CFRU Information Report 31

1992 ANNUAL REPORT AND

RESEARCH SUMMARY OF THE

COOPERATIVE FORESTRY RESEARCH UNIT

COLLEGE OF FOREST RESOURCES

MAINE AGRICULTURAL EXPERIMENT STATION

UNIVERSITY OF MAINE

ORONO, MAINE 04469

Miscellaneous Report 376 December, 1992

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ADVISORY COMMITTEE CHAIR'S REPORT

The year 1992 proved to be another challenging yet productive one for the Cooperative Forestry Research Unit. The biggest challenge continues to be dealing with the difficult financial situation that the University and the cooperators are facing during these recessionary years. However, nearly all cooperators have been faithful to the program by their continued financial support and active participation in CFRU activities. This is undoubtedly recognition of the high level of service that scientists provided to the forest management effort over the years.

There was, however, one cooperator that decided to no longer participate in CFRU activities in 1992. Georgia-Pacific Corp. advised us early in the year that they would no longer contribute financially to the CFRU. This emphasized the need to ensure close and continuous contact with the cooperators.

In order to maintain and improve CFRU productivity and effectiveness we reviewed our primary mission, which is to conduct research and provide forestry research support for the forest industry. In addition, a number of secondary goals were identified as requiring consideration, and committees were established to respond to these needs as follows:

1. Communication Committee: To direct communication efforts to the public in order to inform them of research efforts taking place in the forest sector in an effort to improve the forestry image in Maine and the Northeast region;

2. Technology Transfer Committee: To ensure a mechanism is in place for the timely and effective transfer of research results to the user groups, field foresters, and industrial supporters; and

3. Data Exchange Committee: This committee was established to ensure the most effective use of research dollars. Project cooperation and data exchange opportunities should be aggressively pursued amongst Maine cooperators, between Maine and Canadian cooperators, and with other university and governmental groups in both the U.S. and Canada.

The CFRU Leader position was reviewed, and in recognition of a job well done, Dr. W. Ostrofsky was appointed for a two-year period from May 1, 1992 - April 30, 1994. This will also ensure continuity with the Chair of the Advisory Committee.

The Executive Committee with the three full-time scientists, along with Boise Cascade's Tom Therriault as facilitator, participated in a retreat at Kidney Pond, Baxter State Park, on May 28 and 29. The purpose was to obtain a better understanding of concerns regarding budgetary needs, research direction, and CFRU structure, and to review CFRU Bylaws and Policies and Procedures. As a result of discussions, the following recommendations were made and later adopted by the CFRU Advisory Committee:

- Budget review resulted in the recommendation to maintain a budget level of approximately $480,000 for the 1992-93 fiscal year. In order to accomplish this, a considerable amount of "soul searching" was required. However, the strength and character of a true "cooperative" effort prevailed, and the task was accomplished.

- Bylaws and Policies were modified to reflect the role of the Leader position and to provide flexibility in the establishment of subcommittees.

- The scientists' problem analyses will be updated by February 1993 and every 5 years thereafter, to coincide with the research priorities update.

In closing, I would like to thank the Executive Committee for their commitment in addressing the challenges that presented themselves in 1992, the scientists for their devotion, dedication, and understanding as we continue to operate under a difficult economic climate and, of course, the cooperators themselves without whom the CFRU would cease to exist. I look forward to working with all of you as we proceed into what will undoubtedly be another challenging but exciting year.

Everett Deschenes
CFRU Advisory Committee

DEAN'S REPORT

The College of Forest Resources has met some unique challenges this past year. Perhaps the single-most important issue was the decision to become a new college, with the integration of the College of Applied Sciences and Agriculture and the College of Forest Resources. Planning for this has occurred over the past year, and has involved numerous meetings with all faculty and staff, and at various administrative levels of the University. Approval of this action by the Board of Trustees has put the date of July 1, 1993, as the official start of the new College of Natural Resources, Forestry, and Agriculture. The structure and function of the Cooperative Forestry Research Unit in the new college will remain largely unchanged from what it is today.

The Cooperative Forestry Research Unit has undergone some substantive changes over the course of the year. Adapting to change can be, at times, quite demanding. A commendable effort has been mounted by the CFRU Executive Committee and the scientists to balance a high level of productivity with the budget constraints dictated by a slow economy. Difficult decisions were made regarding budget rescissions and program structure changes. However, these changes will ultimately place the CFRU in a stronger long-term position for continuing its work successfully.

Most recently, Dr. M. L. McCormack has been awarded the "Henry W. Saunders Professor of Hardwood Silviculture Chair" and will officially begin service in this role in early spring. This is a prestigious distinction, and I look forward to the vigor and experience that Dr. McCormack will bring to this position. We look to this as a way to expand our concerns for hardwood silviculture in Maine.

A special note of thanks goes to Fraser, Inc., who helped organize a helicopter tour of their forest properties in eastern Maine for two of Senator Mitchell's aids. In addition, I have made visits to numerous cooperators over the past year, and I'm greatly impressed with the commitment and enthusiasm they have shown toward their profession and towards this University. It is this professionalism, coupled with the strong desire to continually improve the status of our natural resource base that makes my association with you so rewarding.

G. Bruce Wiersma
Dean, College of Forest Resources

BALANCE SHEET

1991-1992 Period
10/1/91-9/30/92

ASSETS:

BALANCE FORWARDED SEPTEMBER 30, 1991	$ 736,685.23	
INVESTMENTS 10/01/91-09/30/92	34,538.23	
CONTRIBUTIONS 01/01/92-09/30/92	403,148.00	
TOTAL ASSETS:		$1,174,371.46

EXPENSES: 10/01/91-9/30/92

ADMINISTRATION-OSTROFSKY	54,495.96	
SILVICULTURE -- McCORMACK SOIL	95,826.11	
SITE - BRIGGS HARDWOOD/ASH -	117,133.42	
OSTROFSKY GROWTH/YIELD -	82,683.62	
SEYMOUR TREE IMPROVEMENT -	15,381.17	
GREENWOOD SLUDGE & ASH -	5,211.61	
SHEPARD TREE IMPROVEMENT -	13,398.22	
CARTER MOOSE &	25,155.10	
HERBICIDES/SERVELLO VEHICLE	42,280.47	
REPLACEMENT	12,940.00	
TOTAL EXPENSES: BALANCE		464,505.68
09/30/92 LESS DEDICATED		709,865.78
FUNDS: LESS CARRY		400,000.00
FORWARD 9/30/92 BALANCE		48,905.57
ENDING 09/30/92		$ 260,960.21

CFRU LEADER'S REPORT

Research on a wide array of topics continued energetically through 1992. This year marks the end of the first full year of the fourth five-year funding period of the Cooperative Forestry Research Unit. This report outlines many of the significant accomplishments achieved over the past year and emphasizes the gains made in many long-term studies.

Substantial progress has been made by Dr. R. Briggs in the establishment of a hardwood site classification system and towards the completion of a refined spruce-fir site classification system. Dr. M. McCormack has spent much effort in reestablishing several long-term study sites in anticipation of acquiring some extremely useful information on effects of herbicide use and on thinning in spruce-fir stands. Most of my research time was spent on establishing another large field study to determine effects of papermill sludge ash and wood ash on sugar maple and red pine growth.

Important information on effects of papermill sludge and wood ash on crop tree growth and nutrition and on plant competition are starting to emerge from studies, now five growing seasons post-treatment, conducted by Dr. R. Shepard. Dr. R. Seymour continues to develop the growth and yield models with which he worked when on sabbatical leave in British Columbia. The moose and deer browse project, directed by Dr. F. Servello, is now in its third and final field season, with a large amount of data currently in review.

Dr. K. Carter has assessed growth and yield characteristics for larch and balsam fir provenances which are now (respectively) 15 and 16 years old. Dr. M. Greenwood has been on sabbatical leave during most of the year, but graduate student T. Eysteinsson has completed his Ph.D. thesis on accelerated larch breeding. This breeding and testing program, initiated in 1987, has resulted in the establishment of a progeny test of 50 full-sib families outplanted during May. All these studies indicate that the long investment in time to obtain useful research results is paying off, and will continue to provide substantial returns in knowledge over the next several years.

The slow economic climate continues, and this has resulted in need for some difficult budget adjustments to be made. During May, a staff retreat was held at Kidney Pond, Baxter State Park, with the full-time scientists and the Executive Committee of CFRU attending. After considerable discussion, all program budgets for the 1992-93 year were reduced from those proposed earlier. The Silviculture program and the two Tree Improvement programs were substantially reduced.

In order to accommodate the refilling of a full-time technician position within the Silviculture program, a significant change in the structure of the program has occurred. Dr. McCormack has agreed to reduce his time commitment to CFRU by 25%, as part of a partial phased retirement program, according to University of Maine guidelines. The cost savings from this change will support a full-time technician, to be hired sometime in early 1993. The two Tree Improvement program budgets received a larger percentage reduction than other programs based on the priorities established during the 1989-1990 evaluation.

Two important accounting changes were initiated this year. The first was the establishment of an Administration account separate from the "Control" account. This will improve efficiency and allow for easier assessment of the expenses in this category. The second, more important change was the accommodation to allow carry-over to the 1992-93 year of 80% of the remaining 1991-92 budget. This practice encourages frugality throughout the year, and discourages untimely expenses as the fiscal year nears its end. The carry-over is calculated on a program basis, and has helped to ease the 1992-93 budget remissions, especially for those programs that have had to accept large reductions.

In February, I attended a leadership training workshop "Chairing the Academic Department - Coping with the present and looking towards the future," held in Durham, New Hampshire. The Conference was financed by the Council of Presidents of the New England Land Grant Universities. Portions of the conference have been quite useful in dealing with situations that have developed over the past year.

Also this year, through the efforts of Dr. R. Briggs and Dr. I. Taviss, a formal communication link has been established between the CFRU and the New Brunswick Forest Research Advisory Committee. This liaison is aimed at fostering the sharing of research information and toward reducing duplication of research efforts.

As the CFRU looks towards the new year, it is confident that the changes that have occurred within the CFRU can be optimized to strengthen our research position in the future. In addition, the new challenges of functioning within a larger and more diverse College will be met with a high level of enthusiasm.

William D. Ostrofsky, Leader
Cooperative Forestry Research Unit

SILVICULTURE

Dr. Maxwell L. McCormack, Jr.

