns associated with various combinations of herbicide treatment and PCT in spruce-fir stands; and
- compare the effects of herbicide treatments and PCT on the composition and diversity of understorey vegetation in spruce-fir stands.

Data from this study also will be used to quantify differences and similarities that have developed among the re-

search plots. From this information we will have an opportunity to refine the future experimental design of Austin Pond by adding new treatments (e.g., commercial thinning, vegetation management, or fertilization) to the current silvicultural prescriptions.

Accomplishments this year include development of regression models for height and DBH relationships. This analysis revealed that the height/DBH relationships are statistically different depending on whether the plots received PCT. The slope of the relationship was steeper for unthinned plots, indicating that trees on unthinned plots are taller for every unit of diameter than trees on unthinned plots (i.e., they have higher height to diameter ratios). This relationship held for all of the dominant species (balsam fir, aspen, red maple, and red spruce) in the study. These regression models are being used to estimate the heights of trees that were not measured so that stem volumes could be accurately calculated for all plots.

Table 10. Treatment means for selected overstory variables for the control and most effective (Roundup and Garlon) herbicide treatments for both thinned (PCT) and unthinned (No PCT) treatments.

Treatment		Trees per acre	Basal area (ft ² /A)	Total volume (ft ³ /A)	Merch. volume (ft ³ /A)	Quadratic mean diameter (inches)	Mean height (ft)	Softwood % by volume
Herbicide	Thinning							
Control	PCT	4,094	92	1,128	667	2.3	15.6	86.2
	No PCT	4,106	142	2,201	1,153	2.7	22.7	22.2
Garlon (2 qts/A)	PCT	3,264	111	1,508	1,112	2.7	15.4	93.4
	No PCT	5,485	174	2,241	892	2.5	18.9	81.5
Garlon (4 qts/A)	PCT	2,920	100	1,301	846	2.6	16.0	89.7
	No PCT	6,743	162	2,044	842	2.3	17.1	76.8
Garlon + 2,4-D (2+2 qts/A)	PCT	2,508	103	1,466	1,066	2.8	17.2	92.3
	No PCT	6,438	138	1,631	513	2.1	16.3	85.0
Roundup (2 qts/A)	PCT	3,985	85	1,032	635	2.0	13.6	89.6
	No PCT	6,300	151	1,807	544	2.1	16.8	76.4
Roundup (4 qts/A)	PCT	2,306	108	1,518	1,137	3.0	16.7	97.2
	No PCT	4,346	139	1,840	845	2.6	19.6	80.9

These stem volumes and other measured variables are being used to accomplish objective 1 above. Preliminary comparisons among herbicide and PCT treated plots revealed substantial differences (Table 10). The effect of the herbicide treatments is indicated in the softwood % by volume variable. The unthinned control plot has only 22% of total volume in softwood and the unthinned herbicide plots range from 76 to 85% softwood.

PCT treatment effects are evident by differences between total and merchantable volumes. Unthinned plots tend to have more total volume than thinned plots, however unthinned plots tend to have less merchantable volume than thinned plots. This pattern holds for the herbicide treated plots and reverses for the control plots. The longer-term influence of the effective herbicide treatments appears to enhance the effect of PCT by pushing more trees into the larger diameter classes (not evident from the quadratic mean diameter), thereby increasing the overall merchantable volume. Work during the coming year will assess whether these differences affect longer-term stand development and the resulting economic returns from these treatments.

Because the Austin Pond plots cover a relatively small area and are only replicated twice, we were concerned about potential differences among plots that may have resulted from soil differences (especially drainage) among the plots, thus potentially confounding our interpretations of treatment effects. Therefore, soil pits were dug in each of the 52 research plots during the 2001 field season. Six soil variables were measured in each pit (depth of organic

layer, depth of rooting, depth to mottling, depth to hard pan, % surface stoniness, and % profile stoniness). If any soil variable (or combination of soil variables) accounted for a significant amount of variation consistently across the overstory variables, we would remove that variation by conducting an analysis of variance on the residuals. Toward that end, we conducted a regression analysis between the key overstory variables and all soil variables, plus some interactions (Table 11).

Although some relationships were statistically significant, none of the soil variables consistently accounted for a significant amount of the variation among any of the overstory variables. As a result, we concluded that the variation in soils variables among the plots was not significant enough (probably due to the small range of variation of these variables within a relatively small area) to be a confounding factor in the experiment. We chose, therefore, not to adjust any differences among research plots due to soils differences before analysis of the treatment effects.

Efforts in the coming year will be directed toward completing the statistical analysis of overstory and understorey effects, projecting long-term stand development of all plots using FVS, and conducting an economic analysis of herbicide and PCT treatment effects. Howard's M.S. thesis is scheduled for completion in 2002.

For more information about this study, contact **Howard Daggett** at roland.daggett@umit.maine.edu or **Bob Wagner** at 207-581-2903 or bob_wagner@umenfa.maine.edu.

Table 11. *p*-values from a linear correlation analysis between key overstory variables and six soils variables. Highlighted boxes indicate *p*-values < 0.05.

Soil Variables	Trees per acre	Basal area (ft ² /A)	Total volume (ft ³ /A)	Merch. volume (ft ³ /A)	Quadratic mean diameter (inches)	Mean height (ft)	Softwood % by volume
Organic depth	0.024	0.228	0.413	0.436	0.194	0.281	0.093
Rooting depth	0.715	0.022	0.001	0.544	0.205	0.267	0.623
Mottling depth	0.169	0.578	0.353	0.546	0.029	0.005	0.931
Hard pan depth	0.015	0.459	0.41	0.398	0.004	0.208	0.906
Profile stoniness (%)	0.043	0.016	0.085	0.585	0.803	0.165	0.541
Surface stoniness (%)	0.926	0.581	0.393	0.932	0.454	0.298	0.278
Rooting X hard pan	0.982	0.087	0.002	0.024	0.129	0.644	0.022
Rooting X profile stoniness	0.076	0.005	0.039	0.731	0.833	0.161	0.378
Mottling X hardpan	0.422	0.758	0.645	0.219	0.093	0.119	0.194

Assessing Silviculture Research Priorities for Maine Using a Wood Supply Analysis

ROBERT G. WAGNER, AND ROBERT S. SEYMOUR, *University of Maine*,
ERNEST H. BOWLING, *J. W. Sewell*

Work continued this year to complete an analysis of silvicultural research priorities using a model of Maine's future wood supply. Stimulated originally by debates among CFRU cooperators about which areas of silvicultural research could provide the greatest benefit and by release of the 1998 Maine Forest Service (MFS) report ("Timber Supply Outlook for Maine: 1995-2045"), this study sought to use a sensitivity analysis of yield assumptions for various silvicultural practices on Maine's long-term wood supply as the basis for evaluating where the most productive areas of silvicultural research might be.

A draft report was completed this year and additional analyses conducted based on reviewer comments and new questions that arose while preparing the report. As a result, completion of the final report was delayed by several months. Details of the initial findings, however, were presented to CFRU members at the May Advisory Committee meeting. In addition, a formal seminar describing the results was presented at University of Maine in May.

In summary, the project used a Woodstock model of Maine's wood supply for the next 100 years that was developed from the ATLAS model used by the MFS in their 1998 report. In the process, we found that Wood-

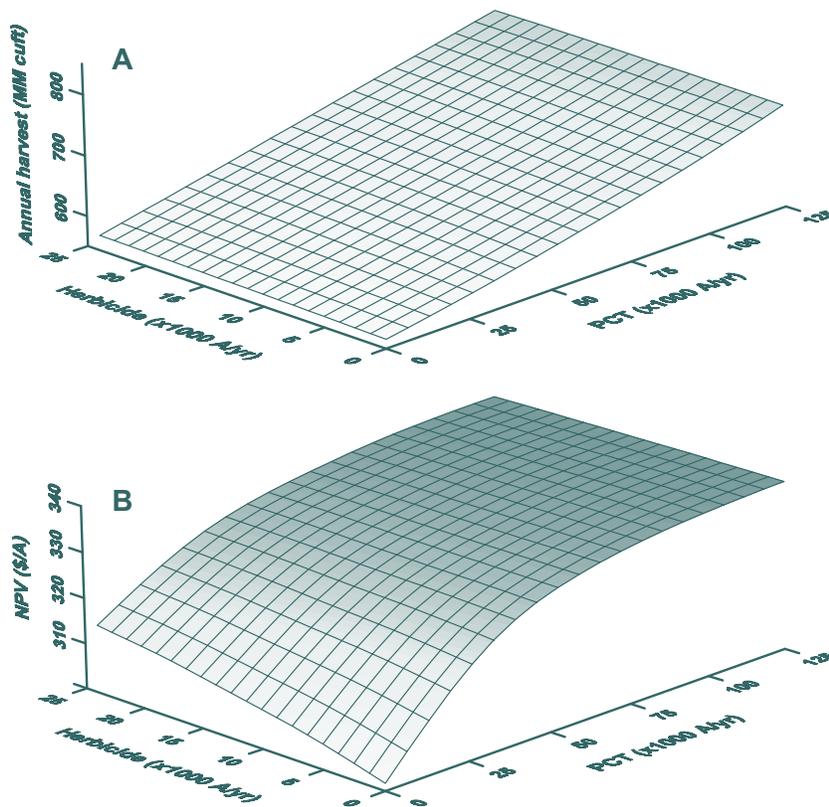


Figure 12 – Effect of various combinations of future herbicide application and PCT on ASHL (A) and NPV (B). Analysis is for all of Maine's forestland (16,952,230 acres). Tree planting was set to zero for all model runs.

stock and ATLAS models produced different projections of Maine’s future growth, harvest, and inventory levels, despite the fact that they used the same database and similar assumptions, objectives, and constraints. Results from the Woodstock model were generally less conservative than those from the MFS ATLAS model.

Once the new Woodstock model was running, we examined the effect of increasing the number of acres treated and by tree planting, herbicide application, and PCT (example shown in Figure 12) in combination with incrementally increasing and decreasing the slope of the yield functions by $\pm 20\%$ (example shown in Figure 13). The principal response variables examined in the analysis were

the annual sustainable harvest level (ASHL) and net present value (NPV).

From this analysis, we found that a $\pm 20\%$ error in the slope estimate of the yield curves can produce an error in calculation of ASHL and NPV that is as large or larger than the projected gain from using tree planting, herbicide application, and PCT at current levels into the future. Therefore, accurately calculating the allowable cut effect from continuing current levels of tree planting, herbicide application, and PCT requires the error in estimating slopes to be well below $\pm 20\%$. By comparing the relative effects of these three treatments

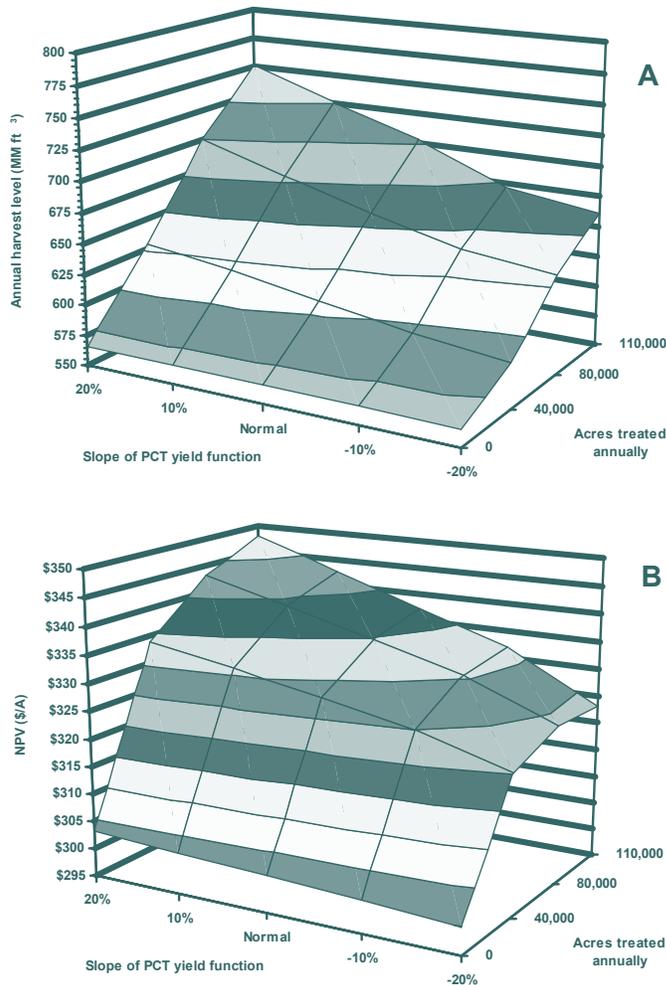


Figure 13 – Effect of various combinations of future herbicide application and PCT on ASHL (A) and NPV (B). Analysis is for all of Maine’s forestland (16,952,230 acres). Tree planting was set to zero for all model runs).

in the analysis, we also concluded that the ranking for more precisely knowing the growth and yield response to these treatments should be PCT > herbicide > planting.

During this initial analysis, we also examined the influence of various assumptions about commercial thinning in Maine's forest on future wood supply. We noted in this analysis, however, that commercial thinning was selected as a harvest option by the model on only a limited number of acres. Early manipulations of the yield assumptions for commercial thinning did not change this result, so additional questions remained about the overall influence of commercial thinning in our model. Since CFRU members have identified the importance of a better understanding about commercial thinning as a high research priority, we extended the analysis by several months so that we could examine the long-term influence of commercial thinning in more detail. Specifically, we examined how changing assumptions related to the 1) slope of the post-thinning yield function, 2) volume requirement for first commercial entry, 3) financial value of the residual stand following thinning, and 4) constraint on the maximum number of acres that could be clearcut in any

residual stand following thinning, and 5) constraint on the maximum number of acres that could be clearcut in any period affected the use of commercial thinning by our Woodstock model.

