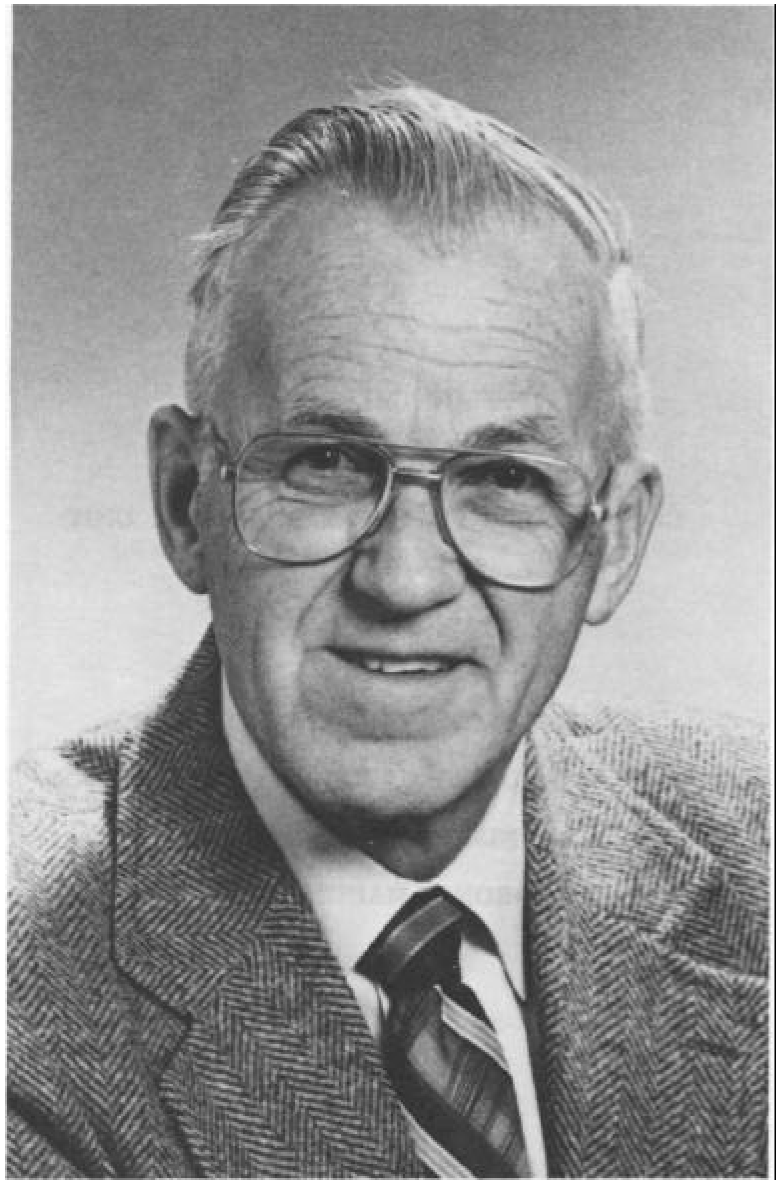
CFRU Information Report 23

1990 ANNUAL REPORT OF THE COOPERATIVE FORESTRY RESEARCH UNIT

COLLEGE OF FOREST RESOURCES
MAINE AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF MAINE
ORONO, MAINE 04469

Miscellaneous Report 353

December 1990



All best wishes to Dr. Fred B. Knight on the occasion of his retirement as Dean, College of Forest Resources, and Director of the Cooperative Forestry Research Unit, December 1990.

MAINE AGRICULTURAL EXPERIMENT STATION MISCELLANEOUS REPORT 353

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ADVISORY COMMITTEE CHAIRMAN'S REPORT

The Cooperative Forestry Research Unit has had a very busy and productive year. Much of the Advisory Committee's year was devoted to setting the stage for the next five years.

A priorities sub-committee was formed to help set the research directions for CFRU. This was a unique joint effort between the committee members and the principal scientists. Once a consensus was reached on the priority research areas, the scientists began drafting project proposals to address the research needs.

The CFRU Forum held in March of 1990 was a success. I would like to thank all those people who organized the two-day event. The Forum was a showcase for the research accomplished over the past 15 years of the CFRU. It also provided a setting to talk about the future. I was very pleased to see the attendance of a large number of foresters who will be on the front line applying the research results.

Several research projects were initiated in 1990. Foremost is a three-year study entitled "The Effects of Herbicides on Habitat and Nutritional Ecology of Moose and Deer in Maine." The effects of intensive forest management on wildlife ranked as one of the top four research priorities. Dr. Brad Griffith of the Maine Cooperative Fish and Wildlife Research Unit and Dr. Fred Servello of the UM Wildlife Department, working with Dr. Maxwell McCormack, have designed a research project that will answer many of the questions that cooperators and the public have about the effect of herbicide use on browse availability and quality. It is particularly encouraging to see the wildlife research community's interest in forestry-wildlife interactions.

Two other research projects were funded under the newly revised policy of accepting additional funding from cooperators to do directed research that is in line with the priorities of the CFRU. International Paper provided funding for a study of the effectiveness of planned herbicide skips in maintaining wildlife habitat, and Scott Paper provided funding for a study of the soil-site variables affecting the growth and development of European larch in Maine.

The issue of long-term base funding of CFRU has risen to the forefront again as a result of the merger in 1990 of Georgia-Pacific Corp. and Great Northern Paper. Both were original members of CFRU, and their combined contributions represent almost 30% of the CFRU annual funding. Georgia-Pacific Corp. has asked the Advisory Committee to change the funding formula to allow for a more equitable funding assessment. This raises questions about future funding of our research programs, which need to be resolved in 1991.

The CFRU participated in interviewing candidates for the position of Dean of the College of Forest Resources. There were many excellent candidates, and Dr. Bruce Wiersma was chosen to be the new Dean, effective January 1, 1991. We are looking forward to working with the new Dean and educating him on the important role that CFRU plays at the College.

Finally, on behalf of all the cooperators, I would like to thank Dr. Knight for the many years of dedicated service to CFRU. Dr. Knight was instrumental in its founding, and without his support there would be no CFRU. CFRU's excellent reputation for research in the Northeast is a testimony of Dr. Knight's high standards. The tenure of the CFRU is testimony to his unwavering commitment to make it work. No one has dedicated more time to CFRU than Dr. Knight. Always the gentleman, he will be missed by all.

Thomas J. Colgan, Chairman
CFRU Advisory Committee

DEAN'S REPORT

1990 has been a year of considerable change for the Cooperative Forestry Research Unit. We are nearing the end of the third five-year period of operations for the cooperative with a transition in process to the new priorities for the future. We have worked hard in developing a set of priorities for the next five years that the major landowners have decided are their real long-term needs. We all know these will change as the five years progress, but they clearly chart the course for our scientists.

Chairman Colgan and I have met with the majority of our large landowners during the past summer to respond to questions and listen to their comments about CFRU. We found solid support for the continuation of the program. It appears that CFRU will continue to receive the funding it needs during our next five-year cycle.

There were some points discussed that must be brought up and will need attention during the next year. First on the agenda is the payment structure. A formula is needed that will be more equitable to all members while bringing in about the same income as in the past. This development is critical to the maintenance of our Unit. Mr. Colgan has appointed a committee to review our contribution plan. This committee has one of the more important charges that has ever been issued since the beginning of our work.

The second issue is one that is based on my own opinion as well as the comments of our cooperators. Although support is solid for the priorities developed, I have a feeling that there are underlying concerns on the part of several members. It appears that in expressing support for the top four priorities, some other priorities, that might be equally high in the view of a few cooperators, were given lower values. The notable areas I hear about are research on hardwoods and tree improvement. We want to assure everyone that hardwoods will continue to receive attention, as the four high-priority areas involve both hardwood and softwood. Tree improvement research will continue because of our long-term investment in the field sites; the maintenance work can be continued at a minimal cost to the Unit.

Chairman Colgan has reported on many of the activities of the past year. I feel we have had a very successful year with a major effort by all our scientists. Their productivity has been high even while devoting much time to the Forum and the research priorities for the next five years. Professor McCormack will be away during most of 1991, but while gone, will provide much needed background for future research in silviculture. His sabbatical will result in benefits for the CFRU during the years ahead.

As I look back on nearly fifteen years of CFRU research, I reflect with considerable pride on the many accomplishments. I know of no place where more has been accomplished for the dollars expended to benefit forestry than has been accomplished here. CFRU is a success story, and the landowners have received a significant return on their investment of research dollars.

All of the scientists have been highly dedicated, and I am proud to have been associated with each of them. Two scientists, Dr. Field and Dr. Seymour, have become members of the teaching faculty following their service with CFRU. We all miss Dr. Mark Houseweart who was an outstanding scientist and very productive member of CFRU. Our three scientists are continuing the tradition of high-quality research and service to our members.

It has been a pleasure to have been associated with the Cooperative Forestry Research Unit from the time the idea began to be discussed to the present. I have valued my association with all six of our scientists and with other faculty who have participated in CFRU research. The association with the cooperators has been enjoyable and beneficial to me. Through CFRU I have come to know many fine individuals, that is a major return on the work I have done.

The next five-year program of work will commence on October 1, 1991. I expect that the CFRU will continue its high level of productivity for the benefit of the cooperators, all Maine citizens, and especially for our forest resources.

Fred B. Knight
Dean, College of Forest Resources
Director, Cooperative Forestry Research Unit

BALANCE SHEET

1989-1990 Period 10/1/89
\- 9/30/90

ASSETS:		
BALANCE FORWARD SEPTEMBER 30, 1989	578,849.98	
CONTRIBUTIONS 1989 RECEIVED AFTER 9/30/89 Great Northern Paper - $20,000.00	20,000.00	
CONTRIBUTIONS	426,730.00	
INVESTMENTS	50,291.86	
SALE OF ALL-TERRAIN VEHICLE	250.00	
TOTAL ASSETS: 09/30/90		$ 1,076,121.84
EXPENSES:		
VEHICLE REPL. - CARTER	12,928.05	
ADMINISTRATION - KNIGHT	43,228.43	
SILVICULTURE - McCORMACK	115,387.98	
SOIL SITE - BRIGGS	114,776.26	
HARDWOOD - OSTROFSKY	64,979.63	
GROWTH & YIELD - SEYMOUR	3,617.09	
TREE IMPROV. - GREENWOOD	10,000.00	
FERTILIZATION - SHEPARD	14,477.13	
TREE IMPROV. - CARTER	41,679.03	
TOTAL EXPENSES:		421,073.60
Less FFF - R. Seymour Account Carry Over		7,896.17
Less Vehicle Account Carry Over		6,674.95
BALANCE ENDING 09/30/90		640,477.12

SILVICULTURE

Dr. Maxwell L. McCormack, Jr.

The summer field season of 1990 was carried out with a reduced level of activity as projects phased into a crop tree growth response period, and Dr. McCormack prepared for sabbatical leave. Many vegetation plots were reevaluated and a series of tank-mix, delivery technology treatments were established with assistance of Annie Narahara, Bill Eschholz, and Kevin Raymond. R.A. Lautenschlager completed his dissertation on red raspberry ecology and competing vegetation interactions with white spruce seedlings.

During the year a strong effort was devoted to technology transfer activities which included a series of research posters for which abstracts were published in conjunction with the New England Society of American Foresters Winter meeting. These posters were exhibited at the CFRU Forum in Nutting Hall and also were utilized at the natural regeneration conference in Fredericton, NB, during March.

The recent research priorities review indicates that, though there will be continuation of efforts based on the original problem analysis of 1977, there will be a transition into some new areas of emphasis. Some phasing out of efforts on thinning and precommercial thinning will take place. Field work at the Weymouth Point Study Area will be reduced, but not terminated. That site continues to offer excellent resources for the study of post-harvest vegetation dynamics and development of spruce-fir regeneration. Work on perfecting and refining herbicide treatments and prescription development will continue. Increased attention is being given to herbicide treatment interaction with wildlife habitat characteristics. Origin and establishment of desirable regeneration will be studied more intensively. Growth responses of potential crop trees following silviculture treatments will be measured in order to gain more preliminary growth and yield data.

Regeneration and Early Stand Development

The Weymouth Point Study Area continues to be maintained and has been reappraised to access its value for research over the next five years. The lysimeter plots will be kept in place and will provide an opportunity to evaluate soil solution chemistry as the developing regeneration begins to express dominance. Vegetation patterns ten years after harvest continue to reflect the mechanical harvesting activity. The transects of permanent photo points were photographed and document (1) impacts of concentrated harvesting machine activity, (2) strong positive presence of natural regeneration with a good spruce component, (3) advance conifer regeneration responses to spruce budworm defoliation prior to harvest, and (4) distinct benefits to species composition and growth rates from a timely herbicide release. Planted tree plots will afford opportunities to evaluate planting procedures and to make comparisons between planted conifers and natural regeneration (Fig. 1).

Assessments of the aerial herbicide strip, precommercial thinning continued in 1990, Conclusions now include:

1. Combinations of picloram and 2,4-D; dicamba and 2,4-D; or the combined three active ingredients provide effective results at rates of 1.0 to 1.5 Ibs ai/ac treated of picloram or dicamba when combined with 4.0 to 6.0 Ibs ai/ac of 2,4-D;

2. Total spray volumes of around 16 gal/ac have provided silviculturally effective results;

3. A range of surfactant additions to the herbicide treatments did not appear to enhance efficacy of the typical June applications;

4. Treatment bands should be at least 6 ft in width, but results from bands up to 10-11 ft wide are yet to be determined;

5. Residual crop tree strips probably should not be less than 3 ft in width; and

6. Patterns achieved with a Thru-Valve Boom (TVB[R]) using a Del Norte Flying Flagman™* for guidance appear to be operationally effective, especially with increased pilot familiarity with the navigation system.