Overview

The first two months of this reporting year were the last two months of my sabbatical year in Europe. Following the experiences reported in the 1991 Annual Report, I conducted several excursions through silvicultural operations and old growth forests in Hungary and Czecho-Slovakia (Fig. 1). It was a surprise, and especially interesting, to tour some long-time studied virgin forests. There is much that can be learned from those unharvested natural systems. Also, with special assistance of Dr. Georg Kenk of the Baden-Wuerttemberg Forestry Research Institute, I conducted an intensive field review of spacing/crop tree density studies with Norway spruce (Fig. 2).

I have sorted and filed my collections of photographic slides and notes from my many European field excursions. Possible seminar and discussion topics include

Silviculture of selection forests (Plenterwald),

Storm damage and stand stability,

Development of stands of mixed species,

Density and distribution of crop trees,

Commercial thinnings in spruce, Production

of high-quality hardwoods, and

Veneer oak production in the Spessart of Germany.

Reduced operating funds resulted in a decreased work effort over the 1992 field season. Early in the year a major project involved moving the CFRU laboratory to new space in Nutting Hall. Renovation and redesign, supported by funding from the University, resulted in a successful reestablishment of the laboratory which included the installation of functional laboratory furniture contributed by International Paper Company. The CFRU Building on the University Forest received needed maintenance and slight modification to function as a facility for processing vegetation samples.

The major commitment of field time was expended on plot boundary and corner maintenance at the Austin Pond Study Site on Scott Paper Company land in Bald Mtn. Twp. This site was treated with a series of operational herbicide treatments in 1977 and now exhibits 15 years of growth responses to the treatments. Some spruce trees that were 3 to 4 ft tall at the time of treatment now have breast

Figure 1. Prof. Ing. Stefan Korpel, Dr. Sc. of the Faculty of Forestry, Zvolen, Czecho-Slovakia standing in a virgin forest area which he has studied intensively over the past 45 years. This stand contains large individual spruce and fir trees with ages of approximately 400 years.

Figure 2. Dr. Georg Kenk of the Baden-Wuerttemberg Forestry Research Institute in a Norway spruce study site which has been thinned to a wide spacing.

Figure 3. White spruce crop trees in a triclopyr-treated plot at the Austin Pond Study Site. At the time of treatment in 1977 they were approximately 4 ft tall. Fifteen growing seasons later they are 7.5 to 9.0 in dbh and have crown diameters of 14 to 18 ft.

Figure 4. Mixed conifer crop trees in a glyphosate-treated plot at the Austin Pond Study Site. This view shows a portion of the plot half that was precommercially thinned operationally in 1986, nine growing seasons after the aerial herbicide treatment had been applied.

high diameters of 6.5 to 9.0 in (Figs. 3 & 4). Additional maintenance was carried out at the Weymouth Point Study Area on land of Great Northern Paper, Inc., in T4R12 WELS. The grid system locations were checked, replaced as required, and the watershed boundaries were repainted. Several publications have resulted, totally or in part, from Weymouth Point data over the last few years. These publications by Jim Hornbeck, Tat Smith, Dave Turcotte, and others are listed in this report. Also listed is the completed M.S. thesis by Patrick Strauch on early development of spruce-fir regeneration.

Cooperation with Dr. Ted Needham, University of New Brunswick, on the extensive study of artificial regeneration of spruce on lands of Eraser Paper Ltd. near Plaster Rock has continued through the year. The 1992 growing season resulted in some very impressive development of the seedlings on treatments where competing vegetation had been successfully reduced. Travel for my involvement in this study was supported by a grant from the Canadian-American Center at the University of Maine.

Among my technology transfer activities were a variety of courses and workshops on herbicide technology. Of special note was a 12-hour field workshop which originated at Nutting Hall and took place on lands of James River Timber Corp. and Champion International Corp. There were more than 75 registrants who participated throughout the long day. Dick Schaertl, Ph.D. candidate and Monsanto representative, contributed significantly and prepared informative handouts for use at the field stops. In addition to Monsanto, financial support was contributed by DowElanco and duPont. During the early part of the year I served as a member of the Steering Committee for the International Conference on Forest Vegetation Management which was held at Auburn University in late April; it was attended by over 200 people from more than 20 nations. Plans are now underway to convene a similar conference in New Zealand during 1995.

Some significant professional activities include my serving as Chair-elect, New England Society of American Foresters, as well as the Chair of the NESAF Silviculture Working Group. During September I participated in a unique opportunity as a member of the Cooperative State Research Service Review Team for the research programs of the Department of Forest Science, Oregon State University, Corvallis. The physical plant, faculty, and total forest science research effort at OSU is one of the largest in the nation.

Silvicultural Methods

In addition to the preceding summary comments, other project work directed at stand improvement and production of high-quality merchantable stems has continued. The long-term spruce-fir thinning sites are under review. Unfortunately, only two of the original five sites remain. In 1993 these two stands will complete 15 growing seasons since

Figure 5. A single-grip harvester carrying out a commercial thinning in a pine stand on land of Baskahegan Company.

the original treatments were established. The individual tree evaluations will be continued on the trees that remain.

Possibilities for effectively carrying out partial cuts and merchantable thinnings are under consideration. New and promising techniques exist through the employment of single-grip processors (Fig. 5). This is a technology utilized effectively in Europe which was illustrated with my comments for the 1991 Annual Report. Efforts will be expanded in the future to address silvicultural practices for production of high-quality hardwood stems (Fig. 6) and establishment of desirable species composition in hardwood stands. Some preliminary work has been done in understory vegetation of a thinned hardwood stand on land of Fraser Paper Ltd.

Figure 6. Brooks Mills examining a young oak tree on his Edgewood Tree Farm. This illustrates the type of condition where regeneration manipulation could be initiated while individual, high-quality stems are being cultured.

Herbicide Technology

Data are being assembled and reviewed from an array of CFRU studies designed to provide information for the perfection of silvicultural uses of herbicide technology. For example, the 26 treatments being evaluated by Dick Schaertl for his dissertation are exhibiting interesting responses from a variety of herbicide tank mix combinations. Figures 7A and 7B illustrate the results achieved from combinations of surfactants and combining residual activity herbicides with glyphosate and triclopyr. Development of efficacy from the first to second year after treatment is worthy of note.

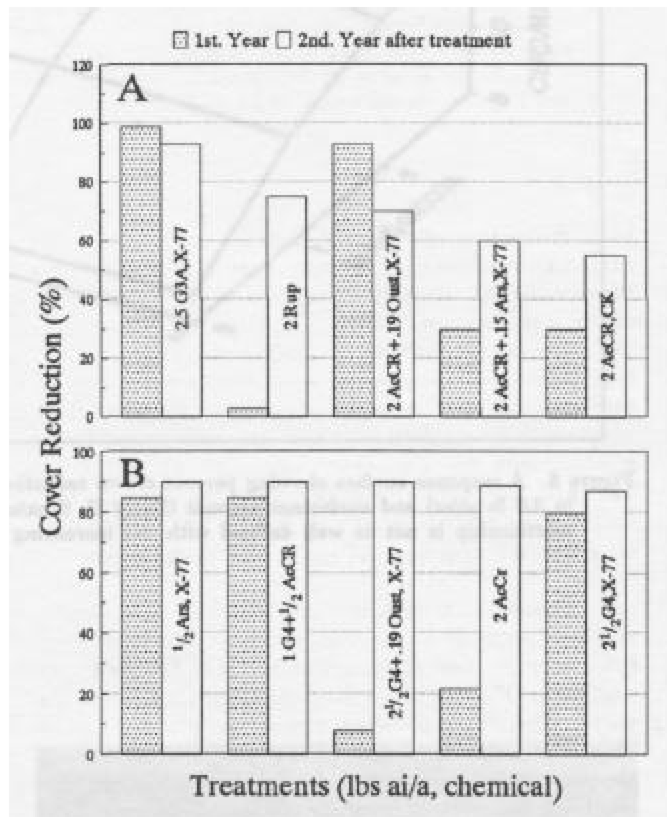

Figure 7. Cover reduction (%) of brambles (red raspberry) (A) and red maple (B) on the Twp 34 study area. Bars indicate cover reduction for each of two difficult-to-control species in the first and second year after treatment for each of the five best treatments for each species out of 26 treatments studied. Ars=Arsenal; G4=Garlon 4 (ester formulation); AcCR=Accord CR; G3A=Garlon 3A (amine formulation); Rup=Roundup; X-77 and CK=Cide Kick are surfactants included in the tank mixes as indicated. Inclusion of Oust was expected to provide some residual activity.

COMMON RED RASPBERRY
BRADLEY TWP. STUDY

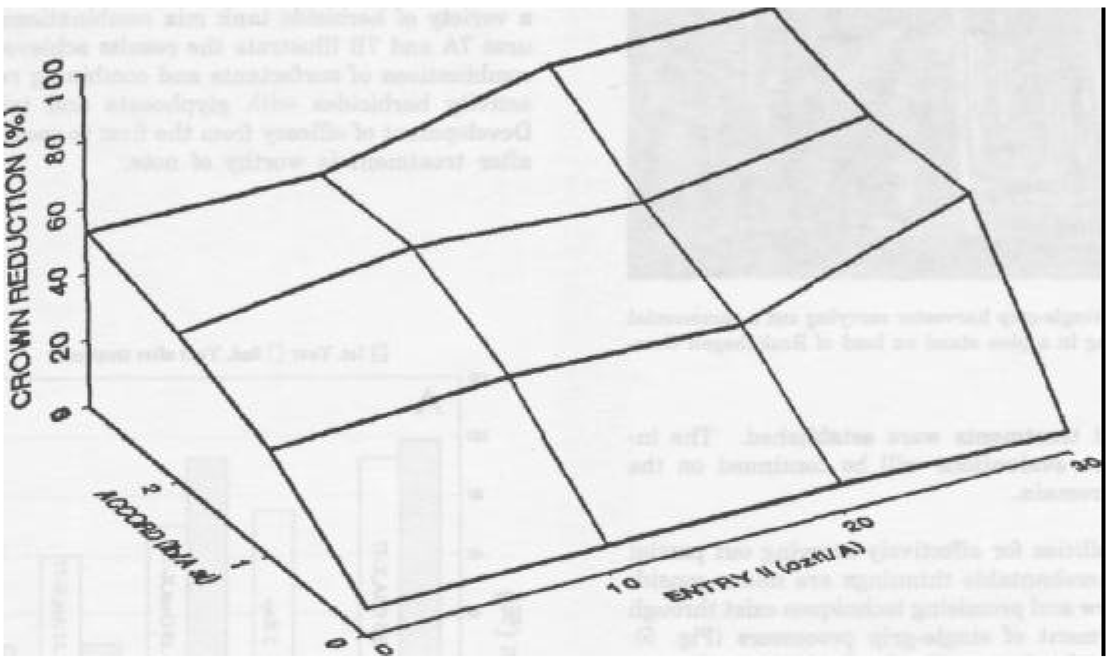

Figure 8. A response surface showing percent crown reduction for red raspberry across 16 combinations of glyphosate level (0.0 to 3.0 Ib ai/ac) and surfactant amount (Entry II, fl oz/ac). Efficacy increases with increasing levels of glyphosate, but the relationship is not as well defined with the increasing amounts of surfactant.