Briefly, we found that factors strongly influencing the amount of commercial thinning chosen by the model had relatively a relatively small influence on ASHL and NPV. Understanding the yield consequences from tree planting, PCT, and herbicide application remained more important for calculating sustainable harvest levels than a better understanding about stand responses to commercial thinning. However, the optimum amount of commercial thinning chosen by the model was strongly influenced substantially by the slope of the post-thinning yield function, the volume threshold for first commercial entry, and the value of the residual stand. Thus better information about these aspects is needed to understand the overall role of commercial thinning in Maine's forest.

For more information about this study, contact **Bob Wagner** at 207-581-2903 or bob_wagner@umenfa.maine.edu

Juvenility and Rooting Potential of Basal Stem Sprouts from Heavily Pruned Hybrid Larch Trees

CARL L. HAAG, *Larix Consulting*

Operational reforestation using hybrid larch is an option used by a number of North American forest products organizations to increase forest productivity and decrease rotation age. Impressive growth rates, approaching 2.5 cords per acre per year on a 25 to 30-year rotation, have been measured in Maine. Intensive site preparation followed by planting of seedlings is generally the regeneration system utilized. One hindrance to the wider use of hybrid larch as a plantation species has been an inadequate supply of seed to produce seedlings. As an alternative, seedlings can be produced successfully by rooting juvenile cuttings taken from the tops of trees younger than two years of age. To date, attempts to produce viable planting material from older trees have been unsuccessful.

I have observed that most larch trees develop suckers along their entire stem length following repeated heavy pruning. Several researchers (M. Greenwood, D. Karnosky, G. Wyckoff) suggest that these suckers, growing from the stem near the base of the tree, may exhibit juvenile characteristics in that they appear to originate from adventitious buds developed during the tree's first few years of life. If the sprouts are in fact juvenile, their cuttings could be used to produce seedlings from superior trees. A propagation method based on this principle has been developed for Chinese fir. The purpose of this project is to 1) initiate production of basal sprouts on older hybrid larch trees and 2) test "rootability" and frequency of upright growth habit in seedlings produced from cuttings taken from a number of different tree positions.

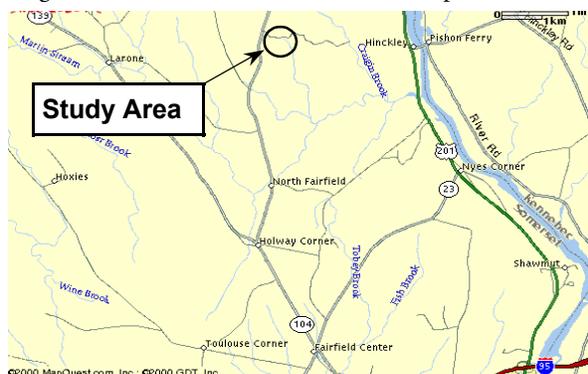


Figure 14. Location of study area



Figure 15. Typical hybrid larch sprouting two months after pruning.

Approach and Results: A 9-year old hybrid larch plantation located on SAPPi land near Fairfield Center, ME was used for this project (Figure 14). In early June 2001, ten trees were heavily pruned and tops cut off in order to initiate sucker growth. Ten additional trees were identified as unpruned controls. All trees were fertilized with a balanced fertilizer mix.

Sprout growth was monitored over the course of the 2001-growing season. Drought conditions were moderate to severe over much of the summer and three trees died. However, despite the lack of rainfall, sprouting on the live trees was significant. Sprouts were observed along the entire length of each tree stem with the majority (>60%) occurring in the upper two to three feet. Figure 15 shows typical sprouting observed two months after pruning. Although not as abundant as in the upper part of the stem, more than 40 basal sprouts were produced in the lower four feet section (Figure 16) and four sprouts in the lower one foot section (Figure 17).



Figure 16. Basal stem sprout three feet above the ground.

When lignification of new growth had progressed to the point where cuttings were rootable (August 30), cuttings were obtained from the following tree stem locations:

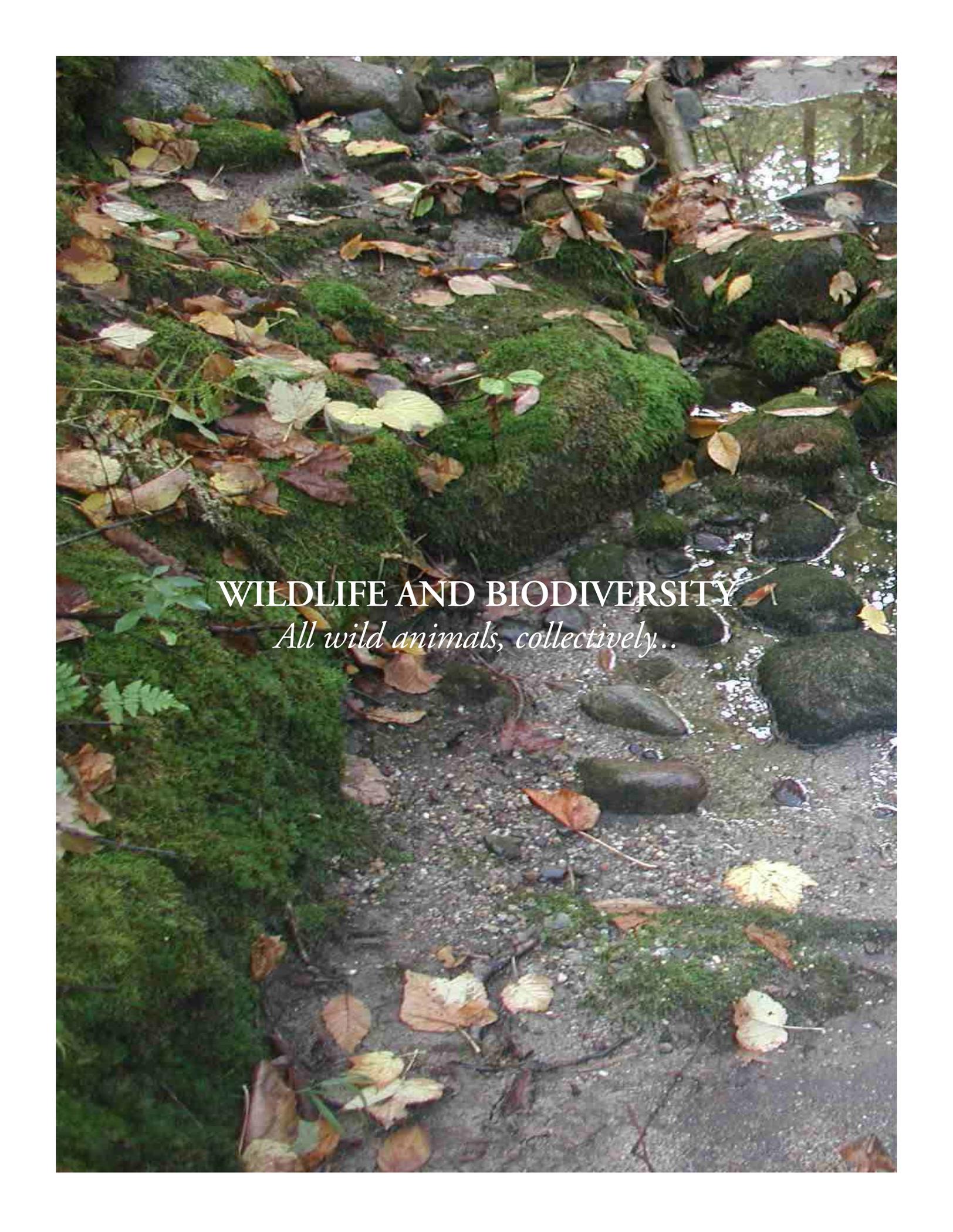
1. Main stem of pruned tree, 0' to 1' above the ground.
2. Main stem of pruned tree, 1' to 4' above the ground.
3. Top of main stem of pruned tree (approximately 7 to 8').
4. Large side branches of pruned tree, 3' to 5' above the ground.
5. Top of unpruned tree (control).



Figure 17. Basal stem sprout eight inches above the ground

Twenty-four cuttings from each location were struck in Jiffy 140, soft-center pellets. Sufficient quantities of sprouts were available for Treatments 2 – 5 to allow the use of the top cutting from each sucker. Because of the limited number of suckers, multiple cuttings from each were used for Treatment 1. Culture is currently taking place in my greenhouse. Once cuttings take root and resume their growth (March to April 2002), growth habit will be observed and frequency of non-vertical seedlings will be recorded. This project should be completed by late May 2002. A final report will be delivered to Mike Greenwood at that time.

For more information, contact **Carl Haag** at 207-872-6562 or email him at clhaag2@yahoo.com.

A photograph of a forest floor. The ground is covered with a thick layer of green moss, interspersed with numerous fallen autumn leaves in shades of yellow, orange, and brown. Several large, dark, rounded rocks are scattered throughout the scene, some partially covered in moss. The background shows more of the forest floor and a hint of a stream or water source on the right side. The overall atmosphere is quiet and natural.

WILDLIFE AND BIODIVERSITY
All wild animals, collectively...

Marten as a Tool for Landscape-scale Habitat Planning in Northern Maine

JEFFERY A. HEPINSTALL AND DANIEL J. HARRISON, *University of Maine*



Figure 18. American marten.

Marten are the most area-sensitive, forest specialized mammal inhabiting forest landscapes in northern Maine. They require large areas of relatively intact forest, are sensitive to forest fragmentation (Chapin et al. 1998); however, marten in Maine use a variety of forest types greater than 20 feet in height within their territories (Payer 1999). Thus, this species is an ideal "umbrella species" to use for evaluating landscape effects of forest harvesting and can be used as a coarse filter to assist in long-term forest planning at the scale of townships or larger landscapes.

This project has three major objectives. First, to develop and evaluate habitat models that will reliably predict the distribution of habitat for marten in the Telos (T4 R11 WELS and T5R11 WELS) and Baxter State Park study areas using field data gathered over 11 years and vector databases on vegetation type, age, and structure. Second, to modify this local area model to be able to predict mar-

ten habitat across the marten's range in Maine. Implicit in this objective will be an evaluation of whether the predicted habitat available will be sufficient to achieve the objective population sizes resulting from MDIFW's species assessment process. Third, to develop a spatially-explicit, long-term habitat projection for northern Maine using marten as an area-sensitive umbrella species, while also incorporating habitat requirements of other forest dependent vertebrates with smaller area requirements than marten.

This project has completed the process of developing and evaluating models designed to predict marten habitat in the Telos and Baxter State Park study areas (Objective 1). We used marten home range data gathered previously in the industrial forest ($n = 150$) and Baxter State Park ($n = 100$) from 1989 to 1998. Because we knew what areas marten occupied and what areas were not occupied, we combined used versus unused areas to analyze habitat thresholds for marten at the scale of the forest landscape. To do this we developed a method to populate the unused areas with simulated marten home ranges. These ranges were designed to simulate the approximate size and shape of observed home ranges for male and female marten. The marten home range data from previous studies in the industrial forest was paired with these simulated home ranges to: 1) estimate thresholds of forest types (e.g., mature closed canopy forest, young forest) that will accurately predict the presence or absence of marten (i.e., habitat currencies); and 2) build the database required to model marten occurrence.

We compared five different possible groupings of vegetation types to determine which grouping was best at differentiating between occupied and unoccupied areas using the Kolmogorov-Smirnov test (Table 12). The grouping of Mature Forest (> 9 m tall, $> 40\%$ canopy closure) + Immature Closed Forest (6-9 m tall, $> 40\%$ canopy closure) + Partial Harvest (> 9 m tall, $> 40\%$ canopy closure) had the highest difference between observed and simulated unoccupied home ranges.

Table 12 Statistical (Kolmogorov-Smirnov test) differences between proportion of occupied and unoccupied (simulated) home range in each vegetation type or grouping of types.

Habitat Currency (Suitable or Unsuitable)	Kolmogorov-Smirnov	
	Statistic	p-value
<i>Mature Forest (MF)</i>	0.36	<0.001
<i>Open and Young Forest (YF)</i>	0.47	<0.001
* <i>MF + Immature Closed Forest (IC)</i>		
+ <i>Partial Harvest (PH)</i>	0.48	<0.001
<i>MF + IC</i>	0.41	<0.001
<i>MF + PH</i>	0.40	<0.001

* - This habitat grouping was used to define suitable habitat for subsequent modeling objectives.

To determine if marten are responding to landscape configuration, FRAGSTATS software was used to calculate landscape metrics. Eight metrics (Table 13) have been included in our logistic regression models. Twenty five models were selected *a priori* using expert knowledge. We used observed marten home ranges (n = 124 for our model build data set, n = 26 for our model test data set)

and simulated unoccupied home ranges (n = 98 for our build data set and n = 41 for our test data set). Models were developed using logistic regression and evaluated using standard measures. We have been able to predict the probability of marten occupancy in potential home range-sized landscapes of 2-5 km² with 70-100% accuracy (Tables 14, 15, 16).