Aerial review of long-term results is encouraging. Though still overstocked, clearcuts treated with bands at least 6 ft in width begin to resemble plantations at 5 to 6 years after treatment. The site on the Cuxabexis Road in

* Del Norte Flying Flagman. Del Norte Technology, Inc., 1100 Pamela Drive, Euless, Texas 76039.

Figure 1. View of a spruce transplant planted plot on the Weymouth Point clearcut watershed. The trees were planted in 1982 directly on a heavily used grapple skidder trail confluence. Natural regeneration is visible across the background along the boundary of the upper skid trail.

T5R12 WELS was revisited (shown in a frequently exhibited one-year-after-treatment photograph of 1984 treatments). A similar view, 6 years later, is shown in Figure 2.

Work, carried out by Kent Redding of Dow-Elanco, is now underway to explore options for second entry treatment of areas previously treated with aerially applied bands.

The completion of R.A. Lautenschlager's Ph.D. dissertation draws together information on vegetation dynamics of competing vegetation, in particular red raspberry and white spruce seedlings. Conclusions further substantiate observations from other vegetation management plots. His study showed that higher quality sites produced more competing vegetation than lower quality sites, though conifer growth potential was reduced in both situations. On the more productive, well-drained sites, competitors quickly developed substantial cover and height, while weed growth on more poorly drained sites was generally low growing and appeared to offer less severe competition. The paperpot seedlings suffered more from plant competition and animal browsing than the larger 2+2 transplant stock. Controlling broadleaved competition on better sites seems to be critical where forest productivity is to be maintained. On poorer sites the greatest crop tree gains might be achieved by controlling competition from other conifers.

Herbicide Technology

Three recently established operational-scale studies address different approaches to intensifying prescription development for silvicultural application of herbicides. Near Telos, in 1988, treatments were established to evaluate enhancement of efficacy by including low amounts of imazapyr with typical glyphosate rates. In Bradley, in 1989, a study was initiated to evaluate different levels of the formulated surfactant across three rates of glyphosate applied at two different times (Table 1). During the recent field season, near 2nd Roach Pond, treatments were applied to study tank mixes of triclopyr plus glyphosate, and triclopyr delivered through two different sprayboom systems.

Figure 2. Aerial view of treat 6 ft - leave 8 ft aerially applied bands of picloram + dicamba + 2,4-D applied in 1984. Visible voids in the regeneration were not stocked at the time of treatment. The view is toward the west with the Cuxabexis Road running across the upper right corner.

Table 1. Summary of treatments applied in the 1989 Bradley study of glyphosate surfactant combinations applied at two different times. Stem reduction of red raspberry by selected treatments is illustrated in Fig. 3.

MON-0818 Surfactant (fl oz/ 5-gal/ac)	--glyphosate (Ibs ai/5-gal/ac)--			
	0.0	m	2LJB	3.0
0.0	Tl	T5	T9	T13
5.0	T2	T6	T10	T14
10.0	T3	T7	Til	T15
15.0	T4	T8	T12	T16

The Telos site was evaluated thoroughly to collect second-year stem and crown reduction data for species present on all plots. Differences of operational importance were observed between treatments. There was injury to some crop trees at the higher rates of imazapyr, but it varied with species and could be incorporated as a calculated cost of otherwise effective treatments which would benefit treatment-tolerant crop trees. To demonstrate the types of gains possible, six of the treatments with an increasing level of imazapyr are summarized in Table 2. The efficacy of these six treatments on red maple stem reduction in the first and second years after treatment is illustrated in Figure 3. An improvement in red maple stem reduction by the second year is evident for the three higher additions of imazapyr.

Table 2. Selected treatments from the 1988 Telos glyphosate-imazapyr release study. All treatments contained 9.38 fl oz/ac of MON-0818 surfactant. Stem reduction of red maple by these treatments is illustrated in Fig. 4.

Treatment	Glyphosate	Imazapvr
	(Ibs ai/ac)	(oz ai/ac)
1	2.0	0.0
2	2.0	0.25
3	2.0	0.5
4	2.0	1.0
5	2.0	1.5

6	2.0	2.0

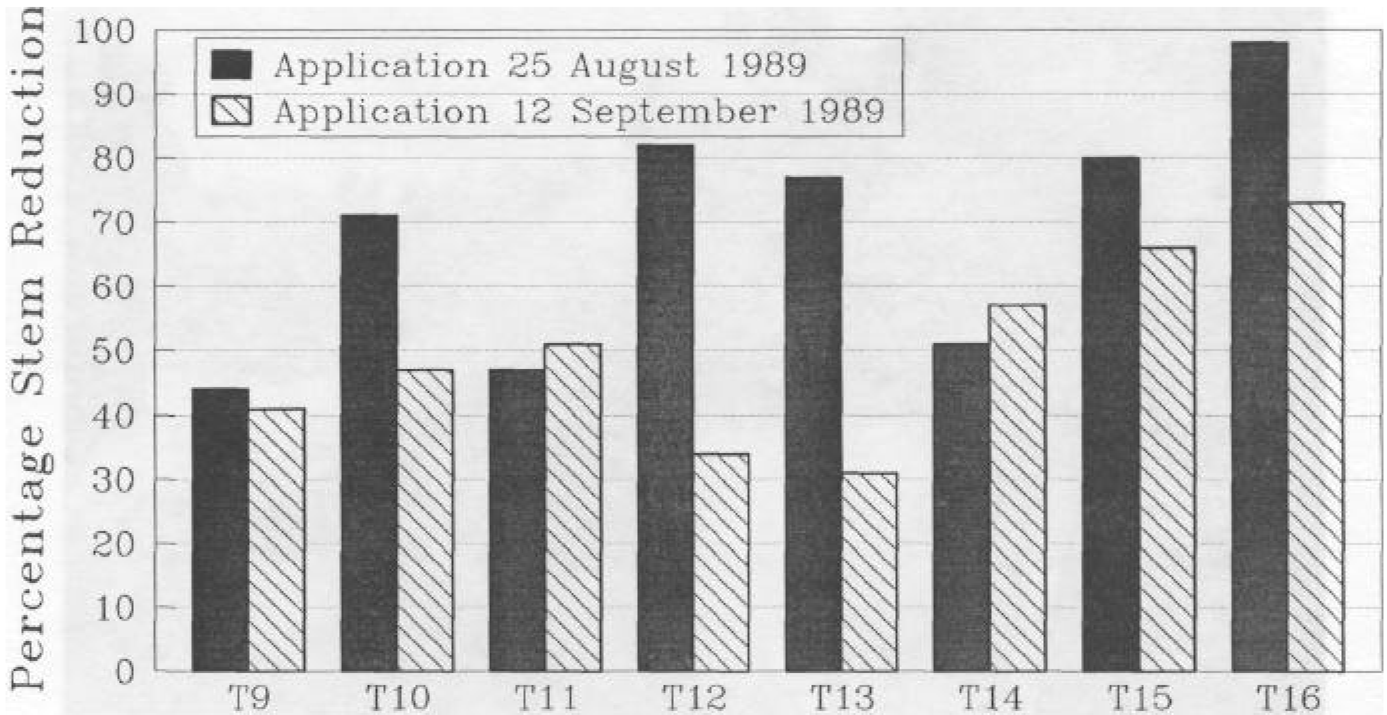


Figure 3. First-year stem reduction of red raspberry for eight of the treatments, applied at two times, summarized in Table 1.

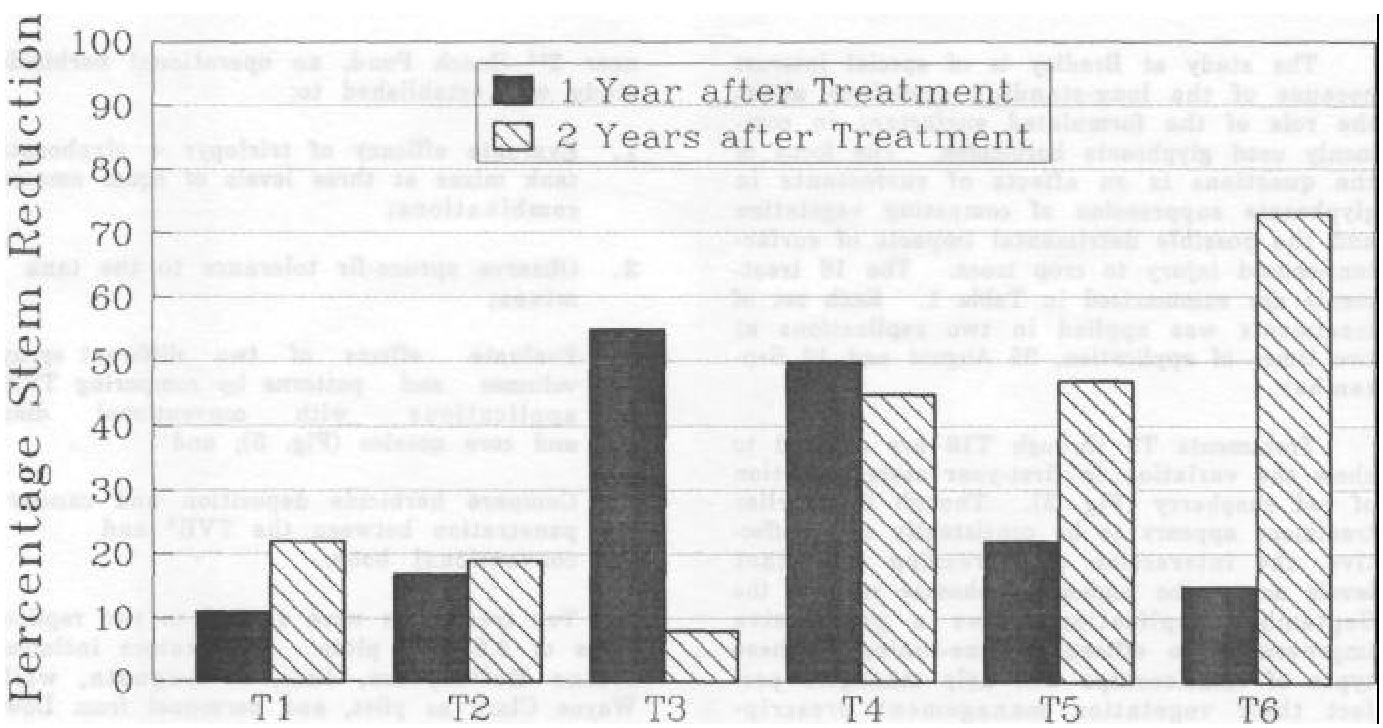


Figure 4. First- and second-year stem reduction (percentage) of red maple for the six treatments summarized in Table 2.

Figure 5. Kent Redding, DowElanco, uses specially designed sampling equipment to collect laboratory samples of the treatment mixture immediately prior to helicopter lift-off in the boom comparison study.

The study at Bradley is of special interest because of the long-standing questions about the role of the formulated surfactant in commonly used glyphosate herbicides. The focus of the questions is on effects of surfactants in glyphosate suppression of competing vegetation and the possible detrimental impacts of surfactant-caused injury to crop trees. The 16 treatments are summarized in Table 1. Each set of treatments was applied in two replications at two times of application, 25 August and 12 September.

Treatments T9 through T16 are selected to show the variation in first-year stem reduction of red raspberry (Fig. 3). Though the earlier treatment appears to be consistently more effective, the interaction of increasing surfactant levels across the highest glyphosate rate in the September application shows a progressive improvement in efficacy. Fine-tuning of these types of relationships will help managers perfect their vegetation management prescriptions.

In late August, on land of Scott Paper Co. near 2nd Roach Pond, an operational herbicide study was established to:

1. Evaluate efficacy of triclopyr + glyphosate tank mixes at three levels of equal amount combinations;
2. Observe spruce-fir tolerance to the tank mixes;
3. Evaluate effects of two different spray volumes and patterns by comparing TVB® applications with conventional disc and core nozzles (Fig. 5); and
4. Compare herbicide deposition and canopy penetration between the TVB® and conventional boom.

Ten treatments were applied in two replications of 6.5 acre plots. Cooperators included Maine Helicopters, Inc., of Augusta, with Wayne Clark as pilot, and personnel from DowElanco and Monsanto. Additional work for this study involved placement of spray pattern targets in the boom comparison plots. Dye was

Figure 6. Roy Johnson, Waldrum Specialties, Inc., supervises the change to a Thru-Valve Boom[R] during the application of the boom comparison treatments which were all applied within a single four-hour spray session.

measured and added during the mixing process, sampled from the helicopter just prior to lift off (Fig. 5.), and collected on the plot targets for laboratory analyses. This information will be valuable in comparing the different spray patterns for target coverage and potential for off-target movement. Execution of these treatments also required a complex boom change during the treatment series (Fig. 6). This change was needed in order to have a valid comparison between the patterns achieved when using the different delivery technologies.

Herbicide Effects on Habitat and Nutritional Ecology of Moose and Deer in Maine

The purpose of this project, developed by Dr. M.L. McCormack, Jr., Dr. B. Griffith, and Dr. F.A. Servello, is to determine the effects of glyphosate application in regenerating spruce-fir stands on moose nutrition and habitat use and on deer nutrition. Our studies will focus on the winter season for moose and the summer season for deer. Our review of previous studies suggests it is during these periods that there is the greatest potential for herbicide effects. We also will be examining both short-term (1-2 year post-spray) and long-term (7-10 years post-spray) effects of glyphosate application. The specific objectives of the project are:

1. To compare winter utilization by moose of sprayed and unsprayed clearcuts 1-2 years and 7-10 years post-spray;

2. To compare browse species composition, browse biomass and utilization, and browse nutritional quality for moose in winter on sprayed and unsprayed clearcuts 1-2 years and 7-10 years post-spray; and

3. To compare forage species composition, forage biomass and utilization, and browse nutritional quality for white-tailed deer in spring-fall on sprayed and unsprayed clearcuts 1-2 years and 7-10 years post-spray.