Figure 9. Application of second-step treatment plots in residual tree bands from aerial strip treatments applied in 1990 on land of Great Northern Paper, Inc.

A study, established in 1989 and summarized in the 1990 Annual Report, on land of Champion International in Bradley to evaluate different levels of the formulated surfactant across three rates of glyphosate has been evaluated. An indication of the range of efficacies across the 16 different combinations is illustrated in Figure 8. These relationships are especially important since the surfactant component has changed for the frequently used forestry glyphosate product in the U.S.

Follow-up on the aerial strip thinning studies has verified the assessments summarized in the 1990 Annual Report. Further recent development of spray pattern delivery capabilities and electronic guidance systems will add security and precision to this approach to precommercial thinning as well as to operational broadcast spray applications. Second step treatments, those that might effectively treat the residual strips of potential crop trees, are under study (Fig. 9).

TIMBER QUALITY IMPROVEMENT AND ASH RESIDUE UTILIZATION

Dr. William D. Ostrofsky

Introduction

Two summer field seasons have now been spent in establishing several experiments to examine the effects of land-spreading papermill sludge ash and wood ash on forest tree and soil parameters. Research on the two principal study sites located in King and Bartlett and Caratunk Townships is being conducted in cooperation with Dr. Robert Shepard. Details of these studies are provided later in this report.

The ash residue utilization program was strengthened in January 1992, with the addition of Yaping Ren to the research team. Ms. Ren is a graduate student working towards the Master of Science degree and is conducting research on the effects of papermill sludge ash on soil microbial populations. She has made an aggressive start, and her research project is well underway.

CFRU Research Associate Peter Caron assisted with the summer field work from July through September. Adam Carmichael, a graduate student in Natural Resources, helped with the field work throughout the summer. Stuart Gardner, an undergraduate student in Forest Management, also provided help with field measurements during June. The high-quality assistance of each individual is greatly appreciated.

Several manuscripts were completed and have reached the publication stage this year. Three reports, one published and two in press, have developed from the Shigometer projects funded during 1989 and 1990 with a USDA Forest Service Cooperative Agreement and by the CFRU. Two additional publications on the Shigometer work are in early draft form. I was also invited to write a book chapter for a text on the history of plant pathology. The chapter describes the scientific contributions of Robert Hartig, considered to be the "father" of forest pathology. Although no project time was devoted to this effort, it is listed in the publications section of this annual report for your information.

Papermill Sludge Ash Utilization-King and Bartlett Township

Objectives of this study are to determine the effects of various ash loading rates on nutrient status and growth of planted black spruce, on soil chemical changes, and on vegetative competition. The study site is located on International Paper Co. land and has been installed with their cooperation and support.

Sixteen square plots measuring 10.67 m (35 ft) on a side were established in 1991 as two blocks of four replicated treatments per block. Treatments were blocked realizing that plots located on the lower side of a slightly down-sloping treatment area appeared slightly wetter for longer periods of time than plots located somewhat higher on the slope. Due to a lower $CaCO_3$ content of the ash than was expected at the time of treatment application, treatments closely approximated 0, 2, 4, and 6 tons/acre $CaCO_3$ equivalent. Treatments were applied in early July of 1991.

Height and diameter growth of black spruce was measured in early October and compared with initial tree size (Figs. 10 and 11). Statistical analyses show that there was a significant effect of block on tree height growth. Black spruce in the lower, wetter block (block two) grew less in height than those in the upper block. However, when variation from the factors of initial tree height and blocking is removed, no significant differences were found in either height growth or root collar basal area growth between treatments. Ash treatments have not yet had a measurable effect on growth of black spruce.

Pretreatment vegetation was sampled by establishing two milacre subplots in each of the 16 study plots. As part of the operational treatment of the area, the entire plantation within which the study plots were located received an herbicide application to control the woody brush competition in late August of 1991. Regrowth of vegetation was recorded from the original milacre subplots in late August of 1992. Pin cherry appeared to be the major competitor of black spruce prior to the herbicide application. This year, common elder •was the most common plant throughout the study area (Fig. 12). To date, no differences in numbers or sizes of competitive species are apparent between treatments. However, based on earlier ash and sludge studies, vegetation differences due to treatments are expected to be expressed over the next one or two growing seasons.

Near the end of the 1991 growing season, samples of pin cherry, red maple, and black spruce foliage were collected for elemental analysis, 3 weeks (cherry and maple), 7 weeks (maple), and 14 weeks (spruce) after ash application. In 1992, black spruce and elder foliage was collected. The 1991 sampling of black spruce foliage from the treated plots showed increased nutrient concentrations for all elements except K, compared with foliage from control plots. Results from the 1992 samples should be available over the next few months.

Changes in elemental status of forest floor and mineral soil layers have also been monitored with

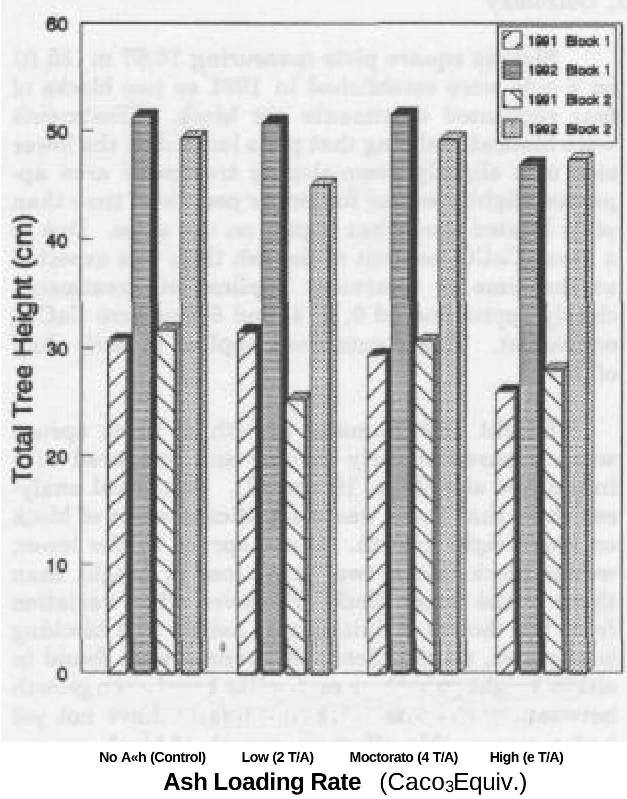

Figure 10. Papermill sludge ash effect on black spruce height growth, King and Bartlett Township, Maine. One full growing season after treatment application, there are no statistically significant treatment effects.

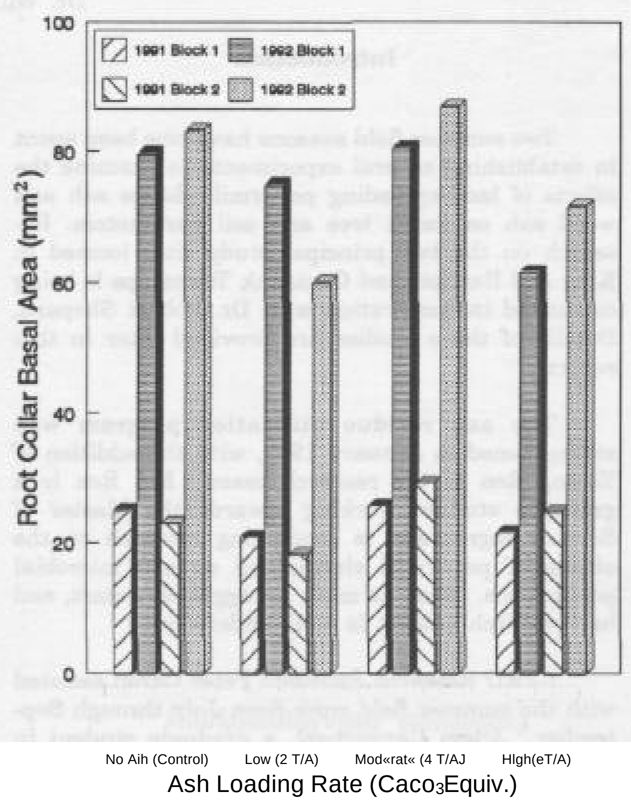

Figure 11. Papermill sludge ash effect on black spruce root collar basal area growth, King and Bartlett Township, Maine. One full growing season after treatment application, there are no statistically significant treatment effects.

Figure 12. Peter Caron and Adam Carmichael tally vegetation in the milacre plots one year after site treatment. The predominant vegetation is common elder.

respect to the ash treatments. In addition, comparisons of elemental status of mineral soils with and without forest floor have been made. These results are reported by Dr. Robert Shepard later in this report. Also this year, samples of forest floor and mineral soil were obtained from the hardwood stand adjacent to the black spruce plantation. Chemical analyses of these samples will provide data with which to compare soil elemental changes in the harvested and harvested/ash-treated plots.

Wood Ash and Papermill Sludge Ash Utilization - Heald Pond

The majority of the field work this season was spent in the establishment of another series of plots with the objective of determining the effects of various rates of wood ash and papermill sludge ash on growth of planted red pine and natural advance regeneration of sugar maple. Another objective of the study is to document changes in soil biological properties as they are related to the application of the ash materials. As with the study installed in King and Bartlett Township, Dr. Robert Shepard is co-principal investigator and assisted with the collection and processing of soils data.

The study site is located on Scott Paper Co. lands in Caratunk Township near the Heald Ponds. The site supported a mature hardwood stand composed primarily of sugar maple, with beech, some yellow birch, and white ash also present. In 1990, a portion of the hardwood stand was clearcut. Red pine was planted in 1991 at a spacing of approximately 2.44 m x 2.44 m (8 ft x 8 ft). Appearance of the study site is shown in Figure 13.

A total of 48 square treatment plots approximately 8.22 m (27 ft) on a side were established. Each plot contains a minimum of 9 planted red pine and 9 sugar maple advance regeneration. An additional 6 plots were established in the adjacent, unharvested hardwood stand. Treatments were of two ash materials (wood and papermill sludge ash) each applied at the four $CaCO_3$ equivalent rates of 0, 3, 6, and 9 tons/acre. Six replicates of each treatment were established. Layout of the study plots is shown in Figure 14.