Table 13. Landscape metrics selected for inclusion as potential explanatory variables for predicting marten occurrence.

Metric Type	Variable Name	Variable Description
<i>Area</i>		
	PHR LPI	<i>Percent of the home range in suitable habitat Largest Patch Index</i>
<i>Patch</i>		
	PD PSSD PD*PSSD	<i>Patch Density Patch Size Standard Deviation Interaction of Patch Density and Patch Size Standard Deviation</i>
<i>Nearest-Neighbor</i>		
	MNN NNCV*PD	<i>Mean Nearest-neighbor Nearest-neighbor Coefficient of Variation * Patch Density</i>
<i>Shape</i>		
	CSI	<i>Class shape index</i>

Table 14. Model rank, pseudo-R², and agreement with model build data (model verification): proportion of correctly classified marten presence (sensitivity); correctly classified marten absence (specificity); and correct classification rate (CCR).

Variables						Model	R ²	Sens.	Spec.	CCR		
						Rank		(n=124)	(n=98)	(n=222)		
PHR	PD			MNN	NNCV	NNCV*PD	1	0.305	0.86	0.71	0.80	
PHR	PD			MNN	NNCV	NNCV*PD	LSI	2	0.311	0.90	0.68	0.81
PHR	PD	PSSD	PD*PSSD	MNN	NNCV	NNCV*PD	LSI	3	0.322	0.85	0.70	0.79
PHR	PD	PSSD	PD*PSSD	MNN	NNCV	NNCV*PD		4	0.315	0.85	0.71	0.79

Table 15. Model agreement with test data from our industrial townships (model validation): proportion of correctly classified marten presence (sensitivity); correctly classified marten absence (specificity); and correct classification rate (CCR).

Variables						Model	Sens.	Spec.	CCR		
						Rank	(n=26)	(n=41)	(n=67)		
PHR	PD			MNN	NNCV	NNCV*PD	1	0.73	0.83	0.79	
PHR	PD			MNN	NNCV	NNCV*PD	LSI	2	0.73	0.80	0.78
PHR	PD	PSSD	PD*PSSD	MNN	NNCV	NNCV*PD	LSI	3	0.77	0.88	0.84
PHR	PD	PSSD	PD*PSSD	MNN	NNCV	NNCV*PD		4	0.65	0.93	0.82

Table 16. Model agreement with test data from our forest reserve (Baxter State Park) study area (model validation): correctly classified marten presence (sensitivity).

Variables						Model	Sensitivity		
						Rank	(n=100)		
PHR	PD			MNN	NNCV	NNCV*PD	1	1.00	
PHR	PD			MNN	NNCV	NNCV*PD	LSI	2	1.00
PHR	PD	PSSD	PD*PSSD	MNN	NNCV	NNCV*PD	LSI	3	1.00
PHR	PD	PSSD	PD*PSSD	MNN	NNCV	NNCV*PD		4	1.00

We are currently adapting the models developed for Objective 1 to run on raster-based vegetation maps and satellite imagery available for Maine. We have statewide data for vegetation and land cover for 1993 developed for the Maine Gap Analysis Project, as well as unclassified satellite imagery from 1991, 1993, and 2000, and additional study area imagery for 1995, 1997, and 1998. The year-specific satellite imagery has been paired as closely as possible with the year-specific marten home ranges. Landscape metrics have been calculated for the same home ranges and simulated unoccupied home ranges using the raster-derived habitat data. These data currently are being used to generate the same logistic regression models as done for Objective 1. Once this is complete, model output will be calibrated to the 1993 vegetation map for Maine. Once this calibration is complete, we will predict marten habitat across their range in Maine.

Work on the final objective of this project, to develop a spatially-explicit projection of marten habitat for northern Maine and incorporate the habitat requirements of other forest dependent vertebrates with smaller area requirements than marten has also begun and will be completed by summer 2002.

This project will develop several products that will complement and enhance the landscape habitat planning and urban sprawl initiatives of the Maine Department of Inland Fisheries and Wildlife (MDIFW) and the State Planning Office, and will provide opportunities to integrate volunteer habitat planning across the diverse ownerships and management objectives in northern, western, and eastern Maine. In addition to map products, it is hoped that we will have the time and funding to complete a more dynamic, spatially-explicit decision

Cooperative Forestry Research Unit

support system based on the results from Objective 3. Final products will be completed and delivered by summer 2002.

In addition to the CFRU funding for this project, funding is provided by Maine Department of Inland Fisheries and

Wildlife, Maine Outdoor Heritage Fund, the Maine Chapter of The Nature Conservancy, the University of Maine College of Natural Sciences, Forestry, and Agriculture, and the Department of Wildlife Ecology at the University of Maine.

Effect of Precommercial Thinning on Snowshoe Hares and Small Mammals in Northern Maine

JESSICA A. HOMYACK, DANIEL J. HARRISON, AND WILLIAM B. KROHN, *University of Maine*

In March 2000, the U.S. Fish and Wildlife Service listed Canada lynx (*Lynx canadensis*) as threatened under the Endangered Species Act (ESA). Although Maine has the only verified population of resident lynx in the northeast, the relationships between lynx, habitat, and forestry practices are not thoroughly understood. Lynx are specialized predators of snowshoe hare (*Lepus americanus*). Hare density is positively and logarithmically associated with stands with high densities of conifer saplings (Long 1995) and at a statewide scale, large areas of regenerating conifer stands is a habitat variable that predicts occurrences of lynx in Maine (Hoving 2001). Thus, extensive areas of regenerating forest may promote persistence of a population of lynx in the northeastern United States.

Precommercial thinning (PCT) is a silvicultural technique that decreases stem density and may reduce densities of hare relative to unthinned, regenerating stands (Sullivan and Sullivan 1988). During 1993 to 2000, 146,249 acres of forest were pre-commercially thinned in Maine (Maine Forest Service 2001, 2000, 1999, 1998, 1997). Because extent of forest that has been precommercial thinned is projected to increase substantially, forest managers in Maine will be required to reconcile silvicultural objectives with societal goals of maintaining wildlife habitat and biodiversity in managed forests.

Insufficient information exists to evaluate how thinning influences the habitat of snowshoe hares, small mammals, and other potential prey species for lynx and other forest-dwelling carnivores. No research has been conducted on the effect of PCT on snowshoe hare for longer than four years post-treatment (Sullivan and Sullivan 1988, de Bellefeuille et al. 2001) and most studies on the effects on small mammals lasted only two or three years (Lautenschlager et al. 1998, Sullivan et al. 1998). Further, low power and few replicates limit most studies of PCT. Thus, we are currently investigating the effects of PCT, at different intervals since thinning, on hare, small mammals, and forest structure in the industrial forests of northern Maine.

This study is funded by the Maine Cooperative Forestry Research Unit (CFRU), the National Council for Air and Stream Improvement (NCASI), the U.S. Fish and Wildlife Service, the Maine Cooperative Fish and Wildlife Re-

search Unit, and the Department of Wildlife Ecology, University of Maine. International Paper Company, Great Northern Paper Company, and Plum Creek generated maps of stand type and management history and granted access to their lands.

Objectives. We will attempt to determine the effects of PCT on selected wildlife species and stand structure 0-15 years post-PCT treatment. We are placing emphasis on the snowshoe hare because of its affinity for habitats with forest structure and high stem densities of conifer saplings, and because of its importance as a food source to Canada lynx and other predators. The specific objectives to be met in the two-year study are:

- to quantify and compare overstory, understory, coarse woody debris (CWD), and vertical and horizontal structure on herbicide treated clearcuts, with and without PCT, at different intervals since thinning;
- to document the stand-level effects of PCT, at different intervals since thinning, on associated vegetation changes, and on densities of snowshoe hare and small mammals and;
- to develop a predictive model of the relationship of hare density to overstory, understory, coarse woody debris, and structural variables.

Approach. Seven townships (Hersey, T 4 R 11 WELS, T 5 R 11 WELS, T 4 R 12 WELS, T 1 R 13 WELS, Spencer Bay, and Days Academy Grant) in northern Maine compose the study area. Hersey Township is located in Aroostook County whereas the other six townships are located in Piscataquis County, Maine. We selected these townships because they fall within the historical lynx distribution (Hoving 2001). We examined site quality, tree density, dbh of dominant trees, and spatial independence of stands before selecting them as study sites.

Treatment blocks are comprised of stands that have been clearcut, treated with herbicide, and precommercially thinned. We paired treatment stands with a control that has similar site quality, dates when harvested, and dates when herbicide was applied. The study design

includes 24 pre-commercially thinned stands at 5-year intervals since thinning (1 year post-thinning, n = 6; 5 years, n = 6; 10 years, n = 7; 15 years, n = 6) and 13 paired control stands (1 year, n = 5; 5 years, n = 5; 10 years, n = 3).

RESULTS

Small mammals. We established 24 grids for trapping small mammals on stands treated with PCT from four age classes: 0 years since PCT (n = 6), 5 years since PCT (n = 6), 10 years since PCT (n = 6), and 15 years since PCT (n = 6). We established 13 grids for small mammal trapping on stands with similar site histories, but without subsequent PCT. We trapped mice, voles, and shrews on 36 stands during June-August 2000 and 2001 (Figure 17, 18, 19). Trapping periods lasted for six nights and we captured small mammals in Bolton live-traps (B. N. Bolton,

Inc. Vernon, B. C.) baited with rolled oats and peanut butter. The 70 m by 70 m trapping grids have 64 trap stations at 10 m intervals. We ear-tagged mice and voles with a uniquely numbered ear tag (Monel no. 1005-1). We recorded species, age, sex, reproductive condition, and presence of external macro-parasites for each individual. During 2000 we captured 350 individual mice and voles and had 211 captures of shrews. Trapping resulted in 597 individual deer mice and red-backed voles and 574 captures of shrews during 2001. During both 2000 and 2001, there was a similar trend of greater numbers of initial captures of mice and voles as stand age increased.

We completed microhabitat analysis on all 37 small mammal grids. Sixteen of the 64 trapping locations per small mammal grid were randomly selected to inten-

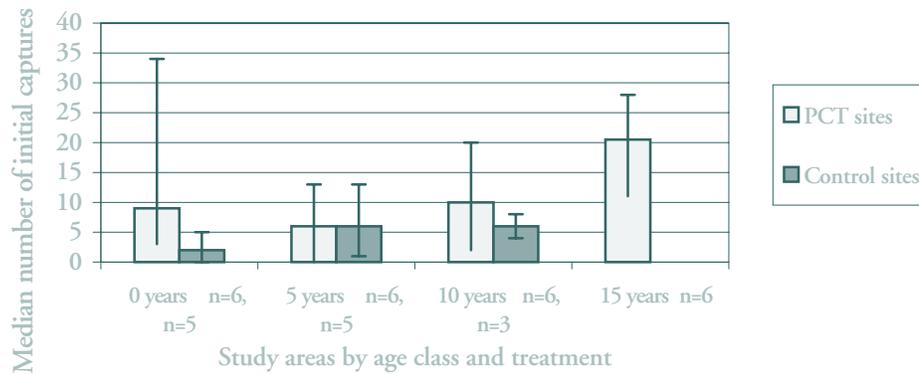


Figure 17. Median and range of the number of initial captures of mice and voles between PCT treated and untreated stands (0-15 years post-treatment), 2000.

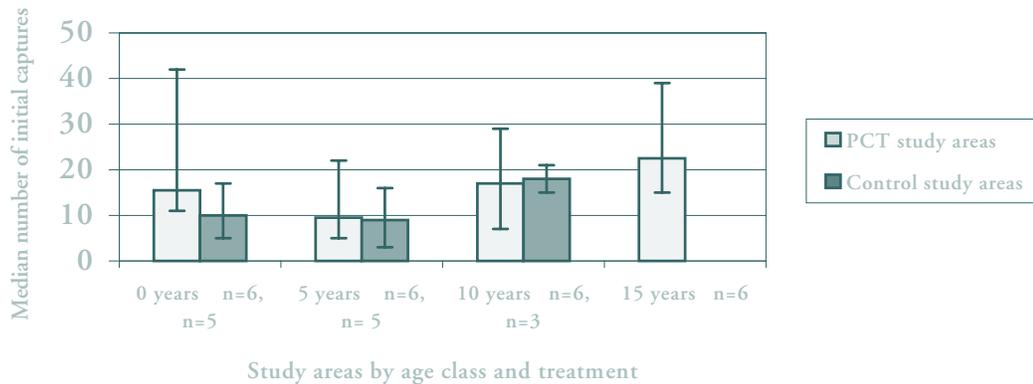


Figure 18. Median and range of the number of initial captures of mice and voles between PCT treated and untreated stands (0-15 years post-treatment), 2001

Relationship of number of initial captures of snowshoe hares and pellet density in four stands in northern Maine, 2001

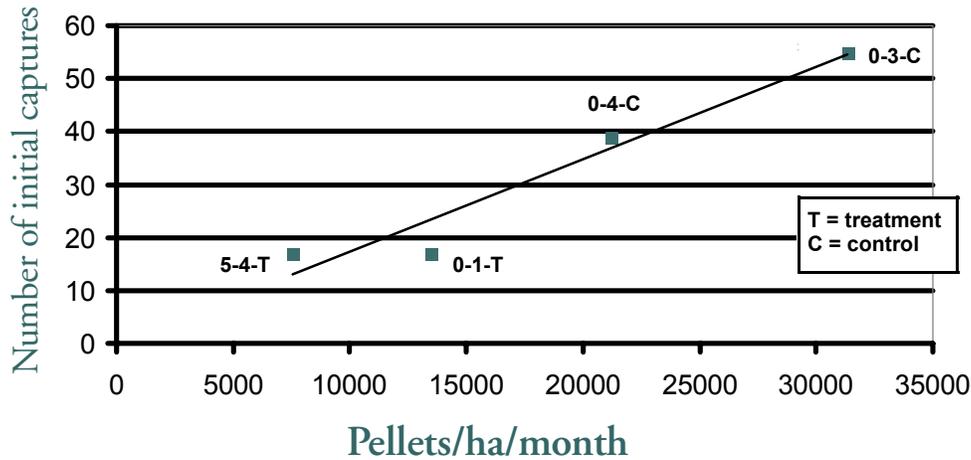


Figure 19. We trapped snowshoe hare in four stands during spring of 2000 to calibrate the relationship of pellet density with abundance of hare.

sively measure vegetation characteristics. A 10-m by 2-m rectangular plot was randomly oriented on each trapping location. We measured habitat characteristics including the number of trees greater than 7.6 cm dbh, number of saplings, volume of logs and stumps, canopy closure, basal area, number of herbaceous and woody ground stems, and other measurements.