Two graduate students, Bill Eschholz and Kevin Raymond, were hired in September 1990.

They are currently writing specific study plans for the first field season (1991). We have decided to conduct the project in the Moosehead Lake region because of its proximity to Orono, the existing large glyphosate spray programs in the area, the high densities of moose, and the availability of flying services. Potential study sites were examined in September and October. A preliminary selection of 14 sites (7 pairs of clearcuts that are ready for operational spraying) that are suitable for the short-term study has been made. After further evaluation, we will make a final selection of 6 pairs of sites. We have begun the process of identifying stands that are 7-10 years post-spray and stands of similar age that have not been sprayed. The initial selection of candidate sites is being made from company computer records of stand treatments and history. Final selection of these 30-40 stands will be made using aerial photography and some site visits.

The first field sampling will be conducted in January-March 1991. Browse and other vegetation measurements will be made in the 12 short-term study sites and moose habitat use will be determined for these stands with aerial surveys. We also will similarly sample a fraction of the long-term study sites in the first field season.

SILVICULTURAL TECHNIQUES FOR THE IMPROVEMENT OF TIMBER QUALITY

Dr. William D. Ostrofsky

Cambial Electrical Resistance of Precommercially Thinned Balsam Fir

The Shigometer has been used to assess vigor of mature conifers and hardwoods, and cambial electrical resistance (CER) has been shown to be well correlated with foliage biomass and tree growth of young stands of balsam fir, as well (Piene et al. 1984). Soil drainage is known to be an important determinant of the growth of conifers and likely affects overall tree vigor. The objective of this study was to test the usefulness of the Shigometer technique for detecting differences in growth rates and tree vigor of balsam fir growing on various soil drainage classes.

In 1989, Dr. Russell Briggs initiated a study of soil-site relationships using precommercially thinned stands of balsam fir and spruce (Briggs 1989). A total of 29 plots were established over four different soil drainage classes in Moose River, Thorndike, Long Pond, and Sandwich Townships on timberlands owned by S.D. Warren Div., Scott Paper Co. During mid-July, 1990, these plots were visited, and the CER and breast height diameter (dbh) of all the spruce and balsam fir crop trees were taken. Summer field technician Janette Staeger, and MF graduate student Berhane Manyazawale assisted in the data collection. The total number of fir sampled was 1,024. Only 112 spruce were measured, so they were not included in the final analysis.

A preliminary analysis of tree growth information and relationships to tree CER and response to thinning is ongoing. The relationship of dbh to tree vigor, as measured by CER, followed a well-established trend and appeared similar to that of other studies (Fig. 7). There was a significant difference (P = 0.025) in both growth rate (dbh) and CER when the well- and moderately well drained classes are combined and compared with the somewhat poorly and poorly drained classes. That a more distinct difference could not be detected between the four drainage categories is disappointing, but may be a reflection of a disproportionate response to thinning between trees on well-

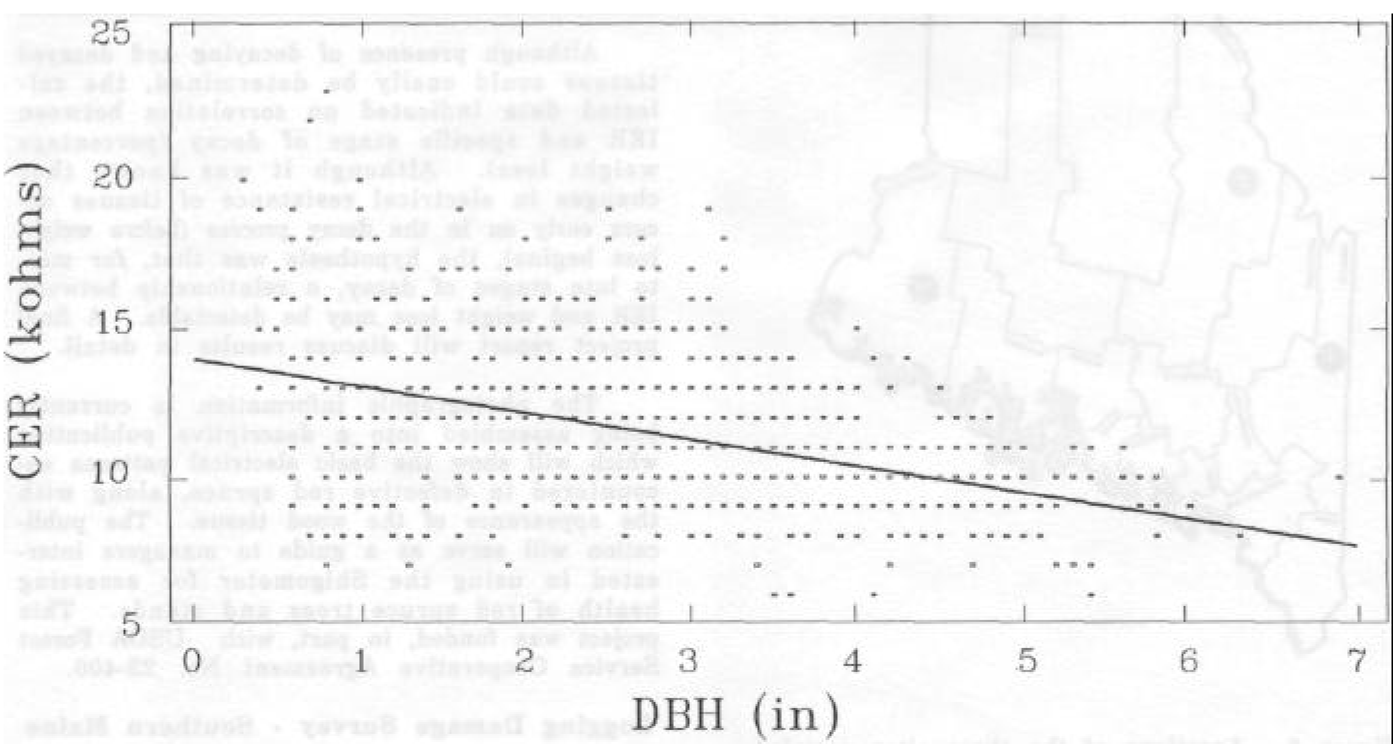


Figure 7. Relationship of cambial electrical resistance (CER) to diameter breast height (DBH) of precommercially thinned balsam fir.

drained sites compared with trees on poorly drained sites. That is, the thinning may have increased the vigor of the most stressed trees (those on poorly drained sites) more substan tially than it did on trees already growing on more suitable sites. Complete data analysis is ongoing.

Patterns of Decay and Internal Electrical Resistance of Red Spruce

The Shigometer was used to measure and describe patterns of electrical resistance in stems of mature red spruce exhibiting various stages of internal decay. The primary objective of the study was to diagram the basic patterns of internal defects occurring in red spruce in relation to internal electrical resistance (IER) measurements using the Shigometer equipped with a twisted wire probe. A second objective was to relate specific internal electrical resistance (IER) readings with the degree of decay as measured by wood tissue weight loss.

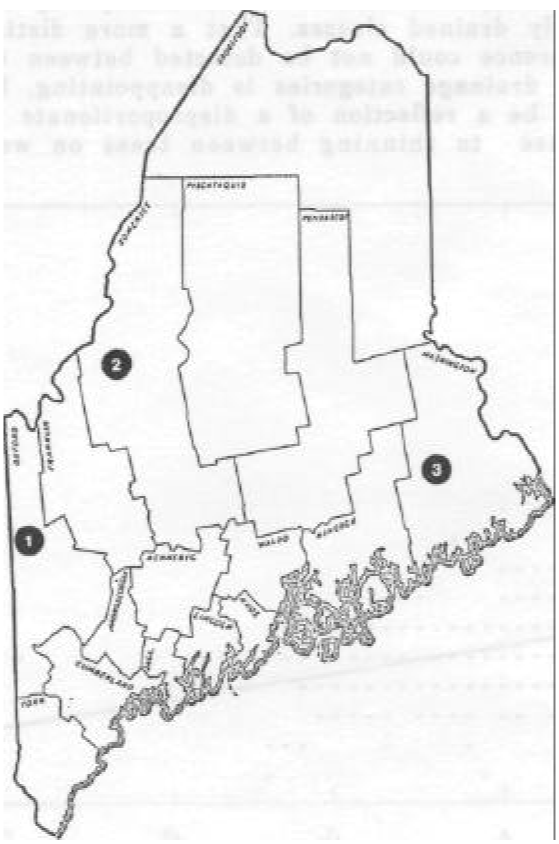


Figure 8. Locations of the three sites sampled for internal defects of mature red spruce. Site 1 is Grafton, site 2 is the Misery-Johnson Mtn. area, and site 3 is Township 36.

The project was undertaken by B. Manyazawale as part of her MF program. Stands in three widely separated areas of the state were surveyed for red spruce with internal defects, but no apparent external indications of decay (Fig. 8, Table 3). The IER of suspect trees was measured along two transects taken at right angles to each other, at the stump and at breast height. Ten trees in which internal defects were detected were selected at each of the three sites and felled. Cross-sectional stem discs cut at the transects were sampled for weight loss due to decay at five measured points along each transect, and the discs were photographed. Electrical resistance patterns were matched with wood tissue appearance (Fig. 9).

Table 3. Summary characteristics of red spruce stands sampled for internal decay.

Site	No. Trees Surveyed	No. Defect Trees	No. Trees Sampled
Grafton	218	15	10
Misery & Johnson Twp.	214	15	1
Twp. 36 & Twp. 30	255	10	0

Although presence of decaying and decayed tissues could easily be determined, the collected data indicated no correlation between IER and specific stage of decay (percentage weight loss). Although it was known that changes in electrical resistance of tissues occurs early on in the decay process (before weight loss begins), the hypothesis was that, for mid-to late stages of decay, a relationship between IER and weight loss may be detectable. A final project report will discuss results in detail.

The photographic information is currently being assembled into a descriptive publication which will show the basic electrical patterns encountered in defective red spruce, along with the appearance of the wood tissue. The publication will serve as a guide to managers interested in using the Shigometer for assessing health of red spruce trees and stands. This project was funded, in part, with USDA Forest Service Cooperative Agreement No. 23-400.

Logging Damage Survey - Southern Maine

A survey was conducted in southern Maine to determine the level of damage resulting to residual trees in stands partially cut using whole-tree harvesting technology for the production of

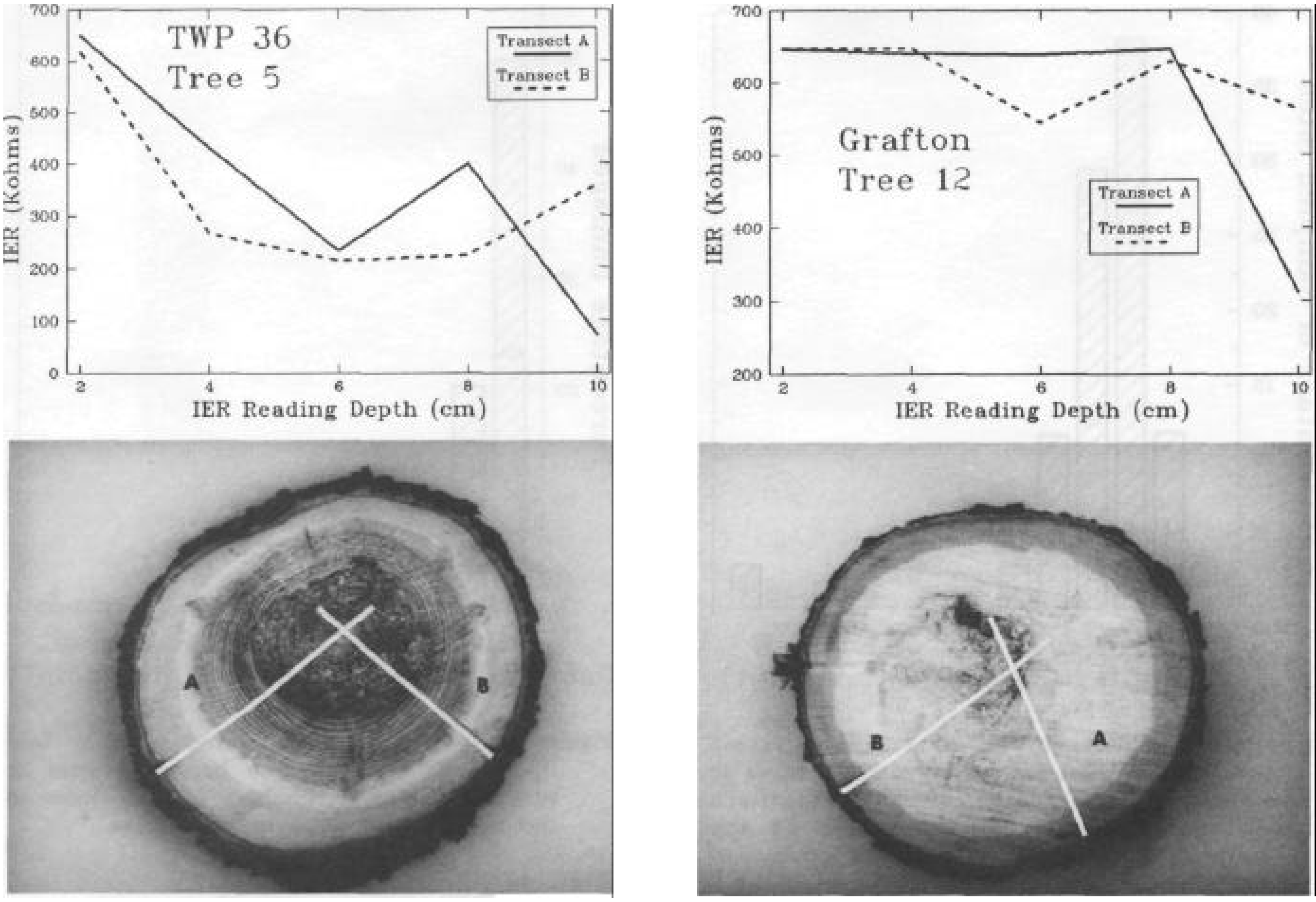


Figure 9. Internal electrical resistance (IER) patterns and appearance of the internal decay. More advanced decay results in lower resistance to the applied electrical current. Transects A and B in graphs correspond with those labelled on photographs.

wood biomass. The survey was administered by J. Dirkman, Maine Forest Service, in cooperation with the CFRU, and was funded by a grant to the Maine Forest Service from the Council of Northeastern Governors (CONEG).