Through June and July, the regrowth of vegetation following the clearcut was substantial, and needed to be controlled if effects of ash were to be properly documented. Since sugar maple was included as part of the experiment, and because changes

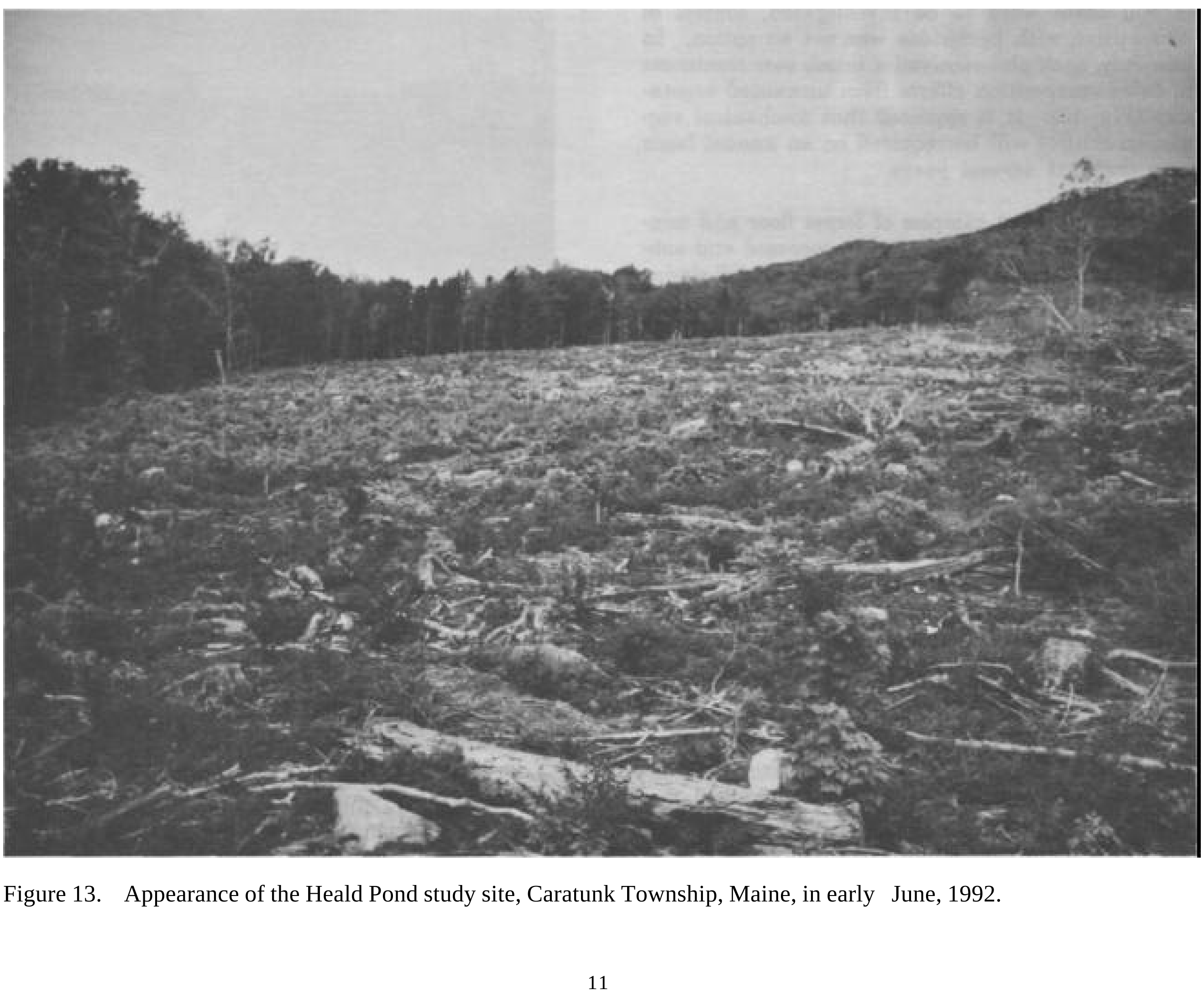

Figure 13. Appearance of the Heald Pond study site, Caratunk Township, Maine, in early June, 1992.

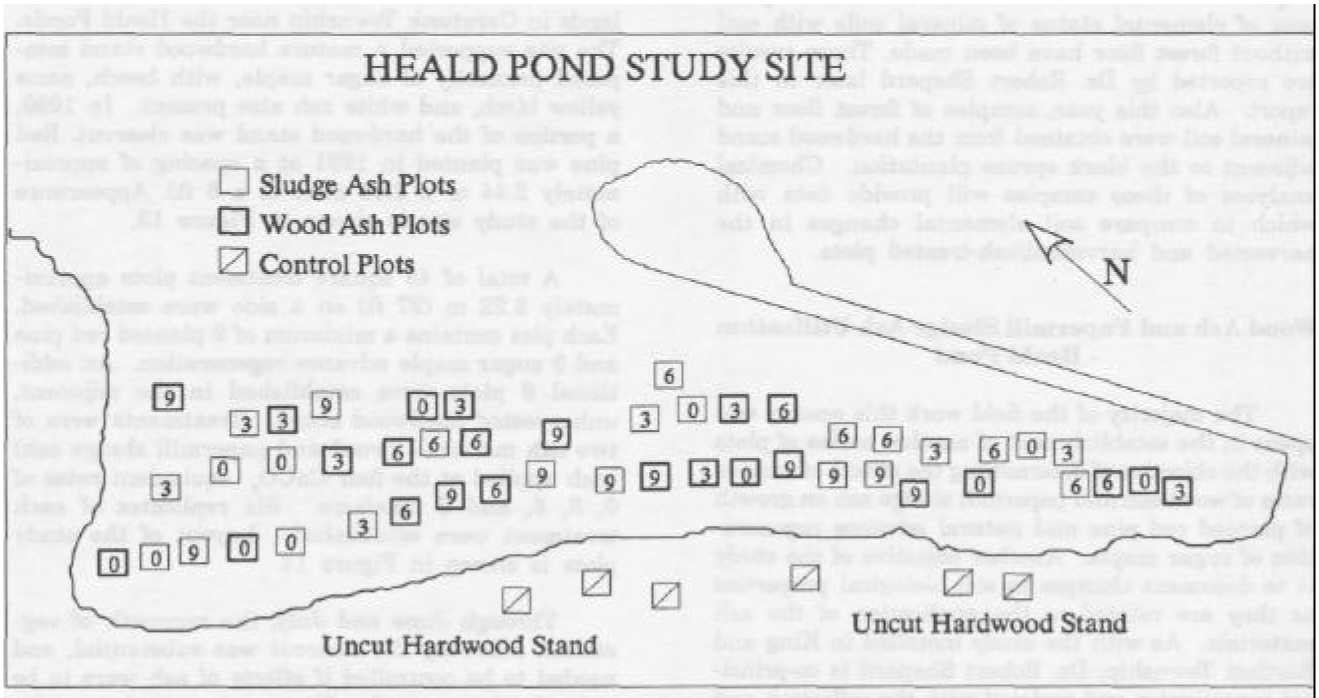

Figure 14. Layout of the Heald Pond study site, Caratunk Township, Maine.

in soil biota were to be investigated, control of competition with herbicides was not an option. In late July, each plot received a brush saw treatment to delay competition effects from unwanted vegetation (Fig. 15). It is expected that mechanical vegetation control will be required on an annual basis over the next several years.

Figure 15. Competition control with brush saws in the Heald Pond study site plots in late July, 1992. Compare the vegetation height here with that shown in Figure 13, taken in early June.

Pretreatment samples of forest floor and mineral soil were obtained in July, processed and submitted for elemental analysis. The papermill sludge ash was applied to the prepared plots during the last week in August, and the wood ash was applied during the first week in September (Fig. 16). The assistance of Carrie Tripp, Scott Paper Co., and Doreen Olson, Resource Conservation Services, Inc., in locating the study site and arranging for the delivery of the ash materials is greatly appreciated. The work of Assistant Scientist Ron Lemin, who helped during the application of the papermill sludge ash, is also gratefully acknowledged.

Microbiological studies of the papermill sludge ash and ash-treated soils have been initiated by Yaping Ren. Preliminary isolations to obtain relative population numbers of the various microbial groups (fungi, bacteria, actinomycetes) were conducted and will be summarized over the next several months (Fig. 17). The first post-treatment soil sampling was done in late October, and studies of microbial respiration, enzyme activities and population counts are currently underway. The microbiological work that she is conducting will continue though the next field season, and will form the basis of her M.S. thesis.

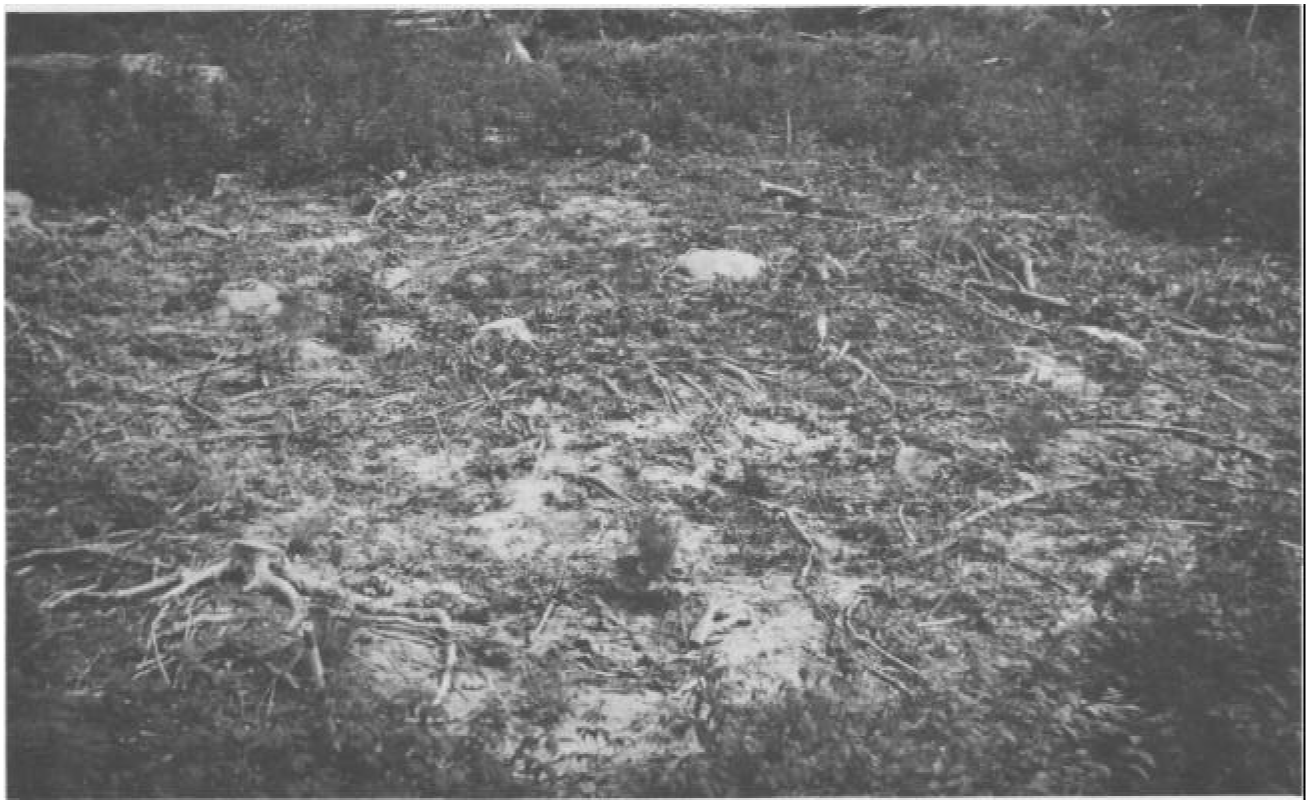

Figure 16. Appearance of wood ash applied to a plot at the rate of 9 tons/acre $CaCO_3$ equivalent, Caratunk Township, Maine.