Figure 20 We captured a total of 350 mice and voles during summer 2000 and a total of 597 during summer 2001 on 24 stands treated with PCT and 13 paired control stands.

Snowshoe hare. We established 46.7 km of pellet transects in 30 stands including 17 treatment stands (0 years since PCT, n = 5; 5 years since PCT, n=5; 10 years since PCT, n=7) and 13 paired control stands. We established 1.6 km of transect in 28 stands and the remaining two stands had 1.18 km and 1.34 km. Transects were placed greater than 35 m from edges to minimize potential edge-effects. When possible, we established four parallel, 400 m transects in a stand and separated transects by 65 m. We marked 5 m by 30 cm pellet plots at 20-m intervals along transects for a total of 84 plots per stand. We cleared all plots of hare pellets October 18th through 25th, 2000 so that only pellets deposited after leaf-off were subsequently counted in spring 2001. We counted hare pellets May 17th through June 14th, 2001 as an index to abundances during the leaf-off season and September 13th through 29th, 2001 as an index to abundances during the leaf-on season.

To calibrate the relationship between pellet density and hare density (Krebs et al. 2001), we live-trapped hare on a sub-sample of four stands during May-June 2001 (Figure 19, 21). Single-door collapsible Tomahawk traps (Model 205) (Tomahawk, Wisconsin, USA) were set on a 465 m by 260 m grid, covering 12.09 ha. Trap stations were spaced 65 m apart, and traps were set < 2 m from the station and baited with alfalfa cubes



Figure 21 128 snowshoe hare were tagged and released 308 times on two treatment and two control stands during spring 2001.

(Litvaitis et al. 1985). We marked hare with a unique, individually numbered ear-tag or foot tag and released them on the trap-site. We recorded sex, reproductive condition, and length of the right hind foot of each captured individual. During spring 2001, we captured a total of 128 individual snowshoe hare 308 times.

We completed extensive habitat measurements on seven of 30 stands. Five plots per 400 m of transect were established at random locations on the pellet transects for a total of 20 plots per stand. We measured forest structure on 25 m² plots in thinned stands 10 m² plots in control stands. Larger plots were established on thinned stands because stem density was reduced in these stands and we wished to sample approximately 100 crop trees per stand. We measured several habitat measurements including the species of tree, diameter class at breast height, the height class, and the height of the crown base of every woody stem ≥ 1.0 m height in the plots. Further, we measured horizontal vegetation structure, the number and type (coniferous or deciduous) of woody stems between 0.2 m and 1.0 m height in a nested subplot, and the volume of downed logs. We estimated the percentage of ground

covered by grasses and forbs, moss, bare ground, rock, litter, and other vegetation.

A third year of fieldwork will be completed in summer 2002. Four additional stands will be live-trapped for population estimates of snowshoe hare. Hare pellets will be counted and cleared on the 46.7 km of transects in 30 stands during early spring. We will also complete extensive vegetation measurements on the remaining 23 stands. The projected date of completion is May 2003.

REFERENCES

- de Bellefeuille, S., L. Bélanger, J. Huot, and A. Cimon. 2001. Clear-cutting and regeneration practices in Quebec boreal balsam fir forest: effects on snowshoe hare. *Canadian Journal of Forest Research* 31: 41-51.
- Hoving, C. L. 2001. Historical occurrence and habitat ecology of Canada Lynx (*Lynx canadensis*) in eastern North America. Thesis, University of Maine, Orono, USA.
- Krebs, C. J., R. Boonstra, V. Nams, M. O'Donoghue, K. E. Hodges, and S. Boutin. 2001. Estimating snowshoe hare population density from pellet plots: a further evaluation. *Canadian Journal of Zoology* 79: 1-4.
- Lautenslager F. W. Bell, R. G. Wagner, and P. E. Reynolds. 1998. The Fallingsnow Ecosystem Project: Documenting the consequences of conifer release alternatives. *Journal of Forestry* 96: 20-27.
- Litvaitis, J. A. Sherburne, and J. A. Bissonette. 1985. A comparison of methods used to examine snowshoe hare habitat use. *Journal of Wildlife Management* 49: 693-
- Long, R. A. 1995. Annual survival and cause-specific mortality of white-tailed deer fawns, and relative abundance of snowshoe hare on Mount Desert Island, Maine. Thesis, University of Maine, Orono, Maine, USA.
- Maine Forest Service. 1995. 1994 Silvicultural Activities Report. Maine Forest Service, Department of Conservation, Augusta, Maine, USA.
- . 1996. 1995 Silvicultural Activities Report. Maine Forest Service, Department of Conservation, Augusta, Maine, USA.
- . 1998. 1997 Silvicultural Activities Report. Maine Forest Service, Department of Conservation, Augusta, Maine, USA.

- . 1999. 1998 Silvicultural Activities Report. Maine Forest Service, Department of Conservation, Augusta, Maine, USA.
- . 2000. 1999 Silvicultural Activities Report. Maine Forest Service, Department of Conservation, Augusta, Maine, USA.
- . 2001. 2000 Silvicultural Activities Report. Maine Forest Service, Department of Conservation, Augusta, Maine, USA.
- Sullivan, and D. S. Sullivan. 1988. Influence of stand thinning on snowshoe hare population dynamics and feeding damage in lodgepole pine forest. *Journal of Applied Ecology* 25: 791-805.
- , R. G. Wagner, D. G. Pitt, R. A. Lautenschlager, and D. G. Chen. 1998. Changes in diversity of plant and small mammal communities after herbicide application in sub-boreal spruce forest. *Canadian Journal of Forest Resources* 28: 168-177.

Can Patch Retention Maintain Biodiversity in Clearcuts and Partially Harvested Forest?

JOHN M. HAGAN AND ANDREW A. WHITMAN, *Manomet Center for Conservation Science*

This is a report on the second year of a 3-year project to test the ability of patch retention to retain vulnerable species and features in the managed forests of Maine. Patch retention is a new practice that involves retaining patches of mature forest in harvest blocks (Figure 22). Patches can be centered on vulnerable ecological features to maximize conservation benefits. These features may be large trees, snags, and logs, uncommon tree species, hard mast producing species, pockets of forest with little past harvesting history, vernal pools, springs, and/or populations of rare species associated with undisturbed forest.

Managed forests in northern Maine may be rich with these ecological features. However other managed forest landscapes such as Sweden's have had decades of intensive management and, as a result, features such as large trees, snags, and logs have become scarce (Ostland and Linder 1993). Forest plant and animal species that depend on

these features account for over a third of Sweden's threatened species (Berg et al. 1994). Sweden is predicted to lose over 1000 forest species due to the loss of these features (Hanski 2001). With changes in technology and markets, Maine's forests may be beginning to follow a trend that Sweden's forests began decades ago. Like Sweden, Maine's forest may become at risk to losing these features and the species that depend upon them. Patch retention may be an effective tool for maintaining Maine's forest biodiversity by accomplishing four objectives:

1. *maintain forest structure* well distributed across the landscape;
2. *provide refugia* for populations of sensitive species from which they can colonize the surrounding managed forest matrix;
3. *maintain habitat patches* that can serve as stepping stones for dispersing propagules;
4. *retain vulnerable ecological features and species.*



Figure 22. An example of a forest remnant surrounded by clearcuts harvested in 1994. It had an ecological value score of 50, just within the range of values found in old growth northern hardwoods (Photo: A. Whitman).

Table 17. Statistical Summary of selected variables from Substudy I plots.

Variable		Forest Type (mean \pm s.d.)	
		Hardwood Forest (<i>n</i> = 33)	Mixedwood Forest (<i>n</i> = 27)
<i>Number of Species</i>	Vascular Plants	44.2 \pm 7.8	39.6 \pm 10.7
	Macro-lichens	15.8 \pm 3.3	20.3 \pm 4.3
	Mosses	20.6 \pm 3.2	21.9 \pm 2.9
<i>Density (number / ha)</i>	Trees \geq 40 cm DBH	2.6 \pm 1.7	1.4 \pm 1.3
	Snags \geq 40 cm DBH	0.6 \pm 0.8	0.4 \pm 0.9
<i>Largest</i>	Tree Diam. (cm DBH)	55.3 \pm 15.5	47.5 \pm 12.4
	Tree Height (m)	23.3 \pm 5.1	22.0 \pm 4.4
	Snag Diam. (cm DBH)	35.0 \pm 19.1	31.6 \pm 14.3
	Log volume (m ³)	1.4 \pm 1.4	1.3 \pm 1.4

THE OBJECTIVES of the Patch Retention Project are to:

1. determine the contribution of new patches to maintaining populations of herbaceous plants, lichens, mosses, and red-backed salamanders.
2. determine the contribution of existing remnants toward maintaining populations of herbaceous plants, lichens, mosses, red-backed salamanders, and ground beetles.
3. provide scientific information about patch retention to land managers, state authorities, and interest groups.

The Patch Retention Project is comprised of three substudies described below. Together the three substudies address the short- and long-term ecological and economic value of patch retention.

SUBSTUDY I is a 3-year before-and-after-control experiment that tests the ability of newly created retention patches to retain ecological features of interest. The goal of Substudy I is to determine the short-term (2 year) impacts of harvesting on species and forest structure in retention patches and harvest areas.

Status: In 2000 we established 60 experimental plots that were sampled for forest structure, macro-lichens, vascular plants, and mosses. Twenty plots were placed in patches to be created, 20 plots were placed in sites to be harvested, and 20 were placed in sites that will remain intact for the duration of the 3-year study. Sites were selected to maximize the number of ecological features

found in a 30-m radius circle and were comparable across treatments. The patches will be 60 m in diameter. Three sites were harvested winter 2001. In the summer of 2001 we sampled the plots in these three sites for microclimate, forest structure, mosses, vascular plants, and lichens. The remaining sites will be harvested winter 2002. Data from 2000 and from 2001 have been entered and proofed.

We expanded our original plan to include experiments in hardwood forest (beyond planned treatments in mixedwood forest). This will make our research results applicable to a larger portion of Maine's landscape. Hardwood sites will receive a partial-harvest treatment and mixedwood sites will receive a clearcut treatment. We will compare percent changes in species diversity and ecological features in both harvest treatments to determine the relative biodiversity benefit of patch retention in each treatment. We were not able to sample for beetles and salamanders in 2000 due to time constraints associated with Year 1 plot setup. Because it may take several years for beetle populations to respond to harvesting, we are only sampling for beetles in retrospective Substudy II. We tested a highly recommended technique of surveying salamander using cover boards. This technique detected few salamanders, probably due to the unusually dry weather conditions. We will use pitfall traps for salamanders in 2002. Because of deep snow, poor wood markets, and equipment breakdowns, Plum Creek Timber Company was only able to harvest 3 experimental sites and create 3 patches. The remaining sites will be harvested winter 2002.

Results to Date: Although we will not have final results until post-harvest data are collected and analyzed, we present two data summaries. In Table 17 we summarize a few important variables. Hardwood plots had more vascular plant species, greater densities of large trees, snags, and logs; and bigger trees, snags, and logs than mixedwood forest. Mixedwood plots had more lichen species.

We also compared plot data from Substudy I to similar data from random plots in mature forest in western and central Maine, in partial cut forest in western and central Maine, and in old growth in Big Reed Forest Reserve (Figure 23). Plots were scored based on the mean percentile rank for (1) diameter at breast height (DBH) of the largest tree, (2) DBH of the largest snag, (3) volume of largest log, (4) number of logs > 20 cm diameter, (5) number of trees ≥ 40 cm DBH, (6) number of snags ≥ 40 cm DBH, (7) number of trees with *Lobaria pulmonaria* (a large-tree lichen), and (8) presence of intermittent and perennial streams and seeps. Sites in Substudy I were selected because they contained these features.

Although scores of Substudy I plots averaged lower than scores of old growth plots, some Substudy I plots had scores comparable to old growth plots. Many Substudy I plots scored higher than plots in mature forest and partial cut forest. Partial cut and mature forest plots had similar scores. This is because in the short term partial cutting only reduces the number of big trees and trees with *Lo-*

baria pulmonaria and leaves many forest wetlands, snags and logs. As partial cutting reduces the number of large trees, we expect that this will be followed by an eventual reduction in the number of large snags and logs. Remarkably there are patches of forest in northern Maine that are similar to old growth. Several questions remain including: how frequently do old growth-like patches occur, can we do better at locating them, and can we conserve them with patch retention?