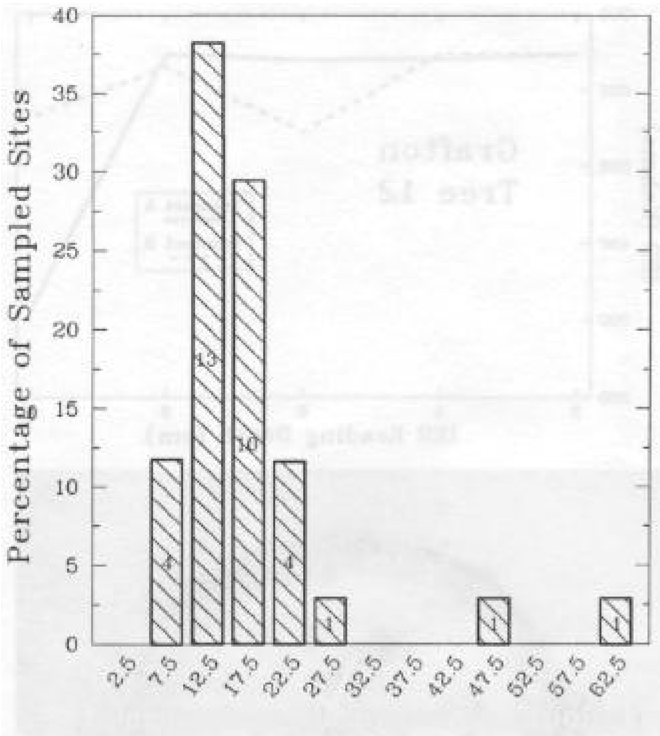
Although various whole-tree harvesting techniques have been widely used in southern Maine for over a decade, there have been no general, region-wide surveys to monitor residual tree damage associated with this practice.

A total of 34 stands were visited and assessed for injuries based on a standard damage-rating classification system. Twenty stands were white pine, five were red oak, and the remaining were mixtures of red oak, white pine, beech, red maple, and/or hemlock. A total of 6,600 trees were examined, of which 1,160 (17.6 %) had been injured by the logging operations.

Selected characteristics of the surveyed stands are shown in Figs. 10 and 11. The survey provides baseline information on stand injury that can be used to monitor damage levels accompanying changes in harvesting technology over time. Similar surveys may be conducted in other forest regions of Maine in the future.

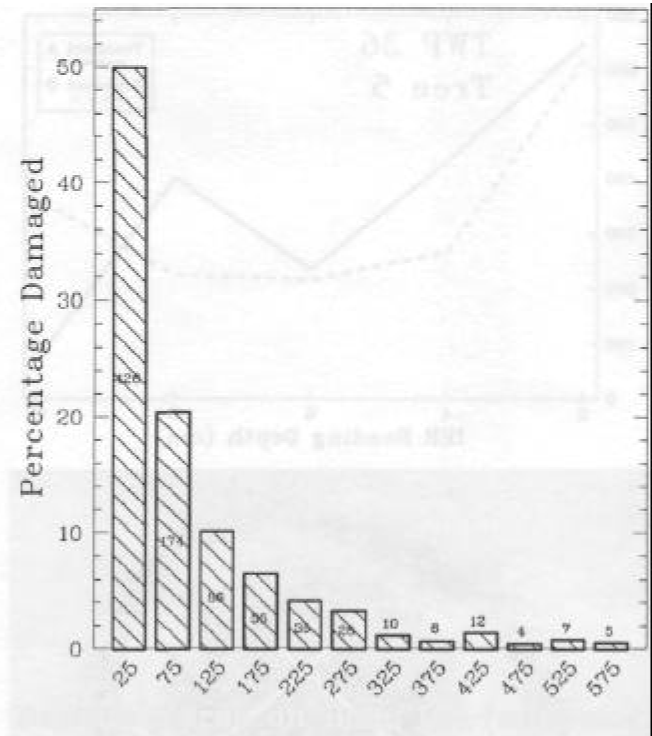
Response of Phloem to Infection by *Inonotus* ***obliquus:*** An Investigation of the Canker Rot Disease of Birches.

The objective of this investigation was to examine the anatomical changes occurring in bark of paper birch after wounding and infection by the canker rot fungus *Inonotus obliquus.* Three experimental treatments were devised. During June, 1987, five paper birch naturally infected with *I. obliquus* and bearing sterile conks of the fungus were experimentally



Percentage Damaged (midpoint)

Figure 10. Percentage of residual stems damaged by percentage of sampled sites in whole-tree harvested sites in southern Maine. Numbers in bars refer to the number of sites in each damage class.



Damaged Area on Bole, In^2 (midpoint)

Figure 11. Percentage of injured trees by bole injury size in whole-tree harvested sites in southern Maine. Numbers in bars refer to the numbers of trees in each class.

wounded; in February, 1988, 10 additional, non-infected birch were wounded and experimentally inoculated with the fungus; and in June, 1988 six non-infected birch were wounded and inoculated. One tree was harvested from each of the three experiments during 1988 for preliminary analysis.

In June, 1990 the remaining trees were harvested and dissected in cross section (12 trees) and longitudinally through inoculated, non-inoculated, and control (no treatment) wounds. Mapping and calculation of volumes of discolored wood, decayed wood, and necrotic bark was done for all wounds. Bark tissues were collected processed, and examined microscopically.

Experimental inoculations were successful in establishing apparently typical cankers in healthy trees (Fig. 12), but necrotic bark volumes were small (1.31 - 25.24 cubic cm.) after 3 years. New cankers were also initiated at uninoculated wounds inflicted on naturally infected trees. Distinctive wound periderms had

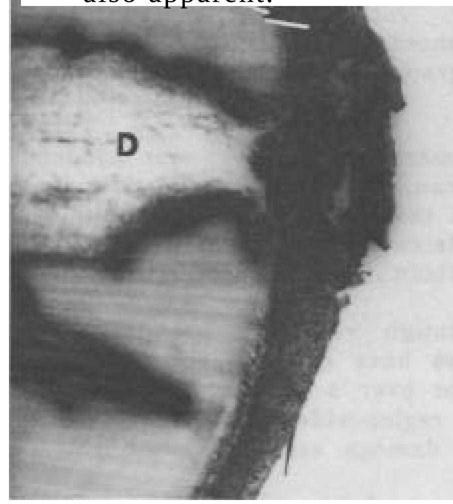


Figure 12. Appearance of an experimentally induced canker of *Inonotus obliquus* on paper birch three years after inoculation. A wound periderm (arrow) has formed in the bark at the margin of the canker. Decay (D) of the wood resulting from the inoculation is also apparent.

formed in bark around all wounds, whether inoculated or left uninoculated, in both previously healthy and naturally infected trees. Data analysis will be continuing over the next few months.

This study, funded by the Maine Agricultural Experiment Station, was initiated in 1986 as part of the Northeastern Regional Technical Committee NE-99, "Vascular Diseases of Trees". This Regional Project was terminated as of September 30, 1990.

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SITE QUALITY

Dr. Russell D. Briggs

Introduction

The objective of the site quality project is to develop a productivity-oriented land classification system for spruce and fir in Maine. The fundamental basis for this project is the hypothesis that the relationship between soil properties and tree growth can be used to classify sites according to their capacity for tree production.

Completion of the 1990 field season marked the third and final year of an intensive field effort in conifer stands. Since the project was initiated in 1988, tree growth and soil-site data have been collected from 94 plots in both unmanaged and intensively managed spruce-fir stands distributed throughout the state (Fig. 13, Table 4). Initially, plots were established in unmanaged, mature stands. The emphasis was shifted in 1989 to young, intensively managed stands.

Analysis of data collected during the 1989 field season documented the impacts of soil drainage class on the response of balsam fir to precommercial thinning (Briggs and Lemin 1990). For trees on poorly and somewhat poorly drained soils, post-thinning volume increment was 1.3 times that of pre-thinning volume increment. In comparison, post-thinning volume increment of trees on moderately well and well-drained soils was 1.6 times that of pre-thinning volume increment. The small sample size for trees on somewhat poorly drained soils may have contributed to the grouping of somewhat poorly drained with poorly drained soils. Additional data collected during the 1990 field season should clarify that result.

The data collected in intensively managed stands during 1989 and 1990 will enable us to determine if there are any differences in thinning response across catenas. Given a favorable moisture regime (moderately well to well-drained), differences in parent material can be expected to produce differences in nutrient availability and consequently, tree growth. Joseph Pitcheralle, a graduate student pursuing an M.S. degree, will be studying the effects of soil texture and soil chemistry on response of spruce and fir to precommercial thinning.

This year, European larch was incorporated into the project. This provided us with an opportunity to work on high-quality sites where spruce and fir do not naturally occur. The rapi growth rate of European larch makes it ideal a a bioassay of site quality. European larch wa chosen over Japanese larch because of report edly greater resistance of the former to fros damage. This report will focus on the accom plishments of the 1990 field season. Personne involved with collection of data were Ronal Lemin, Jr., Assistant Scientist; Daniel Gilmor and Joseph Pitcheralle, graduate students Richard Dionne, Jeffrey Dubis, and End Cullinan, student assistants.

Plot Establishment in Precommercially Thinned Stands

Field

During the summer of 1990, 33, 0.05-ac cir cular plots were established in fully stocke portions of stands that had been precommer cially thinned (PCT) between 1975 and 1986 (Fig. 13, Table 4). Plots were established so that soil properties were uniform within the plot boundaries.

Each plot, divided into an inner and oute subplot (0.025 ac each), was further subdivide into four quadrants (N, S, E, W) for a total o eight subplots. All trees, tallied for dbh an total height by species in each subplot, wer classified as crop trees or volunteers. The di tance and azimuth to each crop tree from th plot center was recorded. Herbaceous veget tion was recorded on each plot by percentag cover of each species in classes of 8 percent ((8%, 9-17%, 18-26%........ 64%+).

A soil pit was excavated near the center o each plot. Thickness of horizons, rooting deptl depths to mottling and to root restricting laye were measured along each pit face and average for the pit. Coarse fragment content was visu ally estimated from the area of each pit face oc cupied by rocks. Soil Conservation Servic drainage classes were assigned according t mottling depth. The forest floor was sampled b horizon (Ol, 02) using a 25 cm X 25 cm samplin frame at eight points along the plot perimete at successive 45° increments from North Following collection of samples, horizon depth were recorded. A composite sample for each plc from each of the 01 and 02 horizons was col lected for chemical analysis.