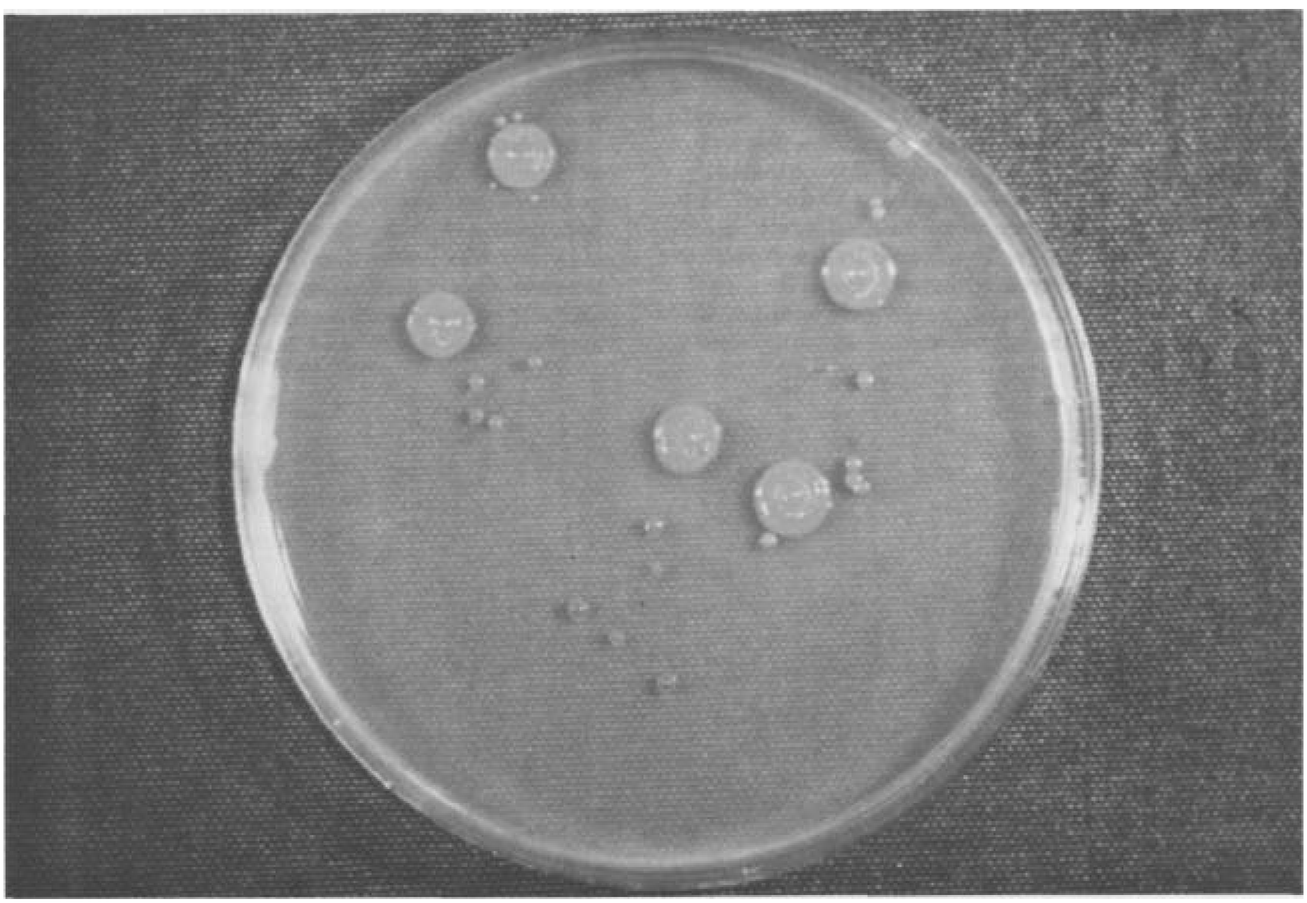

Figure 17. Bacterial colonies isolated from papermill sludge ash prior to application of the ash on a forested site.

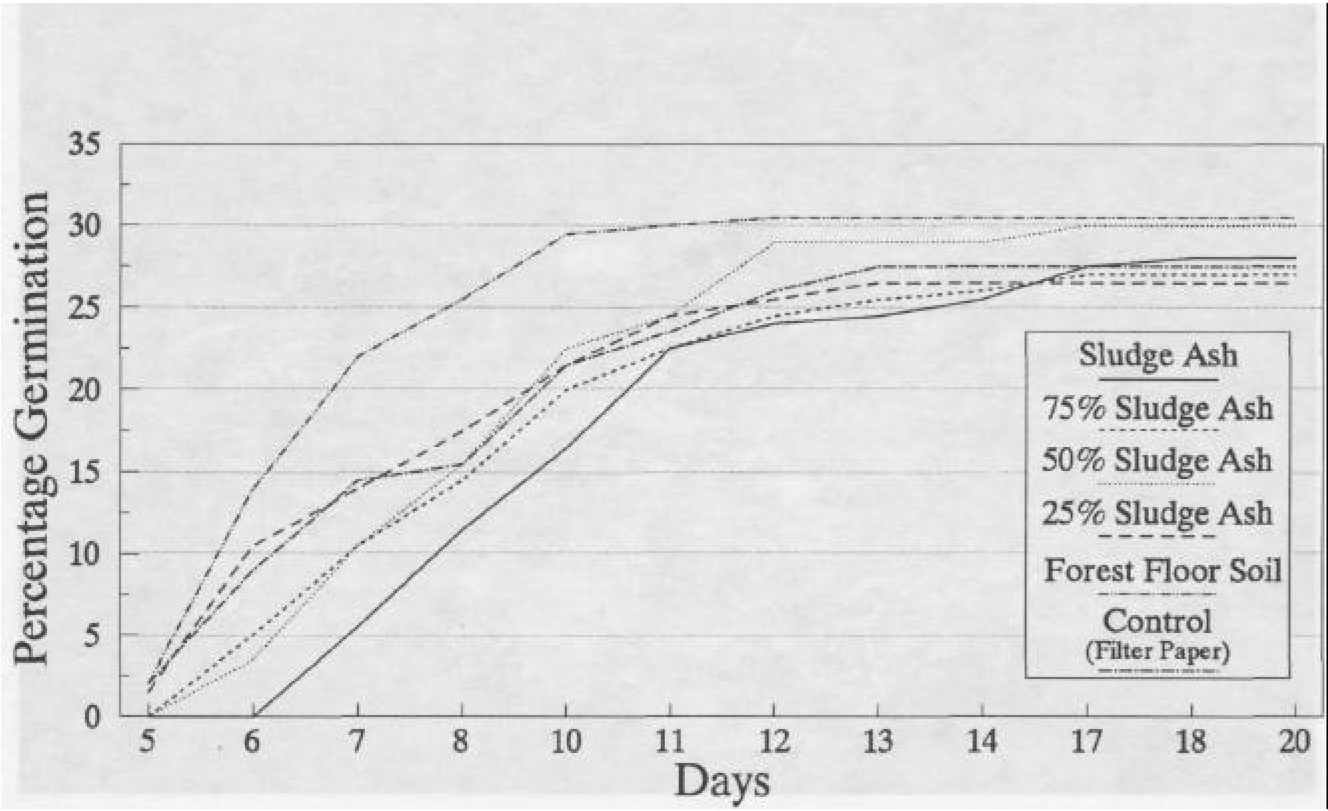

Figure 18. Germination of paper birch seed on ash-amended soils, native soil, and moist filter paper (control). Germination after 12 days was not significantly different for any of the treatments. Values are based on germination of fifty seeds per dish, with four replicate dishes per treatment.

In addition to the microbial studies, Ms. Ren has completed some preliminary work on effects of papermill sludge ash on hardwood seed germination. Paper birch seed germination has been evaluated on the ash substrate first, since it appeared likely that this species could be directly affected by the surface ash on operationally treated areas. Soil alone appears to allow for the most rapid germination of paper birch seed, although no significant difference in germination rate was apparent after 12 days of incubation (Fig. 18). The difference in the timing of germination is tentatively attributed to the better moisture conditions of the soil-alone treatment. We hypothesize that once the ash has absorbed adequate moisture, the seeds then germinate rapidly. Additional studies of seed germination on papermill sludge ash will be conducted over the next year with sugar maple, yellow birch, and black ash.

SITE QUALITY

Dr. Russell D. Briggs

Introduction

This year marks a turning point for the Site Quality program. Emphasis has shifted from conifers to hardwoods in evaluating relationships between soil-site properties and tree growth. Continued analysis of the conifer data collected from both unmanaged and managed stands is expected to result in the first draft of a field guide by summer 1993.

This year was the first full field season for the new study at the Weymouth Point (WP) watershed. The original study consisted of a 122-ac watershed clearcut in 1981 and an adjacent 178-ac control watershed which has been maintained as a mature spruce-fir forest. Stream and soil solution chemistry were monitored from 1979-1988 on both the uncut and clearcut (1981) watersheds by Drs. M.L. McCormack, Jr., and C.T. Smith. The current study is designed to evaluate differential impacts of precommercial thinning (PCT) on soil solution chemistry and crop tree growth across soil drainage classes. This project has provided the means to extend long-term monitoring of stream and soil solution chemistry. The well-documented biogeochemical history of the WP watershed was a primary factor contributing to our success in obtaining funding from the USDA GSRS to support this work.