Major Finding: Readily identifiable patches of forest similar to old growth occur in northern Maine’s managed forests. With patch retention we may be able to maintain the frequency and density of ecological features over time.

SUBSTUDY II is a retrospective study of upland forest remnants (buffer strips, retention patches, and fire remnants) that were created 2 to 70 years ago. The goal of Substudy II is to assess the long-term (2-70 year) ability of retention patches to retain forest structure and forest species.

Status: In 2001 we completed sampling for the buffer width study for a total of 20 sites. We had added the buffer width study in 2000 because our Advisory Team expressed a strong interest in knowing how large patches must be in order to maintain ecological features.

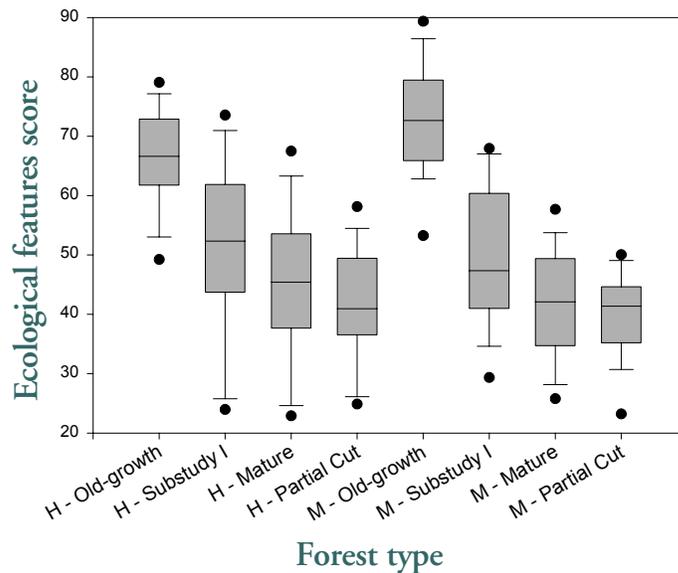


Figure 23 Ecological Features Scores of plots in (1) old growth, (2) Substudy I, (3) mature forest, and (4) partial cut forest in hardwood (H) and mixedwood forest (M). The score is the mean percentile of the 8 ecological features (see text above for list). Shaded boxes indicate the values for the 25 and 75 percentile of plots. The horizontal line indicates the median value.

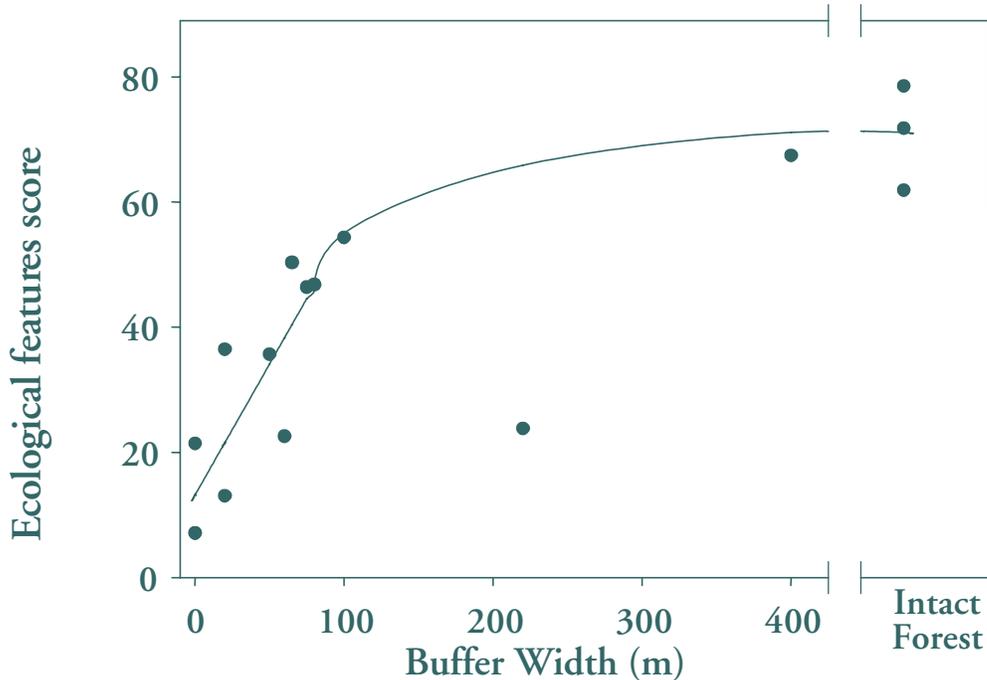


Figure 24. Relationship between ecological features score and buffer width. For comparison the ecological features score of plots in mature forest are added on the right. Zero m buffer width plots were in clearcuts. Plot with a buffer width of 220 m may be an outlier.

In 2001 we concluded sampling for a study of buffer edges and sampled 48 sites in 8-10 year old upland buffers (n=16), adjacent 8-10 year old upland clearcuts (n=16), and nearby upland mature forest (n=16). For this study we sampled plots perpendicular to the buffer edge extending into the buffer center to better understand how the edge affects forest structure and forest species in old remnants. Sites were sampled for trees, logs, shrubs, vertical structure, ground beetles, macro-lichens, vascular plants, and mosses.

In a study of existing retention patches, we also sampled 40 sites in 2 year-old retention patches established by foresters (n=21), clearcuts (n=8), and mature forest (n=11). This study will be used to evaluate how well patch retention can be applied in an operational setting. We placed temperature probes in 6 patches ranging in size from 0.1-1.0 acres. Sites were sampled for trees, logs, shrubs, vertical structure, macro-lichens, vascular plants, and mosses.

While sampling for Substudy I in 2000 we encountered a 70-year-old burn with unburned remnants. We initiated a small study of these remnants to determine the usefulness of patch retention over the very long-term. We concluded sampling for the fire remnant study in 2001 with

and sampled 10 fire remnants and 6 sites in the burn area. Data from 2001 have been entered and proofed.

Results to Date: Ecological features scores of mixed-wood buffers > 100 m wide may be similar to the scores of mature forest (Figure 24). A plot in a buffer 220 m wide may have had a score lower than expected because of timber harvesting 30 years ago.

In the buffer edge study, we have begun preliminary analyses though identification of specimens to species is still in progress. Clearcuts had significantly far fewer numbers of ground beetles than buffers and mature forest (Figure 25). All distances from the buffer edge had numbers of ground beetles that were similar to the number found in mature forest.

In a separate study we measured daily air temperature in the center of five hardwood patches of different sizes to determine what sized patch was most similar to mature forest (Figure 26). In the middle of the day, the clearcut was up to 6° C warmer than the mature forest. The smallest patch, 10 x 20 m, stayed cooler than the clearcut but was warmer than the mature forest by as much as 3° C. Although the center of the largest patches were

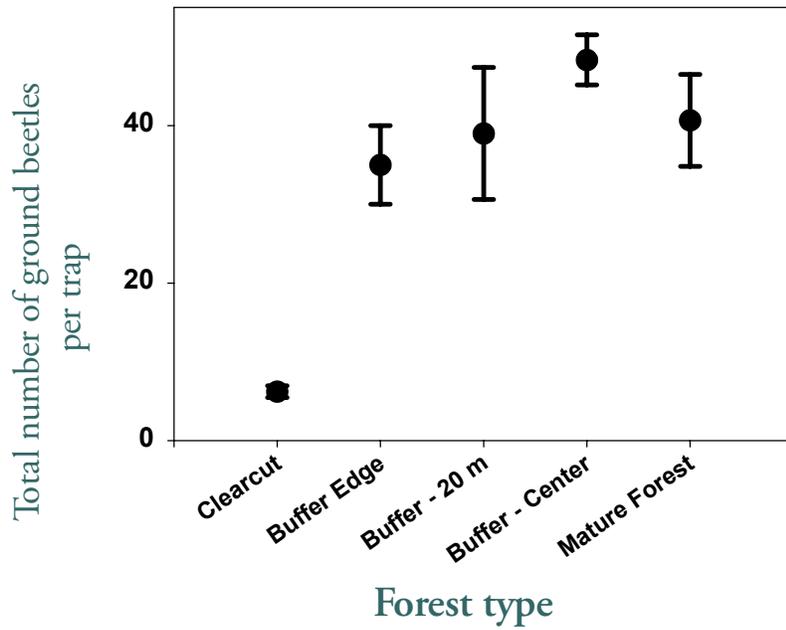


Figure 25. Numbers of ground beetles per pitfall trap (mean \pm s. d.) in clearcuts, buffer edges, interior buffer 20 m from edge, buffer centers, and mature forest sites in northwestern Maine.

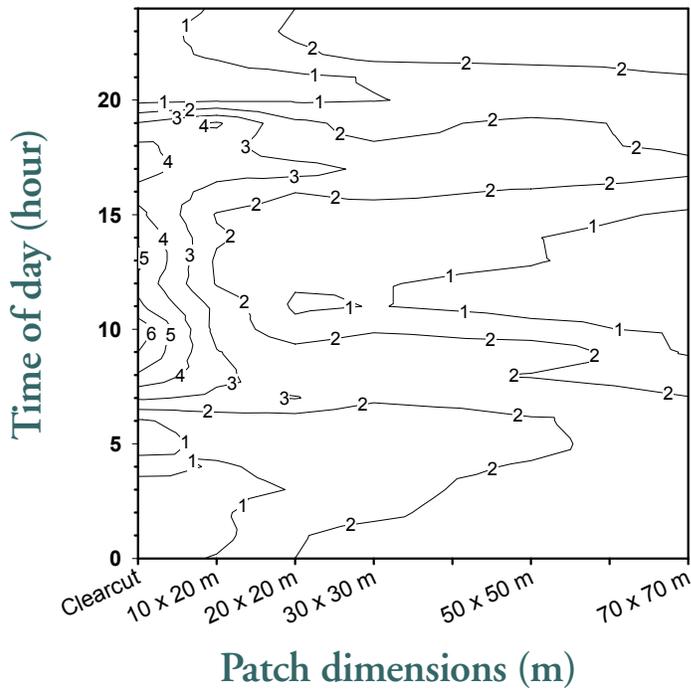


Figure 26. Maximum temperature differences ($^{\circ}$ C) differences throughout the day between mature hardwood forest and hardwood patches of different sizes in a clearcut.

slightly warmer than mature forest, the center of the 30 x 30 m and larger patches never warmed more than 2° C greater than the temperature of mature forest.

Major Finding: Relatively small patches of forest can retain a level of features and microclimate similar to that found in mature forest.

SUBSTUDY III. In this study we are assessing the economic costs of employing patch retention on a scale beyond the experimental work.

This work is a collaboration with Chris LeDoux, Ph.D. (USDA Forest Service), a timber harvest operations and forest growth modeler. We have had one planning meeting with Dr. LeDoux and company staff to determine goals and data needs for modeling costs of patch retention. Dr. LeDoux's visit included a field trip to visit typical harvest operations in north Maine. We are in the process of collecting data on economic value of stands, equipment, harvest block size, and transportation costs to evaluate the costs of patch retention. These analyses will include sensitivity analyses to determine where patch retention costs are minimal and where they are likely to be high.

Advisory Team Formed. We formed an external advisory team ensure that the project is useful to stakeholders. Members include: Peter Etheridge (research Forester, J.D. Irving, Ltd.), Hugh Crammond (Forester, J.D. Irving, Ltd.), and Sue Gawler (Plant Ecologist, Maine Natural Areas Program). We are looking for a fourth member. We met with team members twice to review progress and solicited suggestions for modification of work in 2001. We will meet with team members his winter to review progress and solicit suggestions for modification of work in 2002.