A dominant/codominant crop tree within

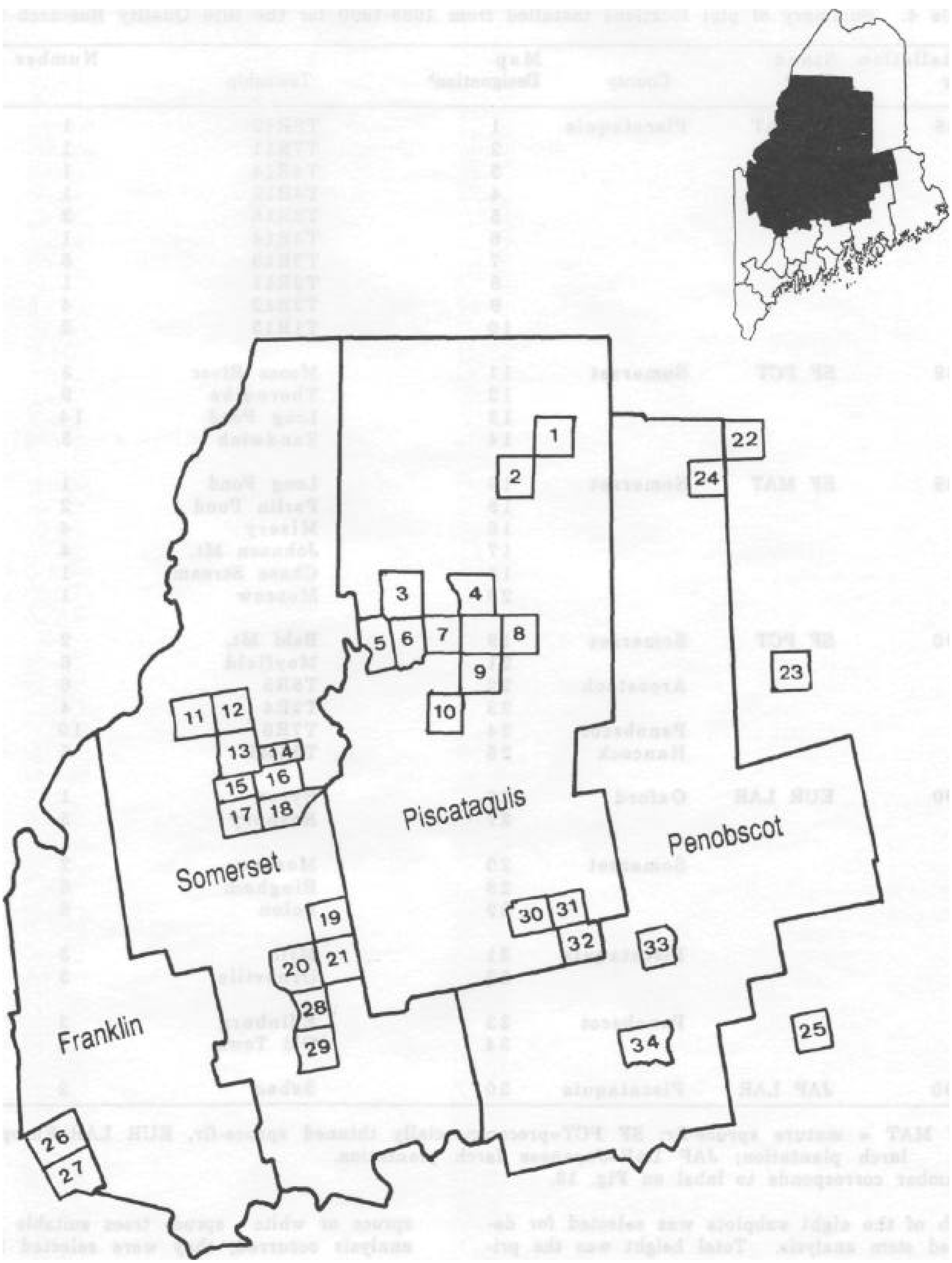

Figure 13. Distribution of plots established during the period 1988 through 1990. Relative location of the four-county area within Maine is indicated by the shaded portion of the map inset in the upper right-hand corner. Additional information is provided in Table 4, which cross-references numbers in townships with number of plots and year of establishment.

Table 4. Summary of plot locations installed from 1988-1990 for the Site Quality Research Project.

Installation Type*	Stand County	Designation[1]"	Map Year	Township	Number of Plots
1988	SF MAT	Piscataquis	1	T8R12	1
			2	T7R11	1
			3	T4R14	1
			4	T4R12	1
			5	T3R15	2
			6	T3R14	1
			7	T3R13	5
			8	T3R11	1
			9	T2R12	4
			10	T1R13	2
1989	SF PCT	Somerset	11	Moose River	3
			12	Thorndike	9
			13	Long Pond	14
			14	Sandwich	3
1989	SF MAT	Somerset	13	Long Pond	1
			15	Parlin Pond	2
			16	Misery	4
			17	Johnson Mt.	4
			18	Chase Stream	1
			20	Moscow	1
1990	SF PCT	Somerset	19	Bald Mt.	2
			21	Mayfield	6
		Aroostook	22	T8R5	6
			23	T2R4	4
		Penobscot	24	T7R6	10
		Hancock	25	T34MD	5
1990	EUR LAR	Oxford	26	Byron	1
			27	Roxbury	3
		Somerset	20	Moscow	2
			28	Bingham	5
			29	Solon	6
		Piscataquis	31	Milo	3
			32	Orneville	3
		Penobscot	33	Edinburg	3
			34	Old Town	1
1990	JAP LAR	Piscataquis	30	Sebec	

"SF MAT = mature spruce-fir; SF PCT=precommercially thinned spruce-fir, EUR LAR=European larch plantation; JAP LAR=Japanese larch plantation.
[b]Number corresponds to label on Fig. 13.

each of the eight subplots was selected for detailed stem analysis. Total height was the primary selection criterion. Trees established on large old stumps, considered to have a growth advantage in excess of existing soil conditions on the plot, were avoided. Balsam fir was the primary crop tree species. On plots where red spruce or white spruce trees suitable for stem analysis occurred, they were selected for stem analysis.

For each stem analysis sample tree, total height, height of each annual node, height to the live crown, and the vertical projections of the crown perimeter at four points, 90° apart, were measured. Diameter outside bark was marked and measured at 0.5, 4.5, 7.0 ft, and at successive 3-ft increments to the top of the tree. A disk, approximately 1 in thick, was cut from each marked point along the stem. Mean radius (half of the diameter as measured by a d-tape) was marked on each disk, which was labelled and returned to the laboratory.

The distance and azimuth to the nearest competing stem and its dbh were recorded. A circular milacre plot was centered on the stump of each stem-analyzed tree. The stubs of trees removed during PCT were tallied in one inch basal diameter classes.

Laboratory

Forest floor samples were placed in a drying room at 60° C and dry weight was measured. Mineral soil samples and composite forest floor samples were air dried in a greenhouse. Mineral soil samples were sieved through a 2-mm screen. Weight and volume of coarse fragments and mineral soil were measured. Volume of coarse fragments, estimated as the volume occupied in a measurement container, was a crude measurement that included pore space between rocks. Nevertheless, it will serve as a useful estimate of the upper limit of the soil volume occupied by gravel sized material.

Composite forest floor samples were sieved through a 0.25-in mesh screen. Subsamples of the sieved material were ground in a Wiley mill to pass a 40 mesh screen. Total N and total C were determined using a Leco analyzer at the Darling Marine Center.

Basal area and number of stems were computed for each subplot and expressed on an area basis. An index of competition, the ratio of sample tree basal area to the average basal area of crop trees in the subplot, was computed for each stem analysis tree (Daniels et al. 1986).

Processing of soil samples in preparation for laboratory analysis is in progress. All of the sample disks from the stem analysis trees have been sanded in preparation for measurement of radial increment to the nearest 0.01 mm on the MeasuChron[R].

Summary of Stand Data

Dbh and total height of crop trees averaged 3.6 in. and 20 ft, respectively (Table 5). Balsam fir was the primary crop tree species, accounting for 87% of the stems across the 33 plots. Red and black spruce comprised 12% of the crop tree stems, with white spruce and white pine accounting for the remainder. Volunteer stems (average 0.4 in. dbh) were considerably smaller than crop trees and comprised a very small proportion of stand basal area (Table 5). Stand data reported for the 1990 field season were similar to the corresponding figures reported for PCT stands sampled in 1989 (Briggs 1989).

Table 5. Summary of stand and tree morphological data for the 33 plots established in precommercially thinned stands."

Variable	Crop Trees'*	Volunteers[0]
Dbh(in)	3.6 (1.0)	0.4 (0.4)
Height(ft)	20.2 (6.3)	6.6 (2.4)
Basal area (ftVac)	49.4 (25.1)	2.3 (3.8)
Stems (#/ac)	698 (278.0)	1856 (1604.0)

"Means above, standard deviations in parentheses below.
[b]n= 264 subplots (33 plots X 8 subplots) °n= 247 subplots; some subplots lacked any volunteer stems.

Data analysis will continue through the spring of 1991. Results from this work, in combination with results of analysis of the existing spruce-fir data base (Steinman *in preparation)*, will form the basis for the site classification system. The first iteration of the classification system is anticipated in late 1991. Emphasis will be shifted to hardwoods in 1992.

European Larch Soil-Site Study

A soil-site study for European larch was initiated in 1990. The primary objective of the project is to examine the empirical relationship between height development of European larch and soil properties. The secondary objective is to determine if volume equations and site index curves developed for European and Japanese larch plantations in New York and Pennsylvania are applicable to European larch in Maine. This project is being carried out by M.S. graduate student Daniel Gilmore.

Twenty-nine plots were established in

plantations that had been identified as European larch by plantation records (Fig. 13, Table 4). Plots were located to take advantage of any differences in soil drainage class and effective rooting depth that occurred within plantations. Following felling of trees for stem analysis, it was apparent that two of the 29 plots were established in Japanese larch plantations.

A 0.05-ac plot was nested within a 0.1-ac plot and dbh of all stems within each plot was recorded. A soil pit was excavated near the center of each plot. Thickness of horizons, rooting depth, depths to mottling and to root restricting layer were measured along each pit face and averaged for the pit. Coarse fragment content was visually estimated from the area of each pit face occupied by rocks. Soil Conservation Service drainage classes were assigned according to mottling depth.

The forest floor, which consisted of an 01 horizon directly in contact with mineral soil, was sampled using a 50-cm X 50-cm sampling frame at four points located 90° apart along the perimeter of the interior 0.05-ac plot. A composite forest floor sample for each plot was collected for chemical analysis. With the exception of analysis for total C and total N, forest floor and mineral soil samples were treated in the same manner as those for the spruce-fir study.

Three vigorous dominant/codominant trees were selected for stem analysis. Stump diameter and dbh were measured and marked on the stem. Following felling, diameter outside bark was measured and the stem was marked at successive 3.3-ft intervals along the stem above breast height. For the ten plots located in the 59- and 60-year-old plantations, an interval of 1.6 ft along the stem was utilized. Total height and height to livecrown were recorded. A disk, approximately 2 in. thick, was removed from the stem at each of the marked points. Mean radius (half of the diameter as measured by a d-tape) was marked on each disk. The tree was carefully dissected and the annual height growth for the first 15 years above 4.5 ft was measured. Disks were returned to the laboratory at Orono where they were sanded and aged.

Summary of Stand Data

Plantations ranged in age from 8 to 60 years old (Table 6). Most of the plantations were established on old fields. Annual height increment of 3 ft was a common occurrence. The 60-year-old plantation at Parkman Hill was particularly impressive, with average tree height greater than 100 ft (Table 6).

Processing of soil samples and age determination of disks removed in stem analysis is currently in progress.

Table 6. Mensurational data for plots in the European larch soil-site study."

Plot	Age	Dbh	Stems	Basal Area	Total Height[b]
	years	in	#/ac	ftVac	ft
B01	18	6.6	304	72	40.6
B02	16	6.0	324	65	37.4
BOS	16	6.5	344	79	33.0
B04	16	6.2	486	104	34.8
D01	33	8.6	405	163	69.5
D02	29	3.0	1012	50	25.3
D03	29	3.8	486	37	26.2
D04	29	3.4	384	25	26.0
DOS	33	6.7	627	153	67.1
D06	33	7.7	587	188	73.0
D07	8	2.6	658	24	18.8
DOS	8	3.5	809	55	22.1
D09	8	3.2	648	37	21.3
D10[c]	32	8.5	445	176	81.7
DIP	32	8.7	405	167	60.3
SOI	16	6.0	567	113	45.8
S02	16	5.4	607	97	43.7
S03	59	11.0	223	147	77.5
S04	59	13.3	162	158	85.2
SOS	59	13.8	283	296	85.6
S06	59	14.9	243	294	100.1
S07	59	14.2	142	158	98.4
SOS	60	13.3	202	197	100.4
S09	60	14.1	202	220	99.2
S10	60	16.6	182	274	108.2
Sll	60	13.1	243	230	105.4
S12	60	14.1	142	155	102.0
S13	60	12.8	162	145	75.6
U01	41	8.1	344	123	63.6

"Mensuration data is for the larch component of the stand.
[b]Average height of dominants and codominants obtained from trees felled for stem analysis.
'Japanese larch.

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TREE IMPROVEMENT

Dr. Michael S. Greenwood and Throstur Eysteinsson

Larch Breeding Program

The accelerated larch breeding program initiated in 1987 (Greenwood and Eysteinsson 1989) continued to yield promising results in 1990. During the year, the focus of research shifted from prototype tamarack orchards to the indoor breeding orchard composed of grafted ortets of 6 select native tamaracks, 6 Japanese larches and 5 European larches. But first we report on results of experiments with the prototype tamarack orchards.

Pollination Study

Larches have notoriously poor seed-set. In seed orchards and wild populations alike, 30% seed viability is considered good (Kosinski 1987). Several factors are cited as being responsible for low seed viability, including:

1. failure of the female gametophyte to develop;
2. embryo degeneration;
3. low pollen viability; and
4. lack of pollination.

When making controlled crosses, timing of pollination is critical since there is evidence that the ovules in each female cone (of Japanese larch) may only be receptive for one day (Villar et al. 1984). Poor seed-set can to some extent be compensated for by increasing the amount of flowering, but when few cones are produced, seed-set can best be increased by improving the effectiveness of pollination.

An experiment to determine the time of peak receptivity of female strobili was carried out in a prototype tamarack orchard in the hope that experience gained would lead to greater effectiveness of pollination in the breeding orchard. Pollination took place in February-March, 1989 in a greenhouse heated to keep temperatures just above freezing. Pollen was applied to female strobili on 4 tamarack grafts on each of the first 15 days after bud burst with a single stroke of a camel's-hair brush. Twenty to twenty-five strobili were pollinated each day, for a total of 334 (each strobilus received pollen only once). The pollen used was a fresh mix from several trees unrelated to the trees bearing the female cones. Furthermore, 25 cones each were pollinated with 2, 3, or 4 strokes of the camel's-hair brush (dipped in pollen between each stroke) when they were judged to be at peak receptivity.

In late summer 1989, cones were collected and full-size seed extracted, counted, and stratified. Seed lots were kept separate by female parent and day pollinated. The seeds were germinated in November-December 1989, germination percentages calculated, and ANOVAs performed.

Peak receptivity was reached on the 10th day after bud burst with 20% of the seed germinating from cones pollinated that day. Pollination at 9, 11, and 14 days after bud burst resulted in 14-16% germination. Pollination on other days yielded less than 5% germination. The maximum germination resulting from 1 brush-stroke was 43% for seed from one of the female parents pollinated on the 10th day.