The faculty grants program provided funding that will facilitate limited evaluation of recently delineated climatic zones (Briggs and Lemin 1992). This work is being carried out in cooperation with Dr. Ivan Fernandez as part of a project to determine the relationship between soil nutrient cycling rates and climatic variables.

Personnel involved with fieldwork include Ronald C. Lemin, Jr., Assistant Scientist; Brad Catling and Jeffery Dubis, graduate students; and Anthony Guay, undergraduate student. Daniel Gilmore completed his M.S. thesis "Soil-Site Relationships for European Larch *(Larix decidua* Miller) Plantations in Maine" and began a Ph.D. program under the direction of Dr. Robert Seymour. Joseph Pitcheralle accepted a position with Seven Islands Land Company and is preparing the second draft of his thesis "Relationship Between Balsam Fir Growth Response to Precommercial Thinning and Soil Chemical Properties." Completion is anticipated in early 1993.

Site Quality and Productivity

Spruce and Fir

Analysis of the effects of soil drainage class on response of balsam fir to PCT has been refined. The initial analysis was based on 218 balsam fir trees sampled in 1989 from 28 plots (Briggs and Lemin 1991). Inclusion of the data collected in 1990 doubled the sample size and improved the distribution of sample trees on the imperfectly drained plots.

Three-year post-PCT volume increment, expressed as a function of three-year pre-PCT volume increment, was significantly affected by soil drainage class (Fig. 19). Increasing the size of the database slightly increased the complexity of the analysis. For the well (WD) and moderately well drained (MWD) soils, the relationship between post- and pre-PCT volume increment was curvilinear. In contrast, the relationship was linear for the poorly (PD) and somewhat poorly drained (SPD) soils.

The differences in the response curve shapes between the imperfectly and better drained soils can be attributed to the range of the data. The data for the better drained soils were distributed along the entire range of the x axis (0-14 dm^3). Most of the data for trees growing on the imperfectly drained soils were largely confined to the smaller pre-PCT increments (0-8 dm^3) (Fig. 20). As a result, the quadratic term (which imparts the curvilinear shape) was significant only for the better drained soils. Consequently, the curve for SPD soils crosses that of MWD soils (Fig. 19). If more trees in the larger pre-PCT volume increments had been available for study on SPD soils, a quadratic term likely would have been included in the model and the SPD curve may not have crossed the MWD curve. Another possibility is that the trees with larger pre-PCT volume increments on SPD soils may have occupied microsites that were actually MWD (i.e., a hummock).

Analysis of the effects soil texture and chemical properties may have on the relationship between three-year post- and pre-PCT volume increment, given the effects of drainage class, is currently in progress.

European Larch

Volume equations and site index curves were developed from a sample of 101 trees selected from 12 plantations established between 1930 and 1982 throughout central Maine. Sample trees ranged from 3 to 21 in. dbh and from 18-110 ft in height. Equations to predict total (TVOB) and merchantable (MVOB = 4" minimum top diameter) volume outside bark in ft^3 are

$$TVOB = 0.146 + 0.002426 \times [Dbh^2 \times Hgt] \quad r^2 = 0.99$$

$$MVOB = -0.332 + 0.002400 \times [Dbh^2 \times Hgt] \quad r^2 = 0.98$$

where Dbh = diameter outside bark (in.) at 4.5 ft and Hgt = total height (ft).

The site index curves (base age 20 years) are provided in Figure 21. Below a bh age of 20 years, these curves projected the same height growth as those developed for southern New York and New England by Aird and Stone (1955). After bh age 20,

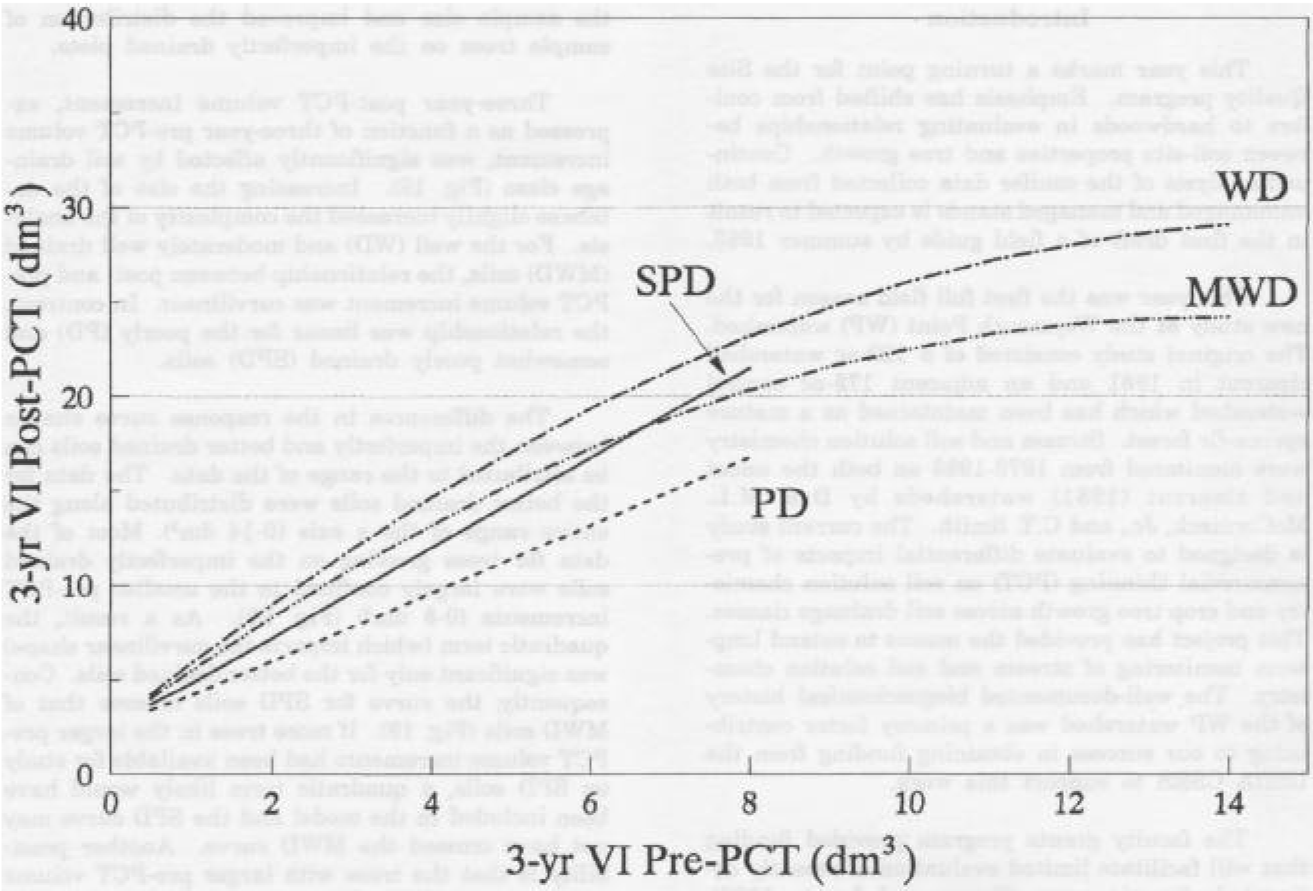

Figure 19. Effects of soil drainage class on the relationship between 3-year post- and 3-year pre-PCT volume increment (VI) for balsam fir.

our curves predicted increasingly greater growth and show a 6-12-ft superiority in height at a bh age of 50. This work is documented in greater detail in an article scheduled for publication in the Northern Journal of Applied Forestry in early 1993.

Stepwise regression and stepwise discriminant analysis were used to quantify the relationship between site index and soil-site variables. The best regression equation, which selected solum thickness, B-horizon clay content, exchangeable acidity and potassium, only accounted for 53% of the variability in site index. This relatively low precision is consistent with results from soil-site studies for other species (Parsonage 1989; Monserud et al. 1990; Steinman 1992).

Classification rules developed using discriminant analyses to predict membership into SI_{20} categories provided better results than stepwise regression. Although the sole discriminator, solum thickness, correctly classified sites having poor potential (avg. SI^ = 48 ft) 88% of the time, good sites (avg. SI_M = 58 ft) were misclassified as poor sites 45% of the time. When B horizon chemical variables were used in combination with solum thickness, the misclassification rate was reduced substantially. Nineteen percent of good sites were misclassified as poor sites, and 14% of poor sites misclassified as good sites.

In contrast to a previous study in New York (Aird and Stone 1955), soil drainage class was found to have no significant effect on the rate of early height growth or site index for European larch in Maine. However, we do not advocate the establishment of European larch plantations on poorly drained sites. These poorly drained plots were small areas surrounded by better drained soils and are not representative of the extensive areas of poorly drained upland soils that commonly occur in the state. In addition, limited sample size, and other factors (e.g., genetic variability, planting techniques, early competition) for which no information was available may have had an influence on these results. Adjacent to one of our study sites classified as poorly drained, we observed mortality from the eastern larch beetle, a possible indication of poor tree vigor or stress.