YEAR 2002 TASKS

- Sample 60 points in retention patches, harvest areas, and mature forest for Substudy I
- Microclimate studies of 3 clearcut sites for Substudy I
- Sample ground beetles and salamanders in 9 points in buffer strips, clearcuts, and mature forest for Substudy II
- Sample 10 sites in retention patches, clearcuts, and mature forest for Substudy II
- Format and provide economic data to economic modeler

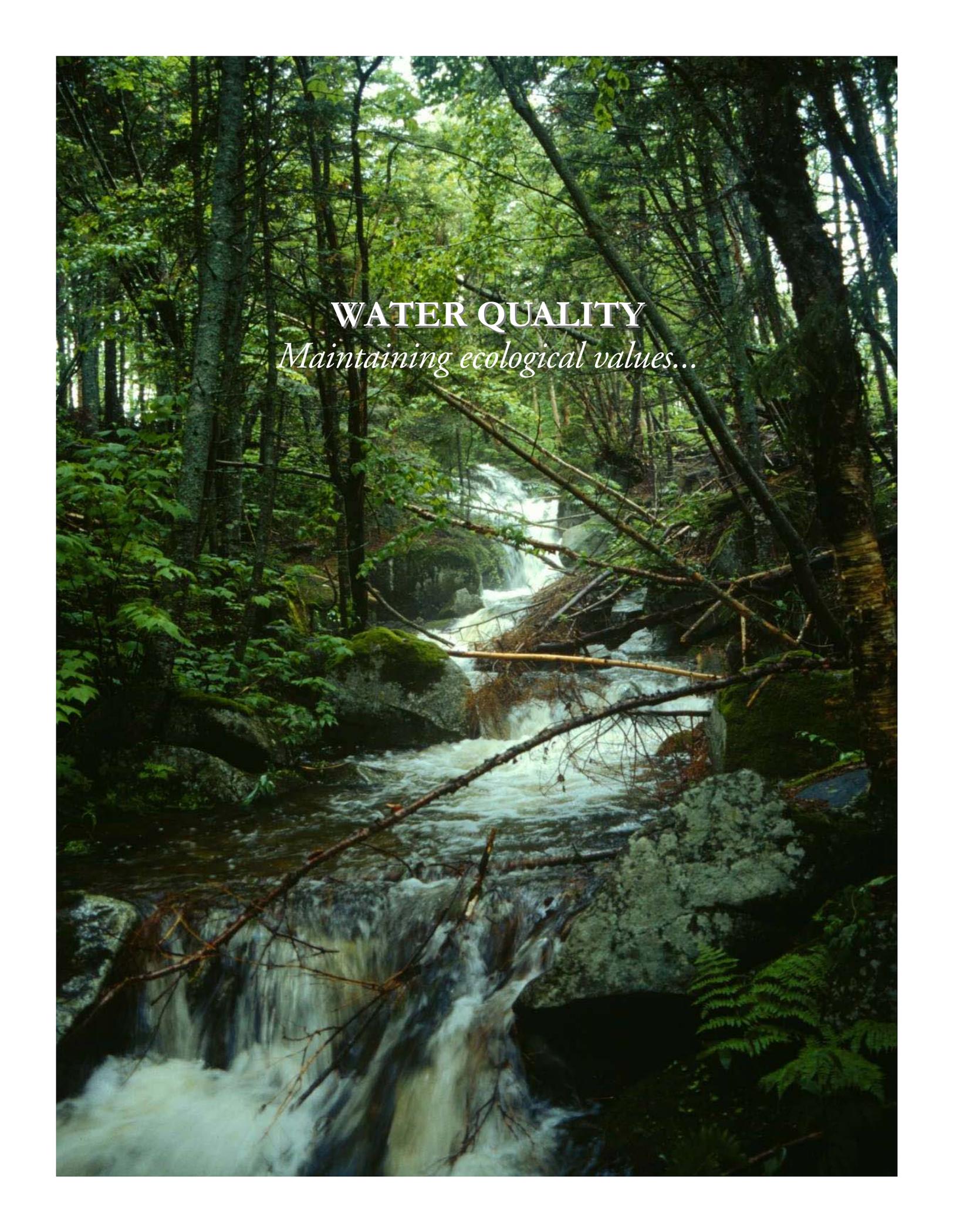
- Report: Plant species and ecological features in upland forest buffers of different widths, mature forest, and clearcuts in western Maine.
- Report: Effects of edges on plants and forest structure in upland forest buffers in western Maine.
- Report: Economic costs of Patch Retention in Maine's industrial forest.
- Report: The retention of forest structure and species through patch retention in clearcuts and partial cuts: a before and after study.

For more information on this study contact **Andrew Whitman** and **John Hagan** at Manomet Center for Conservation Sciences, 14 Maine Street, Suite 404, Brunswick, ME 04011 (207) 721-9040 or email awhitman@ime.net or jmhagan@ime.net.

Acknowledgements. Ground beetle surveys were conducted jointly with Dick Dearborn and Charlene Donahue, Maine Forest Service. Sarah Bendit, David Werier, Lauren Aldrich, Julia Briedis, Christina Lavertu, Justin Meyer, Rachael Straddard, Jesse Twitchell, Aljoscha Requardt, and Jessica Barbay assisted fieldwork. The patch retention study was only possible through the assistance of J.D. Irving staff: Hugh Crammond, Frieda Dickinson, Dan Pelletier, Jesse Saunders, and Eric Dumond.. Funding was provided by the Cooperative Forestry Research Unit of the University of Maine, the National Fish and Wildlife Foundation, the Maine Outdoor Heritage Fund, and Manomet Center for Conservation Sciences.

REFERENCES

- Berg, A., B. Ehnstrom, L. Gustafsson, T. Hallingback, M. Jonsell, J. Weslien. 1994. Threatened plant and animal, and fungus species in Swedish forests: distribution and habitat association. *Conservation Biology* 8: 718-731.
- Hanski, I. 2000. Extinction debt and species credit in boreal forests: modeling the consequences of different approaches to biodiversity conservation. *Annales Zool. Fennici* 37: 271-280.
- Linder, P. and L. Ostlund. 1992. Changes in the boreal forest of Sweden 1870-1991. *Sven. Bot. Tidskr.* 86: 199-215.

A photograph of a forest stream with a waterfall, overlaid with text. The scene is a lush, green forest with many trees and ferns. The stream flows over rocks, creating a small waterfall. The text is centered in the upper half of the image.

WATER QUALITY
Maintaining ecological values...

The Effectiveness of Different Buffer Widths for Protecting Riparian Values

JOHN M. HAGAN AND DARLENE SIEGEL, *Manomet Center for Conservation Science*

The goal of the experiment is to understand which riparian values are protected with different forest buffer widths. With the assistance of Mead, International Paper, Plum Creek, and Seven Islands Land Company, by June 1 we had located 15 headwater streams for the study that met our selection criteria. In June, 2001, we began data collection on an array of riparian values in the pre-treatment (pre-harvest) year of this experiment.

Each of the 15 streams has been randomly assigned to one of the following 5 treatments:

Treatment #	Harvest	No. of replicates
1	Clearcut with 0-m Buffer	3
2	Clearcut with 10-m Partial Cut Buffer	3
3	Clearcut with 23-m Partial Cut Buffer	3
4	200 m Partial Cut Block	3
5	No Harvest (Control)	3

The only significant complication in the work plan has been that 11 of the 15 experimental streams went dry over the course of the summer. This was partly a result of (1) moving the entire study upstream into the high headwaters (per the suggestion of our Study Advisory Committee), and (2) an unusually dry summer in Maine. However, because such small streams ($\bar{x}=2.95\text{m}$) have never been studied in this region, we do not know whether such drying is normal or abnormal; the behavior we observed in 2001 may not be extraordinary. The possibility that some streams would go dry during the summer was considered by our Study Advisory Committee, and it was agreed that such a result would be an acceptable risk for getting data on small headwater streams. Fortunately, in anticipation of this possibility, we collected water quality data intensively in June when streams were flowing.

Because of the keen interest in the study by many organizations, we were able to expand the scope of the study with financial and in-kind contributions from the University of Maine Department of Wildlife, Maine Department of Environmental Protection, Maine Inland Fisheries and Wildlife, and Plum Creek Timber Company.

SPECIFIC PROJECT COMPONENTS

Stream selection

Status: complete

Comments: The streams are more widely spaced throughout western Maine than we would have preferred, from a logistics perspective. The wide spacing was a result of the difficulty in locating streams that met all our criteria (the most critical limitation was the need to have the harvesting take place this fall or winter).

Stream monumenting

Status: complete

Comments: We monumented sample points along each stream reach with precision. Every 20 m, along the 500 m reach of each stream, we embedded galvanized 12" spikes on both sides of the stream (52 spikes per stream). With this layout, we can precisely sample (an resample) the streams for an array of parameters. Also, this system will allow future researchers to be able to relocate sample stations, should long-term monitoring of harvest effects become of interest.

Stream temperature

Status: complete

Comments: Automatic temperature loggers were deployed by mid-June at 100 m intervals along the 500 m reach of each stream (total of 90 temperature loggers). All loggers have been retrieved and data are now being downloaded and summarized. An example of a temperature trace from one stream is shown in Figure 27.

Water Quality

Status: Round 1 completed (June); Round 2 compromised by stream drying

Comments: We collected water quality data on 6 stream parameters between 4 June and 25 June. We completed a second round of water quality sampling in mid-August, but many of the streams had gone dry by that time. Simple summary statistics of June water quality data are shown in Table 18 (with the exception of flow data).

Temperature Trace: Roxbury Stream

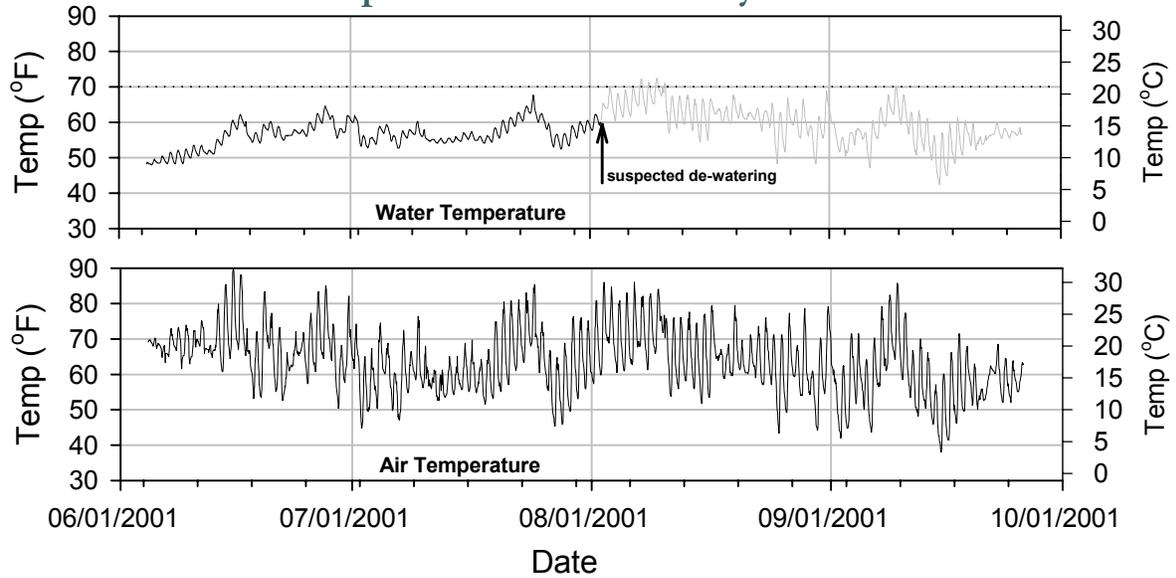


Figure 27. Continuous air temperature (below) and water temperature (above) trace for one of the 15 experimental streams during the summer of 2001. Based on diurnal temperature fluctuations in the water temperature sensor, we deduce that the stream went dry in early August. Thermal stress for brook trout begins at about 70°F.

Table 18. Summary statistics for 5 water quality parameters for the 15 study streams. Data are mean values and standard errors (in parens). Sample size = 18 (6 locations at 100 m intervals x 3 stream visits). Data were collected between 4 and 25 June, 2001. Note: we are not sure why Mass Gore2 was so cold. We suspect the stream originated from a snow field or possible underground ice. The continuous temperature monitors should help us understand what caused this particular stream to be extremely cold.

Stream	Temperature (°C)	PH	Dissolved O ₂ mg/L	Conductivity (mS/cm)	Turbidity (NTUs)
Appleton	8.65 (.41)	5.54 (.06)	10.13 (.15)	0.014 (.0001)	0.03 (.016)
Bald Mountain	12.53 (.43)	5.98 (.07)	8.87 (.19)	0.017 (.0007)	0.10 (.030)
Bryant	11.19 (.63)	5.04 (.05)	9.51 (.25)	0.017 (.0004)	0.01 (.002)
Caratunk	11.97 (.33)	6.74 (.04)	9.35 (.08)	0.030 (.0005)	0.03 (.018)
Dud Brook	12.56 (.35)	6.76 (.02)	9.22 (.09)	0.022 (.0005)	0.10 (.014)
Kibby1	10.18 (.41)	6.36 (.04)	9.55 (.11)	0.017 (.0008)	0.01 (.004)
Mass Gore1	9.74 (.48)	6.47 (.03)	9.86 (.19)	0.024 (.0007)	0.17 (.045)
Mass Gore2	4.37 (.50)	6.60 (.04)	11.29 (.30)	0.030 (.0005)	0.40 (.183)
Pierce Pond1	11.74 (.52)	6.06 (.05)	9.01 (.31)	0.019 (.0006)	0.04 (.014)
Pierce Pond2	11.28 (.47)	6.25 (.08)	9.59 (.20)	0.019 (.0007)	0.02 (.012)
Roxbury	11.18 (.57)	6.62 (.04)	9.77 (.25)	0.026 (.0010)	0.12 (.060)
Sanderson	11.99 (.47)	6.47 (.05)	9.55 (.16)	0.021 (.0005)	0.60 (.041)
Skinner1	8.81 (.31)	6.76 (.06)	10.04 (.11)	0.023 (.0006)	0.55 (.361)
Skinner2	9.85 (.55)	6.75 (.04)	9.34 (.23)	0.029 (.0009)	0.05 (.015)
Up Cup	10.86 (.44)	6.72 (.04)	9.69 (.17)	0.025 (.0003)	0.22 (.050)

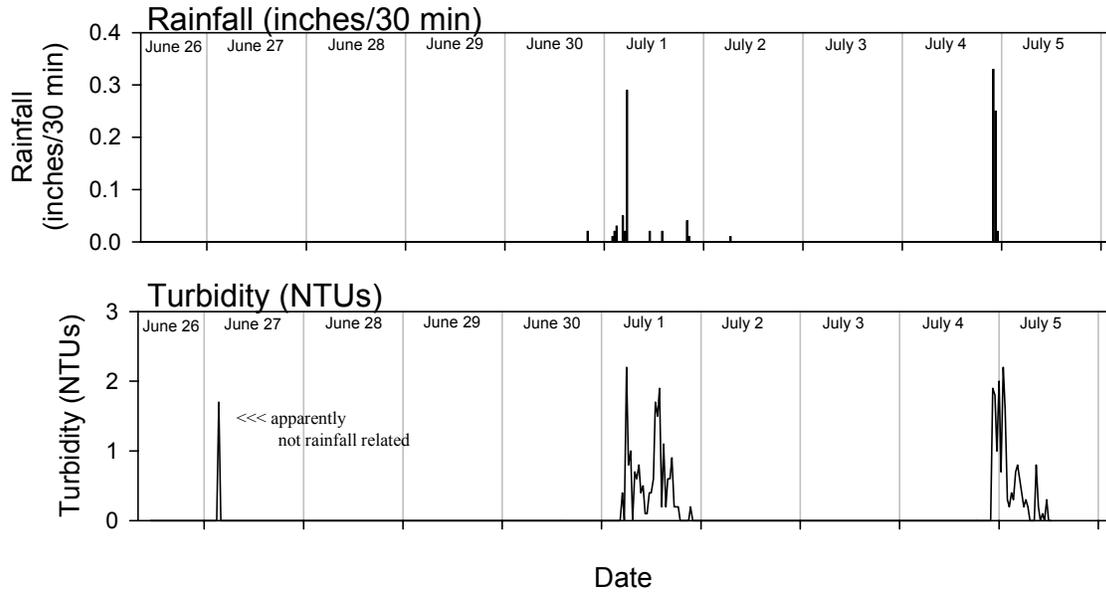


Figure 28. A plot of rainfall (top) and stream turbidity (bottom) in one of the 15 study streams over a 10-day period in late June and July. The data clearly show the relationship between stream turbidity and rainfall. The continuous turbidity data were recorded by Hydrolab datasonde 4a monitors.