Applying more pollen (by 2, 3, or 4 brush-strokes) apparently did not lead to greater seed set, although the lack of success may in part be due to our inexperience in identifying when female strobili were receptive. Most of the multiple-stroke pollination was done 7 to 9 days after bud burst, which was prior to peak receptivity as indicated by the single stroke experiment. Two and 3 brush-strokes yielded 8% seed germination and 4 brush-strokes of pollen resulted in 19% germination. The maximum here for one female parent was 47% germination (4 brush-strokes of pollen on the 11th day after bud burst). Other studies with loblolly pine, Douglas-fir, and white spruce have led to the same conclusion, that increased pollination does not result in increased seed set.

The results of this study served to modify our notion of what a tamarack cone looks like when it is receptive. They also indicate that upwards of 50% seed viability (excellent for larch) can be achieved in intraspecies greenhouse breeding of larch with the right techniques and a little experience.

Flower Induction

Preliminary flower induction experiments were done using a prototype indoor tamarack orchard in 1988 (Eysteinsson and Greenwood 1990). They showed that the plant growth regulator gibberellin ($GA_{4/7}$) effectively stimulates female flowering in tamarack, and also indicated that it was important to apply the $GA_{4/7}$ early in the growing season. In order to further refine methods and answer somewhat different questions, a second set of flower induction experiments was carried out in a second prototype tamarack orchard in 1989. This population consisted of 32 unrelated tamarack grafts divided into 4 age-classes based on donor-tree age when the scions were grafted. Mean ages were 1, 5, 17, and 47 years. The grafts were grown at an accelerated rate in the greenhouse (where light, water, nutrients, and temperature were close to optimum) and were roughly 3.5 m tall at the time of treatment.

Three different $GA_{4/7}$ treatments were tested: weekly applications, for 5 weeks, 5 biweekly applications, and 9 biweekly applications, all commencing at the start of long-shoot elongation (25 April). The $GA_{4/7}$ was applied to individual branches in a foliar spray of 5% ethanol with a surfactant. Furthermore, half the grafts in each age-class were root pruned in early summer (root pruning is sometimes an effective flower stimulation treatment, especially in conjunction with $GA_{4/7}$). The objectives were to test differences in flowering response to concentrated vs. less concentrated $GA_{4/7}$ application regimes and short-duration vs. long-duration application as well as age-class differences in flowering and in the response to $GA_{4/7}$ and root pruning. Male and female conebuds were counted and data analyzed in early 1990. The results were as follows:

1. All 3 $GA_{4/7}$ application regimes resulted in significant increases in flowering over control.

2. Weekly $GA_{4/7}$ applications induced more flowering of both sexes than biweekly applications.

3. The long-duration treatment did not increase flowering over the short-duration treatments.

4. Female flowering was increased 17-fold in the youngest age-class, 25-fold in the intermediate age classes and 40-fold in the oldest age-class by the best $GA_{4/7}$ treatment (5 weekly applications) over control.

5. Male flowering was increased 13-fold in the oldest age-class and 10-fold in the second-youngest age-class by 5 weekly GA^ applications over control. Increases in male flowering in the other two age-classes were nonsignificant.

6. Flowering of both sexes was greatest on the youngest grafts and decreased with scion age on both GA-treated branches and on the untreated parts of the trees (Fig. 14)

7. Root pruning did not affect flowering.

8. Age-class differences in flowering cannot be explained by differences in tree size or vigor.

These results support the outcome of earlier experiments and have helped to refine flower stimulation techniques for indoor breeding of larch. An interesting outcome was that the most juvenile grafts flowered most heavily and flowering declined with scion age. This is exactly the reverse of the generally accepted notion that, after reaching reproductive maturity, fecundity increases over a period of years or decades up to a maximum reproductive competence for each tree. Tamarack is known to be a precocious species but more research is needed to explain the decrease in flowering with age; it may be a greenhouse artifact.

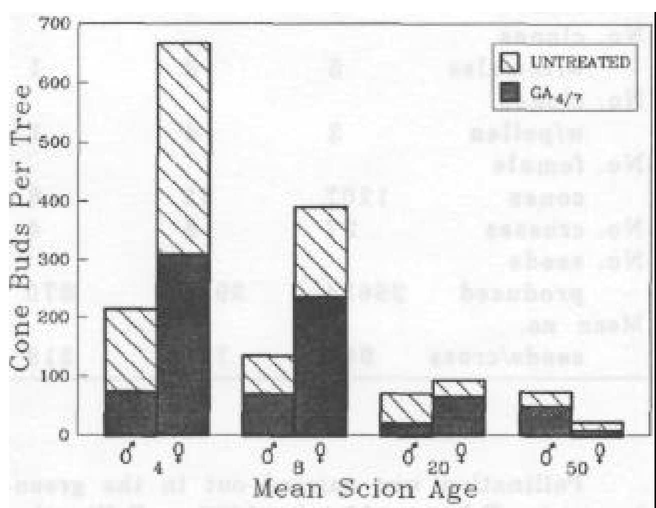

Figure 14. Male and female flowering per tree in an indoor tamarack orchard in 1990. The shaded portions represent flowering on the 9 $GA_{4/7}$-treated branches per tree (out of a total of 100-250 branches per tree).

The Indoor Breeding Orchard

In the fall of 1988, after two summers of accelerated growth in the greenhouse, many of the breeding orchard grafts were over 3 m tall. The 6 largest individuals of each species (tamarack, Japanese and European larch, a total of 18) were selected to receive flower stimulation treatments in 1989 (the third growing season after grafting). Half the grafts received 9 biweekly doses of $GA_{4/7}$ applied as foliar spray to the entire crown starting April 25th, and the other half received foliar spray treatments without $GA_{4/7}$.

Female flowering in spring 1990 was doubled in tamarack and male flowering quadrupled in Japanese larch in response to the $GA_{4/7}$ treatments. Although not statistically significant, this outcome greatly increased the amount of breeding that could be done. European larch was apparently unaffected by $GA_{4/7}$. Table 7 contains a summary of flowering and crosses made in the indoor larch breeding orchard in 1990.

Table 7. Summary of indoor larch breeding orchard flowering and crosses made in 1990.

	Tamarack	Japanese larch	European larch
No. clones	6	6	5
No. clones w/females	5	2	1
No. clones w/pollen	2	4	1
No. female cones	1207	42	8
No. crosses	27	5	4
No. seeds produced	26634	3975	870
Mean no. seeds/cross	986	795	218

Pollination was carried out in the greenhouse in February-March, 1990. Pollination bags were not used since there was no danger of pollen contamination from outside and any pollen shed in the still air of the greenhouse falls straight down. Care was taken to collect pollen as it was shed by hanging paper "boats" directly under pollen-cone bearing branches. During pollination (which was done using a camel's-hair brush) excess pollen falling off the female strobilus was caught in a vial and trees bearing many female strobili were emasculated to prevent selfing. Some control cones were left unpollinated on each tree to act as "contamination detectors". The following crosses were made: 7 tamarack X tamarack (improved native tamarack); 3 Japanese X Japanese (improved Japanese larch); 3 Japanese X European (a proven hybrid); 4 tamarack X European (a little-known hybrid); 19 tamarack X Japanese (a little-known hybrid).

Seed viability resulting from these crosses will be tested in fall, 1990. A new set of flower stimulation treatments was carried out in the entire indoor breeding orchard in the spring and summer of 1990. These include a new gibberellin timing and duration study, root pruning, and drought stress. Considerable flowering is expected in 1991, at which time another set of controlled crosses will be made. The final step in the breeding program, progeny testing, will commence as soon as seeds are collected and germinated in 1991.

Larch Tests and Plantations in Maine and New Brunswick

With the accelerated larch breeding program well underway, a first-hand look at what's happening in the real world was undertaken by touring some tests and plantations of larch in the region. A three-day expedition during the first week in June, 1990, took us to New Brunswick and central Maine. Our guides were experienced and knowledgeable, each willing to share a wealth of information with us.

Dr. Kris Morgenstern accompanied us to his young larch arboretum in Fredericton. It includes several seed sources for each of 7 larch species and hybrids. In a few years, this arboretum could become a valuable source of genetic material for larch breeding in eastern Canada and the northeastern U.S. Dr. Morgenstern also gave us some hybrid larch seed from a well-known German seed orchard (Von Lochow) to test against that which we produce in the breeding program. Hybrid larch from this seed orchard grows extremely fast and is being planted on Scott Paper Co. lands in western Maine.

Dr. Don Fowler was our guide to the Maritimes Forestry Center's test site called Acadia, north of Fredericton. Perhaps the most impressive thing we saw there was a 1962 test planting of 25 Japanese larch provenances with 2 provenances each of tamarack and European larch included for comparison. The best provenances include some impressive trees, at age 28 they are already bigger than much of the 50-100 year old spruce and fir being harvested in the region. The best Japanese larches are three times as tall and have twice the stem diameter as the best Norway spruce in an adjacent stand of the same age. The European larches looked similar in size to the Japanese, but the tamarack was clearly inferior in both straightness and diameter. Dr. Fowler maintains that the growth rate of the three best provenances corresponds to 15 m^3/ha/year (2.5 cords/acre/year).

Greg Adams showed us around some plantations on J.D. Irving lands in New Brunswick and Carl Haag was our host for a tour of Scott Paper Co. plantations in Maine. At each site we visited, the rapid early growth rate of larches was obvious. Larches will generally outgrow their competition (with the possible exception of hardwood stump sprouts) and capture a site. It was also obvious that some form of competition control is desirable in order to realize the diameter growth potential of the larch.

This trip served to strengthen our belief that breeding and planting larch are worthwhile activities. European and Japanese larch and their hybrid can be grown for pulp and sawlogs on rotations of 25-30 years using seed-sources currently available. With improvement, rotations as short as 15 years may be possible.

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TREE IMPROVEMENT

Dr. Katherine K. Carter

Tamarack Clonal Test

One of several tree improvement activities in 1990 was the 5-year evaluation of a clonal tamarack planting trial established at two locations, in cooperation with Dr. E.K. Morgenstern of the University of New Brunswick. These clones are derived from 49 open-pollinated families originating in seven natural stands of tamarack. Ten seedlings from each family were propagated by rooting of cuttings to make 490 clones which were planted in randomized block experiments on two clearcut sites. After five years, survival at both sites averaged 80% and overall mean height was 5.85 ft. There were significant differences in height among stands, families, and clones. Relatively little of the genetic variance is related to geographic parameters or differentiation among stands; and the greatest amount of variation is related to clonal differences. This can be seen in the range of 5-year height means attributable to various groups: stands range in mean height from 5.3 to 6.2 ft, families from 4.0 to 7.3 ft, and clones from 2.8 to 9.8 ft. Heritability for height at age five was low (0.03) when based on individual trees but much larger (0.54) when based on clone means. It appears from this data that clonal selection for height in tamarack would be very effective. Data regarding clonal variation in stem and branch form were also collected and are being analyzed.

Exotic Larch Species and Provenances

Two test plantations of larch species including provenances of European, Japanese, Dahurian, Siberian, and hybrid larches were evaluated after five growing seasons (Table 8). Combined data for the two sites (one located near Kokadjo and the other near Talmadge) indicated that the hybrid of European and Japanese larch averaged 9.5 ft in height and exceeded growth of either parent species by about 20%. Hybrid larch that had a European seed parent exceeded those from Japanese seed parents in height, averaging 12.5 ft and 8.1 ft, respectively. It is not clear whether this is due to the particular parents involved, or if it is a general feature of Japanese-European hybrid crosses. Overall, Japanese and European larches were similar in average height, but there were significant differences among provenances within both species that demonstrate the importance of using an appropriate seed source. Siberian larch (7 provenances) and Dahurian larch (10 provenances) at both sites suffered high mortality and low growth rates. However, these species have large native ranges and only a few provenances were included in this test; other provenances might prove to be more successful. For all species, growth and survival at Talmadge surpassed that at Kokadjo, apparently due to much heavier weed competition at the Kokadjo site.

Table 8. Range of provenance means for 5-year height and survival of exotic larches in two Maine plantations.

Species	Kokadjo		Talmadge	
	Height (ft)	Survival (%)	Height (ft)	Survival (%)
European larch (19 prov.)	4.6 - 9.4	44 - 100	8.5 - 12.6	75 - 100
Japanese larch (35 prov.)	5.4 - 9.2	58 - 100	8.8 - 12.8	66 - 100
Hybrid larch (7 crosses)	7.3 - 10.3	66 - 100	9.7 - 14.2	92 - 100
Siberian larch (7 prov.)	2.5 - 4.0	50 - 92	2.4 - 3.5	75 - 100
Dahurian larch (7 prov.)	1.6 - 9.2	8 - 84	2.1 - 7.4	0 - 100

THE EFFECT OF PROGRESSIVE STRIP CLEARCUTTING ON THE SUCCESSFUL ESTABLISHMENT OF SPRUCE AND BALSAM FIR REGENERATION

Dr. Alan S. White

Introduction

Results reported here are from data collected in the fall of 1989, but not analyzed in time for the 1989 annual report. No data were collected in the fall of 1990, reflecting a change from annual to biennial sampling.

Density and Stocking

The most dramatic change in 1989 was the increase in red spruce regeneration on Site 2 (30-ft cut strips alternating with 60-ft uncut strips). This change was primarily the result of a large increase in small (<3.6 in. height) seedlings in plot positions 1 and 2 of the cut strips. The density of red spruce seedlings in plot position 1 is now higher than that of any plots in the uncut strips. However, overall, density is still higher in the uncut strips (10,360 seedlings/ac) than in the cut strips (7840 seedlings/ac). Although density also increased significantly in Site 1 (50-ft cut strips alternating with 100-ft uncut strips), the increase was approximately the same on cut strips as on uncut strips. In contrast, balsam fir densities remained relatively constant on Site 1 and showed a slight increase in cut strips and a decrease in uncut strips on Site 2.