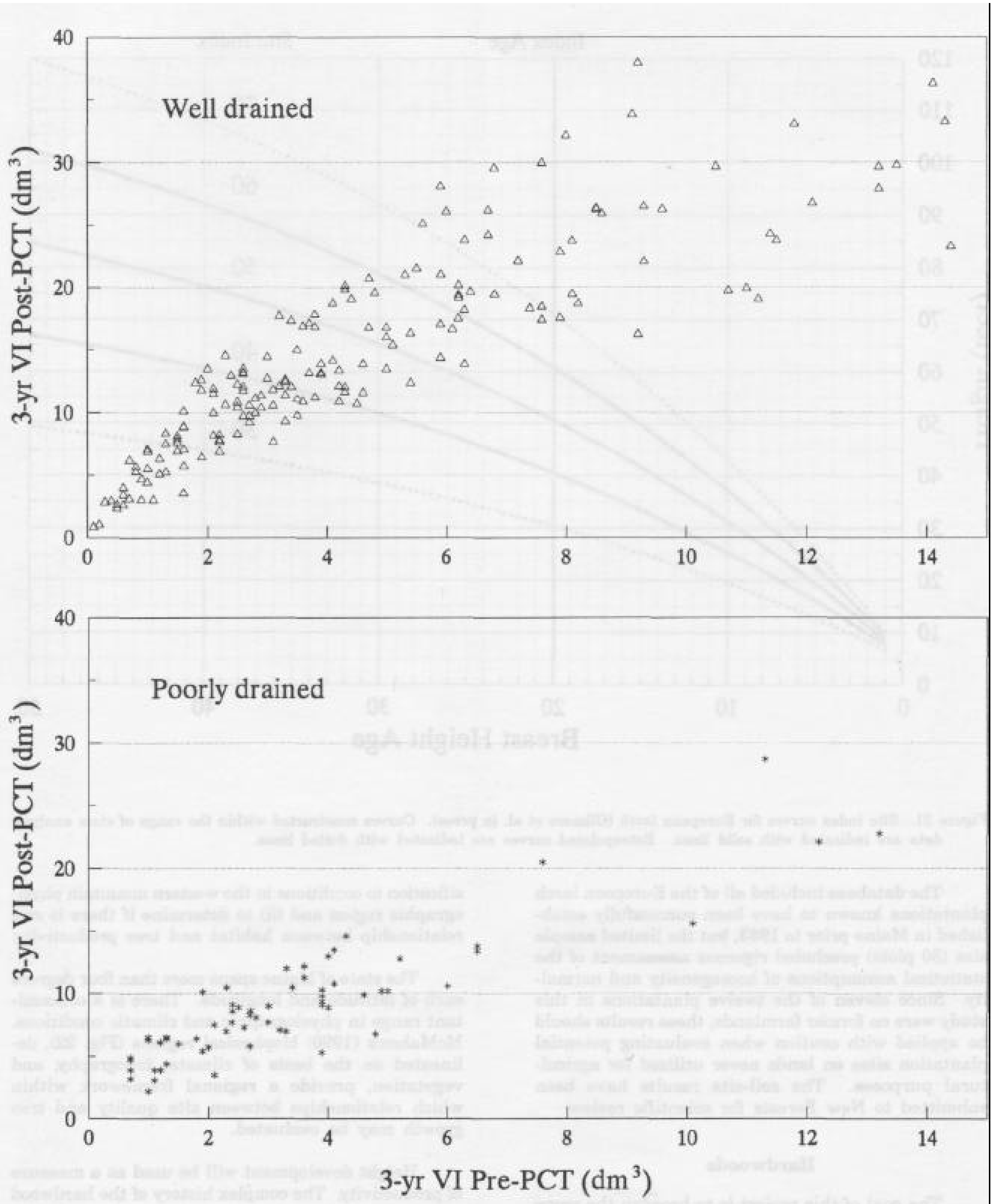

Figure 20. Plot of the data used to model the relationship between post- and pre-PCT volume increment for balsam fir growing on well drained soils (above) and poorly drained soils (below).

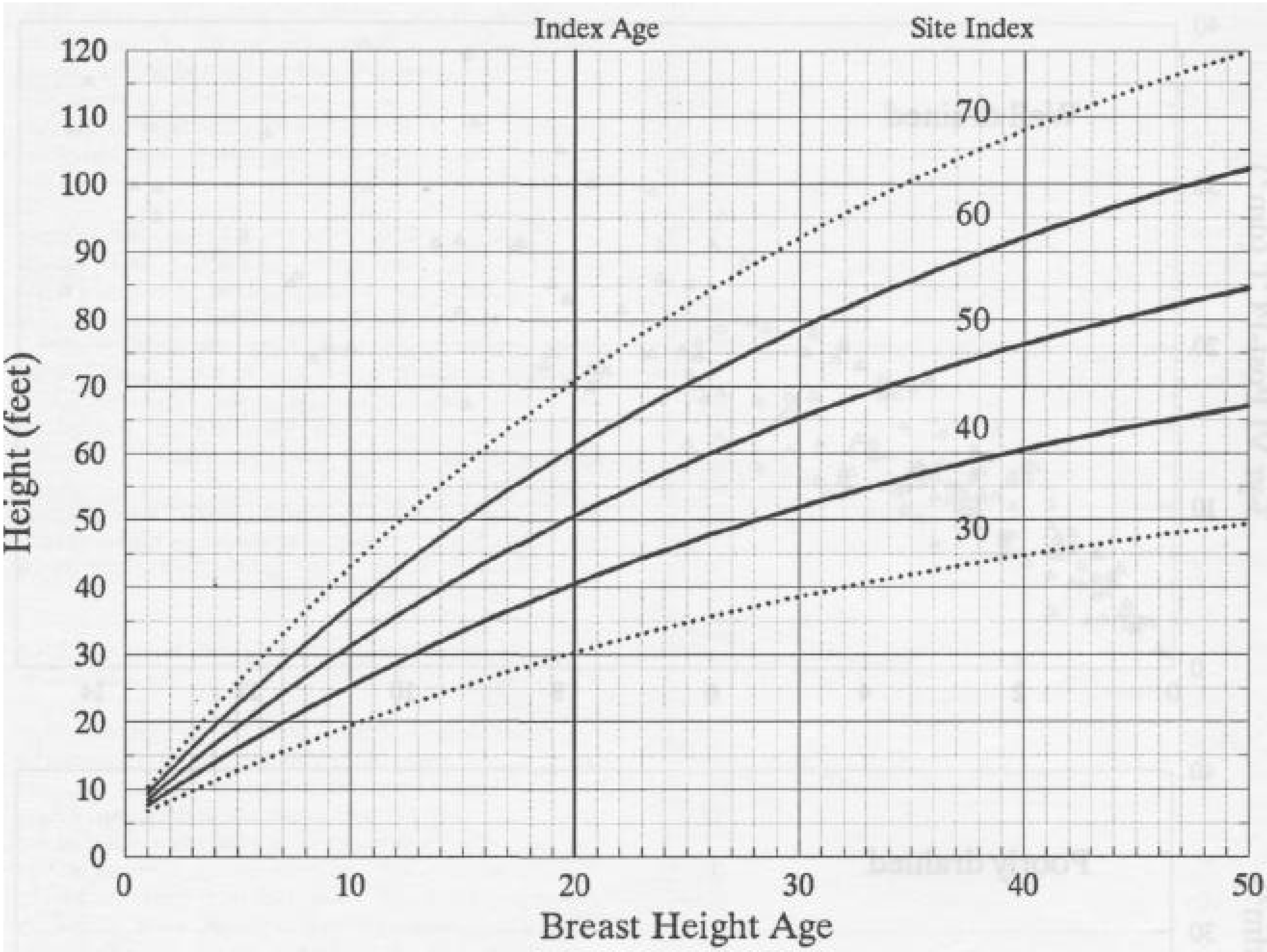

Figure 21. Site index curves for European larch (Gilmore et al. in press). Curves constructed within the range of stem analysis data are indicated with solid lines. Extrapolated curves are indicated with dotted lines.

The database included all of the European larch plantations known to have been successfully established in Maine prior to 1983, but the limited sample size (30 plots) precluded rigorous assessment of the statistical assumptions of homogeneity and normality. Since eleven of the twelve plantations in this study were on former farmlands, these results should be applied with caution when evaluating potential plantation sites on lands never utilized for agricultural purposes. The soil-site results have been submitted to New Forests for scientific review.

Hardwoods

The goal of this project is to broaden the scope of the productivity-oriented site classification system beyond spruce and fir to the hardwoods. The objectives for the first phase of the project are (i) to assess the applicability of Leak's (1982) habitat classification to conditions in the western mountain physiographic region and (ii) to determine if there is any relationship between habitat and tree productivity.

The state of Maine spans more than four degrees each of latitude and longitude. There is a concomitant range in physiographic and climatic conditions. McMahon's (1990) biophysical regions (Fig. 22), delineated on the basis of climate, topography, and vegetation, provide a regional framework within which relationships between site quality and tree growth may be evaluated.

Height development will be used as a measure of productivity. The complex history of the hardwood stands in Maine, which includes multiple entries ranging in intensity from light thinning to group selection, precludes the use of radial or volume increments as measures of productivity.

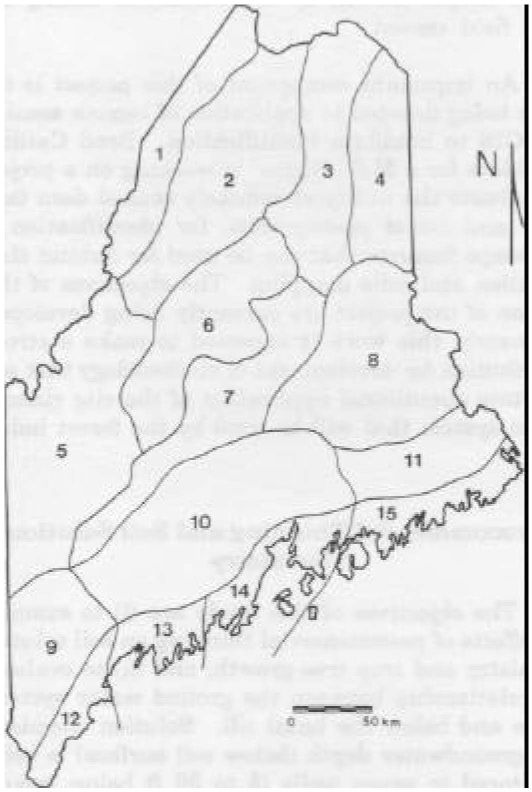

Figure 22. McMahon's (1990) biophysical regions for Maine. The western mountain region is designated by the number 5.

Designing a retrospective study to elucidate relationships between site quality and hardwood productivity presents a challenge far beyond that posed by conifers. The pure, even-aged, unmanaged spruce-fir stands together with the intensively managed younger spruce-fir stands that formed the basis for a large portion of conifer soil-site work are simple (relative to the hardwoods). Furthermore, the unmanaged, pure, even-aged conifer stands tend to be restricted to the lower third of the spectrum of site quality. Hardwood stands, in contrast, generally occupy land encompassing a wide range in site quality and are comprised of multiple species spanning the spectrum of shade tolerance. As noted previously, the complex history of the hardwood stands adds an additional dimension to the problem.

Leak's (1982) system of habitat classification provides an initial framework for grouping sites according to soil characteristics within a biophysical region. A habitat is defined as a small unit of land, from a few acres up to a few hundred acres in size, with a given type of soil material (reflecting a given glacial process), landform and surface condition, and forest vegetation (climax-successional sequence). If the variability in productivity within habitats is less than that between habitats, they could serve as useful landscape units for assessing productivity. Alternatively, if the variability within is greater than the variability between, the utility of the habitat classification system would be limited to site stratification. Evaluation of the relationship between productivity and site quality often meets with greater success when the study populations are stratified (Carmean 1975).