HydroLabs

Status: complete

Comments: Continuous monitoring of water quality (DO, pH, turbidity, conductivity) was not a part of the original proposal. However, with addition financial support from Plum Creek Timber Co., we were able to purchase 5 Hydrolab datasonde 4a continuous monitors. We had difficulty getting these units properly calibrated. However, several of the units provided extremely valuable insight on stream turbidity. A sample plot of data from a pilot deployment is shown in Figure 28. Turbidity was functionally zero, except for a brief period following rain events. It was unlikely that our site visits using hand-held meters would coincide with turbidity events such as shown in Figure 28.

Rain Data

Status: complete

Comments: Two continuous rain gauges were been deployed in Kibby and Carratunk townships. These data are important for linking to the continuous turbidity data generated by the Hydrolabs (Figure 28).

Stream Habitat

Status: complete

Comments: The largest single activity, in terms of person-hours, was devoted to stream habitat work. Detailed

data were collected every 20 m within the 500 m study reach of the 15 streams (26 stations per stream) (Figure 29). Additional stream substrate data were taken every 2 m in the thalweg (stream course center) of each stream (251 readings/stream).

Stream Downed Woody Debris

Status: complete

Comments: Every piece of debris >8 cm center diameter was measured within the 500 study reach of each



Figure 29. Taking measurement on stream habitat. An array of physical measurements were taken every 20 m along the 500 m reach of each of the 15 study stream.



Figure 30. Taking measurements on in-stream downed woody debris. Every piece of debris (>8 cm diam) within the stream channel was measured along the 500 m study reach of each stream.

stream. The location (to the nearest meter) of each piece was recorded. With this method we will be able to detect small (or large) changes in DWD volumes post harvest. In addition, we will have baseline data on DWD loadings in small headwater streams (Figure 30).

Terrestrial Habitat

Status: completed

Comments: We recorded woody and herbaceous vegetation in 5 x 50 m sample quadrats parallel to the stream and at the following perpendicular distances from the stream: 0-5 m, 13-18 m, 25-30 m, and 40-45 m. Detailed data on herbaceous plants was made possible by a grant from the National Fish and Wildlife Foundation.

Macroinvertebrates

Status: incomplete

Comments: We employed a protocol for sampling stream invertebrates used by the Maine Department of Environmental Protection. This method consists of placing rock-filled mesh bags in the streams for 1 month, and then scraping colonizing macroinvertebrates from the rocks at the end of the sample period. Unfortunately, many of the streams went dry just after deployment of the bags. We will use upstream no-harvest zones as controls next year, and use a Serber sampling net instead of rock bags.

Fish

Status: partial completion due to stream drying

Comments: Jeff Light and Ron Steiner from Plum Creek sampled fish in 4 streams with running water in late August. Remarkably, over 70 small brook trout were found along a 100 m section of a study stream in northern

Skinner township. Formerly, we considered these streams too small to support such a fish community.

Periphyton

Status: complete

Comments: We sampled epilithic periphyton from each stream during July. This was not a part of the original proposal. However, the Maine DEP was willing to provide the cost of analysis, and so we agreed to take the samples.

Amphibians

Status: complete

Comments: Any array of drift fences and pitfall traps were placed along each of the study streams from June through August and were monitored regularly throughout the summer. This work also was not a part of the original proposal, but was made possible by the National Fish and Wildlife Foundation grant (also for herbaceous plants, see above) and U. Maine Wildlife Department funding. The amphibian work is being conducted by Mac Hunter and his graduate student, Dustin Perkins, at the University of Maine.

Harvest Block Layout and Harvesting

Status: complete / ongoing

Comments: Harvest block layout has been completed on all streams and harvesting has been completed along some of the streams at the time of this report. All remaining streams will be harvested according to the experimental design this fall or winter.

PLANNED ACTIVITIES

All data will be entered and proofed this fall and winter. Statistical summaries of all stream parameters will be completed before May, 2002. We will produce a summary report of statistics on natural variability in headwater streams (e.g., pre-treatment year). In June, 2002, we will begin sampling in the first post-harvest season.

For more information about this study, contact **John Hagan** or **Darlene Siegel** at 207-721-9040 or email jmhagan@ime.net or dsiegel@ime.net.

ACKNOWLEDGEMENTS

Project Assistants: Sacha Pealer, Chris Collins; Student Conservation Association interns: Liane Beggs, Morgan Hall, Stephanie Hart, Corey Myers, Matthew Peters; U. Maine amphibian project: Dustin Perkins, Ph.D. candidate; Research Assistants: Kristen Dillworth, Melissa Sousa. Funding has been provided by NCASI, Plum Creek Timber Co., the University of Maine Coopera-

Cooperative Forestry Research Unit

tive Forest Research Unit, the National Fish and Wildlife Foundation, the U. Maine Wildlife Department, Maine Department of Environmental Protection, and Manomet Center for Conservation Sciences. We thank International Paper, Mead Paper, and Seven Islands Land, and

Plum Creek Timber Company for exemplary assistance in helping to locate suitable study streams and for arranging harvesting according to our specifications. Our Study Advisory Committee also provided valuable advice for in the design of this study.

Technology Transfer

JOURNAL PUBLICATIONS

Payer, D.C., and D.J. Harrison. 2000. Structural differences between forests regenerating following spruce budworm infestation and clearcut harvesting: implications for American marten. *Canadian Journal of Forest Research* 30:1965-1972.

Wagner, R.G. 2000. Competition and critical-period thresholds for vegetation management in young conifer stands. *Forestry Chronicle* 76(6): 961-968.

ARTICLES

Wagner, R.G. 2001. Forest Vegetation Management: Public Perceptions of Risk, Trust, and Acceptability. *Agrichemical & Environmental News*. March 2001, Issue No. 179. Online publication at: <http://www.tricity.wsu.edu/aenews/>

Wagner, R.G., R.S. Seymour, and D.B. Field. 2000. Question 2 poor forest science. *Bangor Daily News*, November 1, 2000, Bangor, ME

RESEARCH REPORTS

Wagner, R.G. 2001. Arsenal herbicide reduces height growth in red spruce and balsam fir. Cooperative Forestry Research Unit, University of Maine, Orono. CFRU Research Note, CFRU RN 01-02. 4 p.

Wagner, R.G. (Compiler) 2001. Poster Abstracts: New England Society of American Foresters 81st Annual Winter Meeting, March 14-16, 2001, South Portland, Maine 42 p.

CONFERENCE PROCEEDINGS

Randolph, K.C., R.S. Seymour, and R.G. Wagner. 2001. ThinME: Development of Commercial Thinning Guidelines for Maine Spruce-Fir Forests. In *Proc. Thinnings: A Valuable Forest Management Tool – An International Conference*. September 2001, Quebec City, Quebec. Forest Engineering Research Institute of Canada, Point-Claire, Quebec, Canada. Web: publications@mtl.feric.ca

Wagner, R.G., R.S. Seymour, and D.J. McConville. 2001. Maine's Commercial Thinning Research Plot

Network. In *Proc. Thinnings: A Valuable Forest Management Tool – An International Conference*. September 2001, Quebec City, Quebec. Forest Engineering Research Institute of Canada, Point-Claire, Quebec, Canada. Web: publications@mtl.feric.ca

Wagner, R.G. 2000. Competition and critical-period thresholds for vegetation management in young conifer stands. pp. 25-33 In *Proc. 4th Annual PNW-IVMA Forestry and Rights-of-Way Conference*. Integrated Vegetation Management Conference. The Forces of Change: the Power and Politics of Vegetation Management. PNW-Integrated Vegetation Management Association, November 14-15, 2000, Portland, OR.

MacLean, D., A. Smith, J. Higdon, I. Methven, B. Wagner, J. Hagan, K. Porter, and M. Reed. 2001. Spatial and temporal patterns of natural and human-caused forest disturbance on the J.D. Irving Black Brook District. *Foothills Model Forest Symposium*. Natural Disturbance and Forest Management: What's happening and where it's going. March 5-7, 2001. Edmonton, AB

Randolph, K.C., R.S. Seymour, and R.G. Wagner. 2001. Commercial thinning guidelines for Maine spruce-fir forests. pp. 5 *In* Wagner, R.G. (Compiler). *Poster Abstracts: New England Society of American Foresters, 81st Annual Winter Meeting*, March 14-16, 2001, South Portland, Maine.

Wagner, R.G., 2001. Arsenal herbicide reduces height growth in red spruce and balsam fir. pp. 2-3 *In* Wagner, R.G. (Compiler). *Poster Abstracts: New England Society of American Foresters, 81st Annual Winter Meeting*, March 14-16, 2001, South Portland, Maine.

Wagner, R.G., R.H. Daggett, and M.L. McCormack. 2001. Long-term effect of herbicides and precommercial thinning on the composition and structure of Maine spruce-fir stands. pp. 18 *In* Wagner, R.G. (Compiler). *Poster Abstracts: New England Society of American Foresters, 81st Annual Winter Meeting*, March 14-16, 2001, South Portland, Maine.

Wagner, R.G., H.E. Griffin, and D.J. McConville 2001. Maine's Cooperative Forestry Research Unit (CFRU). pp. 21 *In* Wagner, R.G. (Compiler). *Poster Abstracts: New England Society of American*

Foresters, 81st Annual Winter Meeting, March 14-16, 2001, South Portland, Maine.

Wagner, R.G., R.S. Seymour, and D.J. McConville. 2001. Maine's commercial thinning research plot network. pp. 19-20 *In* Wagner, R.G. (Compiler). Poster Abstracts: New England Society of American Foresters, 81st Annual Winter Meeting, March 14-16, 2001, South Portland, Maine.

Wagner, R.G., 2001. Seasonal tolerance of red spruce and balsam fir to glyphosate, triclopyr, and imazapyr herbicides. *In* Proc. 55th Ann. Meeting of the Northeastern Weed Science Society, Cambridge, MA, Jan 2-5, 2002.

Wagner, R.G., 2001. Competition and critical-period thresholds for vegetation management in young conifer stands. *In* Proc. 55th Ann. Meeting of the Northeastern Weed Science Society, Cambridge, MA, Jan 2-5, 2001.

Wagner, R.G., Griffin, H.E. and McConville D.J. 2000. Maine's Cooperative Forestry Research Unit (CFRU). 2000 Society of American Foresters National Convention. November 16-20, 2000, Washington, DC.

Randolph, K., Seymour, R.S., and Wagner, R.G. 2000. Commercial thinning guidelines for Maine spruce-fir forests. 2000 Society of American Foresters National Convention. November 16-20, 2000, Washington, DC.

COMPUTER SOFTWARE

Randolph, K.C., R.S. Seymour, and R.G. Wagner. 2001. ThinME commercial softwood thinning guide for Maine. Cooperative Forestry Research Unit, University of Maine, Orono, ME.

THESES

Hoving, C.L. 2001. Historical occurrence and habitat ecology of Canada lynx in eastern North America. Thesis, University of Maine, Orono. 200pp.

PRESENTATIONS

Fuller, A.K., and D.J. Harrison. Fuller, A.K. and D.J. Harrison. Influence of partial harvests on American marten habitat selection in Maine. Final contract seminar presented to Advisory Committee, Maine

Cooperative Forestry Research Unit, Sugarloaf Mountain, Maine, October 3, 2000.

Fuller, A.K., and D.J. Harrison. "Partial harvest guidelines for maintenance of marten in Maine." Invited lecture presented at the "Newfoundland Marten Endangered Species Recovery Team Meeting", St. John's, Newfoundland, January 12, 2001.

Harrison, D.J. Fragmentation thresholds for American marten: preliminary results. Presentation to Advisory Committee, Maine Cooperative Forestry Research Unit, Sugarloaf Mountain, Maine, October 3, 2000.