The increase in spruce density resulted in a much greater increase in spruce-fir stocking on cut strips than on uncut strips, especially on Site 2. The uncut strips were already between 88% and 100% stocked prior to 1989 so could not increase much. The plots in the cut strips are now between 60% and 92% stocked on Site 2 and between 52% and 76% stocked on Site 1.

White pine and hemlock increased greatly on Site 1 in both cut and uncut strips in 1989; white pine also increased greatly on Site 2. For white pine, this was an abrupt change from rather constant densities in past years. The hemlock increase seems to be a continuation of a trend in the uncut strips, but represents a more substantial change on the cut strips. For both species, the density increases resulted in much greater increases in stocking on cut strips than on uncut strips. As with red spruce, these increases are almost all in the smallest size classes so the probability of survival of these seedlings is quite uncertain.

In contrast to conifer trends, red maple and the birches showed declines in density but maintained relatively constant stocking, at least in the cut strips. This could have several explanations. One possibility is that the larger hardwood stems are excluding colonization by new seedlings while also exhibiting self-thinning as they grow. This seems more plausible for the birches than for red maple because the birches showed large increases in the tallest (12+ in.) size classes whereas the red maple increases were less noticeable (Site 1) or nonexistent (Site 2). Another possibility is that the data are simply reflecting natural variation in seed production by these species, especially given that the declines are greatest in the smallest size class. Unfortunately, another possibility is that yearly differences in sampling time are contributing to an apparent decline. With the rather prolonged sampling period in the fall of 1989, it is possible that more mortality to the small seedlings occurred prior to sampling or that more seedlings were uncounted because they (a) had dropped their one or two very small leaves or (b) were covered by falling leaves from larger stems.

As with past preliminary analyses, it is important to recognize the importance of seedling size to the results. Small seedlings contribute the most to all density and stocking values. Because they are also the size class most susceptible to change, they make results a little more tenuous. High plot-to-plot and year-to-year variability also remain prominent features of the data.

GROWTH AND YIELD PROGRAM

Dr. Robert S. Seymour

Wood Supply Modelling and Analysis

The ForMAINE wood supply model (Version 2.0), modified during 1989 to simulate partial cutting and to be more user-friendly, was extensively debugged, tested, and revised. The draft user's manual, also written in 1989, has been extensively modified in response to reviewers' comments, and the published manuscript should be available in early 1991.

Continued funding from the Maine Department of Conservation's Forests for the Future Program was used to begin sensitivity analyses of the previously completed timber supply projections for Maine (Seymour and Lemin 1989). Completion and publication is expected in 1991. A bulletin describing the 136 empirical yield curves used in the state wood supply analysis has been largely completed, and will be sent out for review in late 1990. Publication is also expected in 1991.

Regional Growth and Yield Cooperative - NEC 71

The once-promising effort to establish a cooperative regional project on growth and yield models for the Northeast has been abandoned. After approval for this project was deferred at the national level in 1989, it became clear that there was insufficient interest and participation by scientists from other forestry schools, experiment stations, and the USDA Forest Service to warrant continuation as a regional effort. My future research will focus on producing yield tables for managed conifer stands by site classes, in order to address this subject which ranked as a very high priority in the recent review by CFRU cooperators.

Stand Development

Mary Ann Fajvan, supported by a grant from Champion International Corporation, has completed preliminary analyses of the composition and structure of mixed pine-hemlock-spruce stands in eastern Maine. Age structures proved to be more complex than originally believed. In the oldest of five stands sampled which contained trees up to age 200, white pine was represented in each of the four oldest 25-year age classes; spruce and hemlock were represented in all but the youngest class (Fig. 15).

Xiandong Meng has completed his Ph.D. dissertation on the subject of spruce-fir growth and biomass production in 12-15-year-old, herbicide-treated stands as influenced by drainage class. Most but not all trees of both species originated as small advance seedlings (Fig. 16). Fir is clearly more responsive to improved drainage than was spruce in terms of both diameter (Fig. 16) and height (Fig. 17) growth. The more rapid growth of fir leads to higher biomass production on better drained soils, although stand density has an even stronger influence (Fig. 18).

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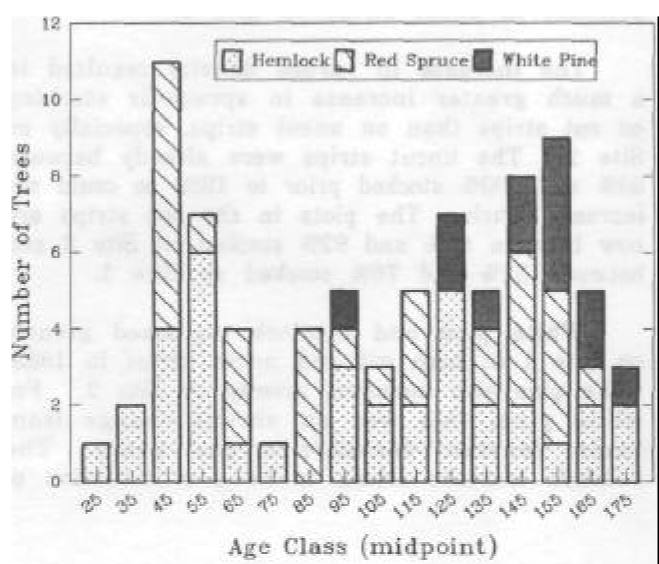

Figure 15. Estimated age structure of a mixed white pine-red spruce-eastern hemlock stand, T42, Maine.

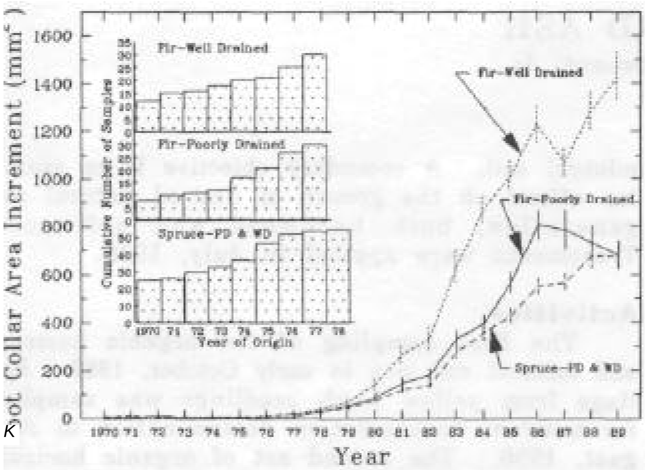

Figure 16. Comparison in annual area increment (root collar) and age structure of herbicide-released, dominant red spruce and balsam fir saplings between drainage classes, Telos, Maine. (Spruce was not statistically different between drainage classes.)

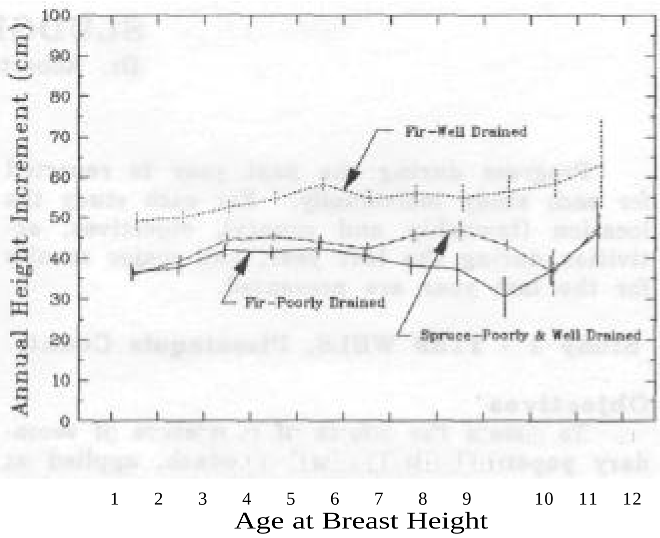

Figure 17. Comparison of annual height growth of herbicide-released, dominant red spruce and balsam fir saplings between soil drainage classes, Telos, Maine. (Height growth of spruce was not statistically different between drainage classes.)

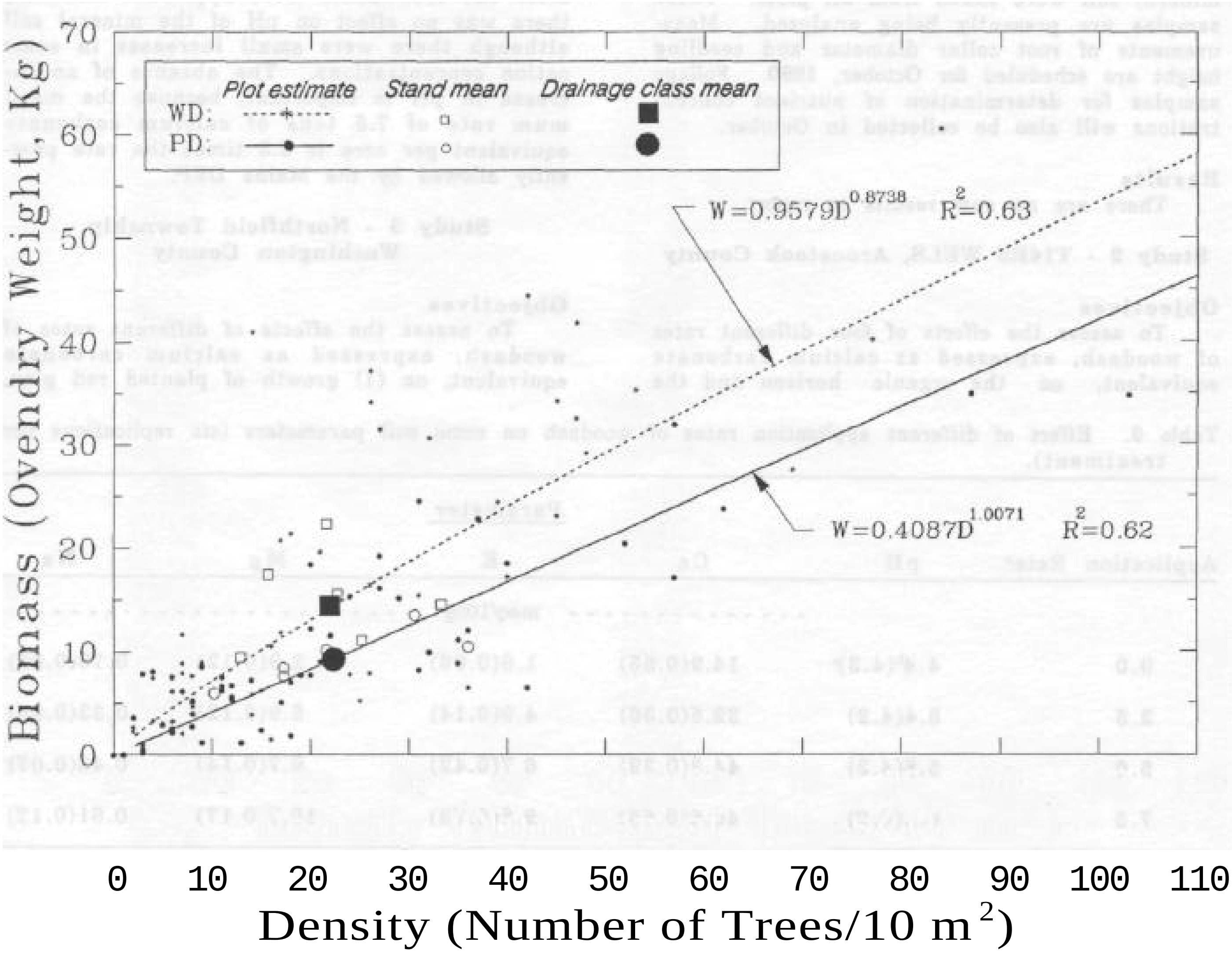

Figure 18. Relationship between total above-ground biomass and stand density of herbicide-released 12-14-year-old spruce-fir stands on well-drained and poorly drained soils, Telos, Maine.

SLUDGE AND ASH

Dr. Robert K. Shepard, Jr.

Progress during the past year is reported for each study individually. For each study the location (township and county), objectives, activities during the last year, and major results for the last year are presented.

Study 1 - T1R9 WELS, Piscataquis County

Objectives

To assess the effects of a mixture of secondary papermill sludge and woodash, applied at four different rates, three different times during the year, and for 1, 2, or 3 years in succession on (1) growth of planted black spruce, (2) the organic horizon, and (3) the mineral soil.

Activities

The third-year sludge-ash treatments were applied. Samples of the organic horizon and mineral soil were taken from all plots. These samples are presently being analyzed. Measurements of root collar diameter and seedling height are scheduled for October, 1990. Foliage samples for determination of nutrient concentrations will also be collected in October.

Results

There are no new results to report.

Study 2 - T14R5 WELS, Aroostook County

Objectives

To assess the effects of four different rates of woodash, expressed as calcium carbonate equivalent, on the organic horizon and the mineral soil. A secondary objective is to examine effects on the growth of desired natural regeneration, both hardwood and softwood. Treatments were applied in July, 1989.

Activities

The first sampling of the organic horizon and mineral soil was in early October, 1989. Foliage from yellow birch seedlings was sampled for nutrient concentration determination in August, 1990. The second set of organic horizon and mineral soil samples is scheduled to be collected in October, 1990.