Harrison, D.J., J.Homyack, and A.K. Fuller. Led a field trip and presented preliminary data on effects of forest harvesting on snowshoe hares and small mammals at field tour for Maine forest industry representatives, Maine Cooperative Forestry Research Unit Fall Field Tour, October 4, 2000.

Harrison, D. J. , T.G. Chapin, and C.L. Hoving. "Distribution, extent and connectivity of potential habitat for wolves in Maine and eastern Canada." Invited poster presented at the "Carnivores 2000 Conference", Denver, CO, November 12-15, 2000.

Harrison, D. J. "Influence of dispersal on social ecology of coyotes: do social pressures or prey size promote pack formation?" Invited paper presented at the "Carnivores 2000 Conference", Denver, CO, November 12-15, 2000.

Harrison, D.J. Landscape scale habitat requirements and fragmentation thresholds of marten. Lecture at workshop attended by Canada Parks scientists and invited advisors to address habitat needs of endangered marten in western Newfoundland. Gros Morne National Park Newfoundland, January 9, 2001.

Harrison, D. J., and D.C. Payer "Influences of trapping mortality on current distribution and population dynamics of marten: a biogeographical and empirical perspective." Invited paper presented at "Newfoundland Marten Accidental Trapping and Snaring Workshop", St. John's, Newfoundland, January 12, 2001.

Harrison, D.J. An update of lynx and marten issues related to forest management. Presentation to Advisory Committee, Maine Cooperative Forestry Research Unit, Orono, January 25, 2001.

- Harrison, D. J.** "Marten and Forestry: Conflict or Opportunity." Invited paper presented at J. D. Irving, Limited's 2001 Science Forum, Frederickton, NB, April 3, 2001.
- Harrison, D.J.** "Forestry and Forest Carnivores: Conflict or Opportunity." Talk presented at the University of Maine, Department of Wildlife Ecology, Forestry Noontime Seminar Series, April 6, 2001.
- Harrison, D.J.** Potential forest management issues and research opportunities with federally threatened lynx in Maine. Presentation to Advisory Committee, Maine Cooperative Forestry Research Unit, Orono, Maine, May 3, 2001.
- Harrison, D. J.** "Extent and distribution of wolf habitat in eastern North America and niche characteristics of wolves versus eastern coyotes." Served as invited panelist and presenter at Wolf Symposium for invited government agencies, university personnel and non-governmental organizations, Burlington, VT, May 16, 2001.
- Harrison, D.J.** Served as an invited panelist and presenter of a talk titled "Where could wolves live in the northeast and how are they different from coyotes" at Public Wolf Forum sponsored by Defenders of Wildlife, Burlington, VT, 16 May 2001.
- Harrison, D.J., D.C. Payer, J.A. Hepinstall, A.K. Fuller, and D.D. Katnik.** "Landscape thresholds and nonlinear responses to fragmentation by American marten. Paper presented at 15th Annual Meeting of the Society for Conservation Biology, Hilo, Hawaii, 31 July 2001.
- Hearn, B.** "Annual survival and mortality factors of American marten in Newfoundland." Invited paper presented at workshop on accidental trapping and snaring of endangered Newfoundland marten. St. John's, Newfoundland, Canada, January 11, 2001.
- Hepinstall, J. A., D. J. Harrison, D. C. Payer, A. K. Fuller, and D. D. Katnik.** "Using marten as an umbrella species for forest management." Invited paper presented at the 37th Annual North American Moose Conference and Workshop, Sugarloaf, ME, May 14, 2001.
- Hepinstall, J. A., D. J. Harrison, D. C. Payer, and A. K. Fuller.** "Predicting the occurrences of American marten in harvested landscapes." Presented at the Annual Meeting of the Wildlife Society, Reno, NV, September 25-29, 2001.
- Homyack, J. A.** "Effects of precommercial thinning on snowshoe hares and small mammals in northern Maine." Oral presentation at the 2001 Northeast Wildlife Graduate Conference, University of New Hampshire, Durham, NH, March 2-4, 2001.
- Hoving, C.L.** Historical occurrence and habitat ecology of Canada lynx in eastern North America. Final contract seminar to Maine Department of Inland Fisheries and Wildlife, March 22, 2001.
- Hoving, C. L.** "Historical occurrence and habitat ecology of Canada lynx in eastern North America." Talk presented at the Maine Audubon's Wildlife Conference, Maine Audubon Society, Falmouth, ME, April 7, 2001.
- Hoving, C.L.** Historical occurrence and habitat ecology of Canada lynx in eastern North America. Final thesis seminar presented to Department of Wildlife Ecology, University of Maine, April, 12, 2001.
- Hoving, C. L., R. A. Joseph, and W. B. Krohn.** "Historical and current distributions of lynx in Maine, 1833-1999." Paper presented at the 57th Northeast Fish and Wildlife Conference, Saratoga Springs, NY, April 22-26, 2001.
- Hoving, C. L., D. J. Harrison, W. K. Krohn, W. J. Jakubas, R. A. Joseph, R. Lafond, and M. O'Brien.** "A probability model of Canada lynx occurrence in eastern North America." Poster presented at the 57th Northeast Fish and Wildlife Conference, Saratoga Springs, NY, April 22-26, 2001.
- Hoving, C.L., D. J. Harrison and W. B. Krohn.** "Habitat ecology of Canada lynx in eastern North America." Presented as a poster at the U. S. Fish and Wildlife Service regional office, Hadley, MA, April 26, 2001.
- Hoving, C.L.** Historical occurrence and habitat ecology of Canada lynx in eastern North America. Final thesis seminar presented to Department of Wildlife Ecology, University of Maine, April, 12, 2001.
- Hoving, C. L., D. J. Harrison, and W. K. Krohn.** "Multi-scale habitat relations of Canada lynx in eastern North America." Presented at the 2001 Meeting of the Northeast Fur Technical Committee, Providence, RI, September 13, 2001.
- Hoving, C. L., D. J. Harrison, W. K. Krohn, W. J. Jakubas, R. A. Joseph, R. Lafond, and M. O'Brien.** "Canada lynx habitat associations in eastern North America." Presented at The Wildlife Society 8th

- Annual Conference, Reno, NV, September 27, 2001.
- Wagner, R.G.** - Overview of CFRU research, Milliken family meeting on Baskahegan land management, Southwest Harbor, ME (Aug, 2001)
- Wagner, R.G.** - Research Updates: U. Maine Forest Research Advisory Committee (May, 2001)
- Outcome-based forestry legislation
 - Eastern CANUSA Forest Science Conference
- Wagner, R.G.** - Research on commercial thinning using single-grip harvesters. Wagner Forest Management, Ltd. Workshop, Bangor, ME (May, 2001)
- Wagner, R.G.** - Research Updates: CFRU Advisory Committee meeting (May, 2001)
- Wood supply/silviculture research priorities report
 - Hardwood Silviculture Research Subcommittee
 - Eastern CANUSA Forest Science Conference
- Wagner, R.G.** - Assessing silviculture research priorities using wood supply analysis. Forestry Noontime Seminar, University of Maine, Orono, ME (May, 2001)
- Wagner, R.G.** - The Maine Forest Service's proposed outcome-based forestry pilot project. Forest Resources Advisory Committee, University of Maine, Orono, ME (Apr, 2001)
- Wagner, R.G.** - Testimony in support of Outcome-Based Forestry legislation to Maine State Legislative Agriculture and Forestry Committee (Apr, 2001)
- Wagner, R.G.** - Competition thresholds, Arsenal damage to spruce and fir, and Austin Pond update. International Paper Pesticide Training Session, Bangor, ME (Apr, 2001)
- Wagner, R.G.** - Public Perceptions of Forestry Practices: A Trust and Risk Communication Challenge, J.D. Irving Limited Science Forum: Using Science To Improve Business, Hugh John Fleming Forestry Complex, Fredericton, New Brunswick (Apr, 2001)
- Wagner, R.G.** - Forest vegetation management: Principles and practice. Instructor for ½-day session, Module II: Silviculture Regeneration Principles, Alberta Advanced Forest Management Institute, Hinton, Alberta (Feb, 2001)
- Wagner, R.G.** - Research Updates: CFRU Advisory Committee meeting (Jan, 2001)
- Austin Pond study
 - Arsenal herbicide damage to spruce and fir
 - Commercial Thinning Research Network
- Hardwood Silviculture Research Committee
- Wagner, R.G.** - Overview of CFRU. JDI Scientific Advisory Committee. Fredericton, NB (Jan, 2001)
- Wagner, R.G.** - Keynote address: The public's perception of risk and trust. 4th Annual PNW-IVMA Forestry and Rights-of-Way Conference. Integrated Vegetation Management Conference. The Forces of Change: the Power and Politics of Vegetation Management. PNW-Integrated Vegetation Management Association, November 14-15, 2000, Portland, OR. (Nov, 2000)
- Wagner, R.G.** - Panel debate: Ecology and Politics of Maine's Forests: The 2000 Maine Forestry Referendum. Bates College, Muskie Archives, Lewiston, ME (Nov, 2000)
- Wagner, R.G.** - Panel debate: Maine's Forestry Referendum. University of Maine, Fort Kent, ME (Oct, 2000)
- Wagner, R.G.** - Keynote Address: Public perceptions of risk from using pesticides. Joint Meeting of the 18th Eastern Spruce Budworm Research Work Conference and Spray Efficacy Research Group. Oct 29-Nov 2, 2000. Fredericton, New Brunswick. (Oct, 2000)
- Wagner, R.G.** - Scientific basis and implications for ballot question #2. Forestry noontime seminar series, University of Maine, Orono, ME (Oct, 2000)
- Wagner, R.G.** - Vegetation management practices and long-term results from the Austin Pond study, FES 508 Industrial Spruce-Fir Ecosystem class lecture, U. Maine, Orono, ME (Oct, 2000)
- Wagner, R.G.** - Principles of vegetation management, FES 408 Silviculture class lecture, U. Maine, Orono, ME (Oct, 2000)
- Wagner, R.G.** - Research Updates: CFRU Advisory Committee meeting (Oct, 2000)
- Commercial Thinning
 - Hardwood Research Committee
 - Cooperating Scientists
- Wagner, R.G.** - Organizer and Moderator. Forestry and the Riparian Zone, Forest Ecosystem Information Exchange, October 26, 2000, Wells Commons, Orono, ME (Oct, 2000)
- Whitman, A. and J.M. Hagan.** 2001. Patch Retention. A presentation given to Mead foresters, December 6, 2001. Rumford, ME.

Whitman, A. 2001. Patch Retention. Northeast SAF Meeting, March 14-16, 2000 Portland, ME.

Whitman, A. and J.M. Hagan. 2001. Vertical structure in managed and old growth forest. Poster at Forest Structure, a meeting of the Forest Ecosystem Information Exchange October 25, 2001, Orono, ME.

Whitman, A. and J.M. Hagan. 2001. An assessment of ecological value in old growth and managed stands in northern Maine. Poster at Forest Structure, a meeting of the Forest Ecosystem Information Exchange October 25, 2001, Orono, ME.

Appendices

COMMON NAME SCIENTIFIC NAME

Plants

Balsam fir	<i>Abies balsamea</i>
Fir	<i>Abies spp.</i>
American beech	<i>Fagus grandifolia</i> Ehrh
White spruce	<i>Picea glauca</i>
Red spruce	<i>Picea rubens</i> Sarg.
Spruce	<i>Picea spp.</i>
Red pine	<i>Pinus resinosa</i>
White pine	<i>Pinus strobus</i>
Hemlock	<i>Tsuga canadensis</i>
Paper birch	<i>Betula papyrifera</i>

Animals

Goshawk	<i>Accipiter gentilis</i>
Great horned owl	<i>Bubo virginianus</i>
Red-backed vole	<i>Clethrionomys gapperi</i> Vigors
Snowshoe hare	<i>Lepus americanus</i> Erxleben
Canada lynx	<i>Lynx canadensis</i>
Bobcat	<i>Lynx rufus</i>
American marten	<i>Martes americana</i> Turton
Fisher	<i>Martes pennanti</i>
Barred owl	<i>Strix varia</i>
Fox	<i>Vulpes vulpes</i>

Insects

Spruce budworm	<i>Choristoneura fumiferana</i> Clemens
----------------	---

Appendices

CONTACTS

<i>NAME</i>	<i>PHONE</i>	<i>EMAIL ADDRESS</i>
Howard Daggett		roland.daggett@umit.maine.edu
Mike Greenwood	207-581-2838	greenwd@umenfa.maine.edu
Chip Griffin	207-581-2893	chip_griffin@umenfa.maine.edu
John Hagan	207-721-9040	jmhagan@ime.net
Dan Harrison	207-581-2867	harrison@umenfa.maine.edu
Bill Krohn	207-581-2870	wkrohn@umenfa.maine.edu
Dan McConville	207-581-2861	dan_mcconville@umenfa.maine.edu
Bill Ostrofsky	207-581-2877	ostrofsk@umenfa.maine.edu
Bob Seymour	207-581-2860	seymour@umenfa.maine.edu
Darlene Segal	207-941-9040	dsiegel@ime.net
Suzhong Tian	207-581-3795	suzhong_tian@umenfa.maine.edu
Bob Wagner	207-581-2903	bob_wagner@umenfa.maine.edu
Andy Whitman	207-721-9040	awhitman@ime.net