Results

Results of the analyses of the 1989 samples are presented in Table 9. A pronounced impact on both the pH and base cation concentrations of the organic horizon was evident 10 weeks after the treatments were applied. However, there was no effect on pH of the mineral soil although there were small increases in some cation concentrations. The absence of an increase in pH is important, because the maximum rate of 7.5 tons of calcium carbonate equivalent per acre is 2.5 times the rate presently allowed by the Maine DEP.

Study 3 • Northfield Township, Washington County

Objectives

To assess the effects of different rates of woodash, expressed as calcium carbonate equivalent, on (1) growth of planted red pine,

Table 9. Effect of different application rates of woodash on some soil parameters (six replications per treatment).

	Parameter				
Application Rate'	PH	Ca	K	Mg	Na
0.0	4.4[b](4.3)[c]	14.9(0.55)	1.6(0.06)	2.9(0.12)	0.18(0.02)
2.5	5.4(4.2)	32.5(0.36)	4.9(0.14)	5.9(0.12)	0.33(0.05)
5.0	5.8(4.3)	44.3(0.39)	6.7(0.42)	9.7(0.14)	0.43(0.07)
7.5	6.1(4.2)	40.6(0.68)	9.8(0.73)	10.7(0.17)	0.61(0.12)

"Calcium carbonate equivalent (tons per acre)
[b]Organic horizon
[c]Upper 4 inches of B horizon

(2) growth of competing vegetation, (3) the organic horizon, and (4) the mineral soil. Treatments were applied in early November, 1989.

Activities

Diameter at breast height of all trees was remeasured after the 1990 growing season. Competing herbaceous vegetation was sampled for determination of both weight and nutrient concentrations. Sampling of the organic horizon, mineral soil, and red pine foliage is scheduled for October, 1990.

Results

Weight and nutrient concentrations of competing herbaceous vegetation have not yet been determined, but visual observation suggests that growth of raspberry, the dominant competing species, was markedly improved by the ash. After 1 year there was no effect of the ash on tree diameter growth.

Study 4 - T1R5 WBKP (Jim Pond Township), Coplin Plantation, and Township E, all in Franklin County

Objectives

To assess the effects of a combination of primary and secondary papermill sludge on: (1) growth of planted red pine, (2) growth of competing vegetation, (3) the organic horizon, (4) the mineral soil, (5) soil solution, and (6) streamwater. This study is being carried out at three different locations, and not all objectives apply at each location. Plots in T1R5 WBKP were treated in mid-June 1989, plots in Coplin Plantation were treated in early October, 1989, and plots in Township E were treated in mid-September, 1989.

Activities

A. T1R5 WBKP. The organic horizon and mineral soil were sampled. Competing herbaceous vegetation was sampled for weight determination, and foliage samples were taken from the planted red pine for determination of nutrient concentrations. Diameter measurements were made on the red pine. Soil and foliage samples will be analyzed during the winter of 1990-91.

B. Coplin Plantation. The organic horizon and mineral soil were sampled. Raspberry was sampled for determination of nutrient concentrations. Diameter measurements were made on the red pine, and foliage samples were collected for determination of nutrient concentrations. Soil and foliage samples will be analyzed during the winter of 1990-91.

C. *Township E.* The organic horizon, mineral soil, soil solution and streamwater were sampled periodically throughout the summer. Additional sampling and diameter measurements of red pine seedlings were scheduled for October, 1990. Samples will be analyzed during the winter of 1990-91.

Results

A. *T1R5 WBKP.* Analyses of 1989 samples showed an increase in pH and base cations in both the organic horizon and mineral soil. Foliar nutrient concentrations indicated that a severe nitrogen deficiency exists on this site. There was a small but significant increase in foliar N, P, K, and Mg in trees from the sludge-treated plots. Diameter growth of trees from the sludge-treated plots exceeded that of trees from the control plots by 0.08 in. in 1990 (0.66 in. vs. 0.58 in.). Over the 1989 and 1990 growing seasons combined, treated trees grew 0.11 in. more than the non-treated trees. The difference in amount of competing vegetation between treated and control plots was not significant.

B. Coplin Plantation. Trees from sludge-treated plots grew 0.04 in. more in diameter during 1990 than trees from untreated plots, a nonsignificant difference. Visual observation indicated that growth of raspberry, the dominant competing species, was improved by sludge application. It also appeared that foliage of trees from the treated plots was a deeper green than foliage of trees from the control plots.

C. *Township E.* Samples taken in October, 1989, one month after sludge treatment, revealed short-term changes in both the forest floor and soil water. The pH and base cation concentrations of the forest floor increased and concentrations of Na, Ca, and SO_4 as well as pH increased in the soil water. Many samples collected in 1990 are yet to be analyzed, but those analyses that have been completed indicate that effects on both the soil and soil water were more pronounced than those observed in 1989 and that they were occurring at greater depths.

EFFECTIVENESS OF PLANNED SKIPS FOR MAINTAINING WILDLIFE HABITAT IN HERBICIDE-TREATED CLEARCUTS IN MAINE

Dr. Catherine A. Elliott

Introduction

Recent studies suggest that the use of herbicides to control hardwood species on clearcuts in Maine reduce habitat quality, population size, and species diversity of small mammals and birds for at least three years after treatment. Such treatments may also reduce food and cover for species such as deer and moose during the initial years following treatment although the long-term effects may be the opposite. It has been suggested that incorporating planned skip areas into a spraying program could mitigate some of these effects by maintaining small patches of habitat for rodents and birds and providing food and cover for larger mammals. Such skips should be larger than accidental skips to provide blocks of cover and travel ways for wildlife. However, little is known about the effectiveness of skips of different sizes and dimensions.

Objectives

The primary objectives of the study are to:

1. Assess the effectiveness of planned skips in maintaining the diversity of the flora and fauna in herbicide-treated clearcuts; and
2. Assess the effectiveness of pilot-created planned skips versus ground-marked planned skips.

Project Status

This study is being conducted with the support and cooperation of International Paper Co. Two study areas are being used, each with a treatment block containing a planned skip and a control block with no planned skips. Planned skips are approximately 100 m by 200 m (2 ha).

Spot-mapping of songbirds was conducted in June on plots of 150 to 200 m by 250 m. Small mammals were trapped for four nights in July on a 7 by 9 grid of traps 10 m apart. Two snap traps were located at each grid point, and a pitfall trap was located at every third grid point. Small mammal trapping will be repeated in October. During winter, track counts of deer and moose will be conducted to determine if planned skips are used more or less than other portions of the cuts. Data analysis is underway, and a report will be prepared as a basis for determining future study.

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ADDITIONAL TECHNOLOGY TRANSFER ACTIVITIES BY CFRU PERSONNEL

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----------Delineation of climatic regions in Maine following multivariate analysis of meteorological data. Poster presentation to the Cooperative Forestry Research Unit Forum, March 13-14, 1990, Orono, ME.

_____ Soil and Precommercial Thinning Workshop for S.D. Warren Foresters. 12 p. handout. 24 participants. July 23, 1990. Jackman, ME.

_____ Precommercial Thinning and Site Quality. Advisory Committee Summer Meeting. 22 participants. July 24, 1990. Jackman, ME.

_____ Chairman, Northeastern Forest Soils Conference. Aug. 12-14, 1990. Orono, ME.

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__Balsam fir Christmas tree production. Corinth, Maine Kiwanis Club. March, 29, 1990. Corinth, ME.

_Forestry herbicide prescription development. Workshop presentation, Champion International. April 25, 1990. Ellsworth, ME.

__Silvicultural use of forestry herbicides. Seminar-Workshop. New Zealand Forest Research Institute. June 11, 1990. Christchurch, NZ.

_ Silvicultural use of forestry herbicides. Seminar-Workshop. New Zealand Forest Research Institute. June 13, 1990. Rotorua, NZ.

__Forest vegetation management with herbicides. Seminar, 7 radio, TV, newspaper interviews. June 19, 1990. Hobart, Tasmania, Australia.

— Forest vegetation management with herbicides. Seminar, 3 radio, TV, newspaper interviews. June 20, 1990. Melbourne Zoo, Australia.

__Forest vegetation management with herbicides and associated research needs. Seminar. June 21, 1990. CSIRO, Canberra, Australia.

__Forest vegetation management with herbicides and development of delivery technology. Seminar; radio, trade journal interviews. June 22, 1990. Sydney, Australia.

McCormack, M.L., Jr. Herbicide use in forest production and interactions with wildlife habitat. Field tour, The Wildlife Society, Maine Chapter. July 9, 1990. Mayfield, ME.

_____ Operational considerations for assuring establishment of commercially viable conifer stands in northeastern North America. Invited paper. Div. 3, XIX IUFRO World Forestry Congress. August 8, 1990. Montreal, Que.

--------- Uses of herbicides in Maine forests. Tour for Legislative Commission to Study The Use of Herbicides. Sept. 15, 1990. Farmington-Mayfield, ME.

Meng, X. and R.S. Seymour. Relationship of soil drainage class to early development of released spruce-fir stands. Poster presentation, Cooperative Forestry Research Unit Forum. March 13-14, 1990. Orono, ME.

Ostrofsky, W.D. Impact of herbicide treatments on management for quality timber. Presentation, 47th Annual Meeting of the Maine Hardwood Association. Oct. 12, 1989, North Conway, NH.

_____ A standard damage classification system for logging injuries. Poster presentation, NE Div., SAF, March 7-9, Manchester, NH., and the Cooperative Forestry Research Unit Forum. March 13-14, 1990, Orono, ME.

--------- Tree grade and vigor changes in two northern hardwood stands five years after thinning. Presentation at the Cooperative Forestry Research Unit Forum, March 13-14, 1990, Orono, ME.

_____ New observations from monitoring the health of red spruce: forest stress from spruce budworm to spruce decline. Presentation at the Cooperative Forestry Research Unit Forum, March 13-14, 1990, Orono, ME.

_____ Compartmentalization of discoloration and decay in living trees. Presentation and field demonstration to FMT 210A, April 10, 1990, Orono, ME.

__ Forest health considerations in silvicultur al management systems. Workshop presentation, College of Forest Resources. Sept. 19-20, 1990, Orono, ME.

Schaertl. G.R. Aerial herbicide treatment efficacy to release natural spruce-fir regeneration. Poster presentation, Cooperative Forestry Research Unit Forum. March 13-14, 1990. Orono, ME.

Seymour, R.S. Cooperative regional growth-and-yield modelling research. Poster presentation, Cooperative Forestry Research Unit Forum. March 13-14, 1990. Orono, ME.

Shepard, R.K. Sludge and ash research. Presentation, Cooperative Forestry Research Unit Forum, March 13-14, 1990. Orono, ME.

Shepard, R.K., Jr., and W. Bragg. Response of red spruce to fertilization with nitrogen. Poster presentation, Cooperative Forestry Research Unit Forum. March 13-14, 1990, Orono, ME.

_____ Response of eastern white pine to fertilization with nitrogen. Poster presentation, Cooperative Forestry Research Unit Forum. March 13-14, 1990, Orono, ME.

Shortle, W.C., and W.D. Ostrofsky. 1990. Shigometric detection of diseased tissues in trees. Presentation (by Shortle) and abstract at the XIX IUFRO World Forestry Congress, August 5-11, Montreal, Que.

Steinman, J.R. Assessment of spruce-fir productivity using soil physical and chemical variables. Poster presentation, Cooperative Forestry Research Unit Forum, March 13-14, 1990, Orono, ME.

Strauch, P.J. Establishment and early development of spruce-fir regeneration. Poster presentation, Cooperative Forestry Research Unit Forum. March 13-14, 1990. Orono, ME.

White, A.S. Review of strip clearcutting study. Field presentation, Champion Intl. Corp. Sept. 19, 1989. Twp. 32, ME.

______ Effects of strip clearcutting on regeneration and windthrow. Poster and presentation, Cooperative Forestry Research Unit Forum, March 13-14, 1990, Orono, ME.

Effects of strip clearcutting on regen eration and windthrow. Poster presen tation, Conf. on Natural Regeneration Mgt. March 27-28, 1990. Fredericton, NB.

COOPERATIVE FORESTRY RESEARCH UNIT ADVISORY COMMITTEE 1990 Membership

The CFRU Advisory Committee sets priorities and reviews proposals for the Cooperative Forestry Research Unit. Members active during all, or part, of 1990 were:

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CFRU STAFF (September 30, 1990)

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William D. Ostrofsky, Associate Research Professor of Forest Resources
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APPENDIX
Terminology

SCIENTIFIC NAME	COMMON NAME
Abies balsamea (L.) Mill.	Balsam fir
Abies spp.	Fir
Acer rubrum L.	Red maple
Betula alleghaniensis Britton	Yellow birch
Betula papyrifera Marsh.	Paper birch
Fagus grandifolia Ehrh.	American beech
Inonotus obliquus (Pers. ex Fr.) Pilat	Birch canker fungus
Larix decidua Mill.	European larch
Larix gmelinii (Rupr.) Kuzeneva	Dahurian larch
Larix laricina (DuRoi) K. Koch	Tamarack (Eastern larch)
Larix leptolepsis (Sieb. & Zucc.) Gord.	Japanese larch
Larix siberica Ledeb.	Siberian larch
Picea abies (L.) Karst.	Norway spruce
Picea glauca (Moench) Voss	White spruce
Picea mariana (Mill.) B.S.P.	Black spruce
Picea rubens Sarg.	Red spruce
Picea spp.	Spruce
Pinus resinosa Ait.	Red pine
Pinus strobus L.	Eastern white pine
Pinus taeda L.	Loblolly pine
Pseudotsuga menziesii (Mirb.) Franco	Douglas-fir
Rubus idaeus L.	Common red raspberry
Quercus rubra L.	Red oak
Tsuga canadensis (L.) Carr.	Hemlock