During the summer of 1992, 83 one-fifth-ac plots were systematically established along 12 transects in the western mountain biophysical region (Table 1). The western biophysical region was chosen due to its similarity with physiographic features of the White Mountains, where the habitat classification was developed. Recognizing the impossibility of locating undisturbed hardwood stands, the initial criteria for study area selection were

1. Opportunity to extend transect from plateau top (or hardwood-conifer border on higher moun tains) to lower slope (preferably along more than one aspect), and

2. Closed canopy stands that have not been entered for harvest within the past 20 years.

Elevation was measured to the nearest 10 ft using a hand-held altimeter calibrated at a nearby pond or lake. Dbh was tallied by species for each tree on the plot. Two dominant or codominant stems for each species present on a plot were selected for the following measurements: radial increment (increment core) at bh, total and merchantable height (Fig. 23). Seedlings and saplings were tallied by species in 1-in. dbh classes along a six-foot-wide strip extending across the plot through the plot center. Herbaceous vegetation was recorded by percent cover classes for each species.

In order to assess the variability in soil conditions, three soil pits were excavated in each plot. A main pit was located near the plot center, and two

Table 1. Location of sample plots established in western Maine during the 1992 field season.

Township	No. of Transects	No. of Plots
Adamstown	1	4
Township C C	1	10 7
Surplus	1	24
Lynchtown	3	13 8
Parmachenee	3	8 9
Bigelow/Wyman	1	
Carrying Place	1	
Dead River	1	
	12	**83**
Total		

Figure 23. Jeff Dubis measuring dbh at a sample plot in Parmachenee township.

satellite pits were located along the contour near the plot extremities. Horizon thicknesses, depths to mottling and root-restricting layers were measured for each of the three pits. Samples were taken from the lower B horizon and returned to the laboratory for textural analysis. Habitat, soil drainage class, coarse fragment content, slope shape, and slope position were also recorded.

Stand data collected during the field season are currently being summarized. Soil samples are being prepared for textural analysis by the pipette method; oxidation of the organic matter in the lower Bs horizons is expected to require approximately two months. The distribution of sample plots by drainage class and habitat type is summarized (Table 2).

Following analysis of the data, a subset of those plots will be designated for measurement of sugar maple height growth by stem analysis during the 1993 field season.

An important component of this project is the effort being devoted to application of remote sensing and GIS to landform identification. Brad Catling, candidate for a M.S. degree, is working on a project to evaluate the utility of remotely sensed data (satellite and aerial photographs) for identification of landscape features that can be used for habitat classification and soils mapping. The objectives of this portion of the project are currently being developed. Ultimately, this work is expected to make a strong contribution for "development of methodology that will facilitate operational application of the site classification system that will be used by the forest industry.

Precommercial Thinning and Soil Solution Chemistry

The objectives of this study are (i) to examine the effects of precommercial thinning on soil solution chemistry and crop tree growth; and (ii) to evaluate the relationship between the ground water systems above and below the basal till. Solution chemistry and groundwater depth (below soil surface) is being monitored in seven wells (8 to 30 ft below ground surface) (Fig. 24). Streams passing through the control and clearcut watersheds are also being sampled for solution chemistry.

Soil solution is being extracted for chemical analysis on 27 plots (32.8 x 32.8 ft) located across the clearcut watershed. The current study consists of three treatments (control, PCT, PCT + fertilization) replicated 3, 4, and 2 times, on poorly drained (PD), somewhat poorly drained (SPD), and moderately well drained (MWD) soils, respectively. PCT treatments were applied in October 1991 and fertilizer treatments will be applied following snow melt in the spring of 1993. Soil solution samples continue to be collected from three lysimeters installed at two depths (25 cm and 50 cm) on each of the SPD and MWD plots. Lysimeters on the PD

Table 2. Distribution of sample plots by drainage class and habitat.

Habitat	No. of Plots	Drainage Class	No. of Plots
Poorly Drained Wet compact	4 6 till	Excessively Well	2
till Dry compact + dry	51 6 3	Moderately well	26
cemented Enriched Sandy	13	Somewhat poorly	33
sediment Shallow to bedrock		Poorly	12
			10

Figure 24. Russell Briggs withdraws a sample of groundwater from well no. 6, 6 ft in the basal till.

plots were installed only at 25 cm below the soil surface due to the shallow depth to basal till.

The collection schedule for solution chemistry samples is provided in Table 3. Deep well and stream samples have been collected monthly (with the exception of February and March) since study installation in August 1991. Soil solutions could not be collected from lysimeters during the period December 1991 to April 1992, due to freezing. The lysimeters located on the control plots did not thaw out until the middle of May 1992, almost two weeks later than those located on treated (PCT) plots.

Table 3. Dates for collection of samples at Weymouth Point Watershed for laboratory analyses.

Sampling Date	Solution Source		
	Soil	Streams	Wells
9/24/91	X	X	X
10/15/91	X	X	X
11/21/91		X	X
1/8/92		X	X
4/16/92		X	X
5/11/92	X	X	X
6/4/92	X	X	X
6/30/92	X	X	X
7/22/92	X	X	X
9/4/92	X	X	X
10/23/92	X	X	X

All of the laboratory analyses, with the exception of sulfate and chloride, have been completed and are in the process of being analyzed.

Verification of Climatic Zones

Four transects, three of which each span two climate zones delineated by Briggs and Lemin (1992), were established across the climatic gradient in Maine (Fig. 25). Stand criteria for plot location were closed canopy hardwood stands having a red maple component growing on well and moderately well drained glacial till soils. Red maple was chosen because of its presence throughout the entire state.

This study is being carried out in cooperation with Dr. Ivan Fernandez to study the relationship between climatic variables and rates of nutrient cycling in soils. Four sets of three plots will be located

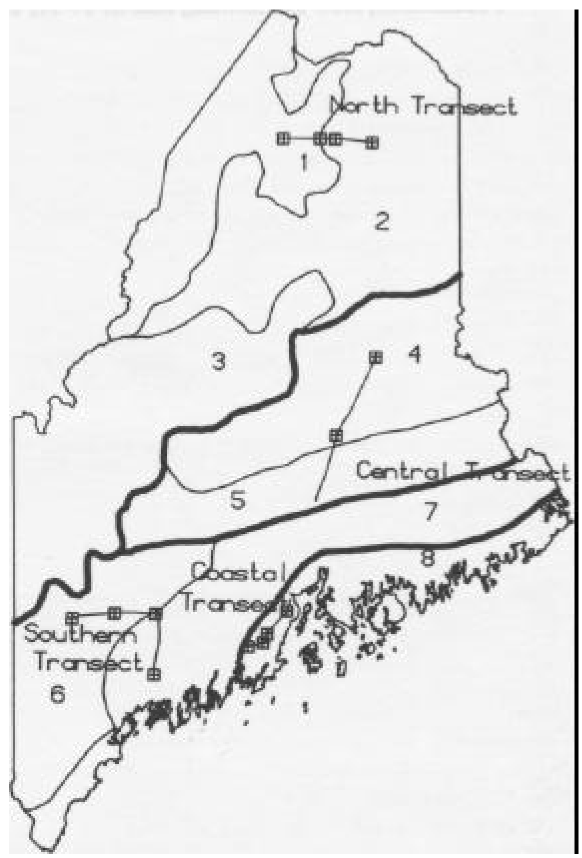

Figure 25. Location of the four transects spanning climate regions across Maine.

along each transect. Rates of organic matter decomposition, nitrogen mineralization, and CO_2 evolution will be monitored by Dr. Fernandez. The site quality program will be measuring soil and air temperatures, as well as precipitation during the growing season, at the two ends of each transect (eight locations) using data loggers. These data should provide us with verification of the recently delineated climatic zones. Combined analysis of the data is expected to facilitate development of a model relating nutrient cycling rates to temperature and precipitation.

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TREE IMPROVEMENT

Dr. Michael S. Greenwood, Throstur Eysteinsson, and Hugo Volkaert

Flowering and Seed Production

A flowering stimulation study, utilizing stem injections of GA^, was initiated in spring of 1991 on European and Japanese larches that had not responded to earlier stimulating treatments using foliar GA^, applications. Fifty mg of GA^ in 10 ml of 95% ethanol was injected in the stem of one ramet of each clone. Another ramet of each clone was used as a control and received an injection of 10 ml of 95% ethanol.

GA^-treated ramets produced over 3 times more seed cones than the control ramets, consistent for all 5 European larch clones and 4 out of 5 Japanese larch clones. The fifth Japanese larch clone flowered abundantly with or without GA^ treatment. Estimation of the number of pollen cones indicated that most, if not all, GA^-treated ramets produced more cones than untreated ramets.

Progeny Testing

A progeny test of intra- and inter-specific *Larix* crosses was established in May 1992 (Table 4). The crosses were made in the spring of 1991 in the greenhouse and have been described earlier (Greenwood and Eysteinsson 1991). The seed was harvested in the fall of 1991, stratified and germinated in Leach tubes in February 1992. The seedlings were grown in the greenhouse with supplemental lighting from March to the end of April. They were subsequently moved outdoors for a few weeks. The planting was done from the third week of May until the second week of June.

The planting site is a clearcut area (1990) on Scott Paper Company land in Johnson Mountain Township (T2R6) on a site formerly occupied by hardwoods. Herbicide treatment of the site was done in the fall of 1991. The test location is representative of high site index spruce-fir forest and is located on a ridge top.

The plantation consists of ten blocks each containing a three-tree row of each of 52 families: 49 experimental crosses and 3 checklots.

Mortality assessments done one month after planting and again in the fall indicated that most of the mortality was due to an abnormally dry period right after planting.

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Greenwood, M.S. and T. Eysteinsson. 1991. Tree Improvement, pp. 24-25. *In:* 1991 Annual Report of the Cooperative Forestry Research Unit. Maine Agric. Expt. Sta. Misc. Rept. 365. 42 pp.

Table 4. Larch crosses planted at Johnson Mountain in Spring 1992, and mortality in Fall 1992.

Cross[1]	Number of Families	Number of Trees	Mortality Fall, 1992	
			Number	Percent
TxT	9	270	8	3.0
ExE	7	210	11	5.2
JxJ	7	210	20	9.5
ExJ	8	239	12	5.0
JxE	9	263	47	17.9
TxE	6	180	12	6.7
ExT	1[2]	30	4	13.3
TxJ	2[3]	55	8	14.5
JxT	0	0	—	—
Subtotal	49	1457	122	8.4
Checklots	3	90	3	3.3
Total	52	1547	125	8.1

T = tamarack; E = European larch; J = Japanese larch A mixture of different full-sib families. [3] Each "family" is a mixture of full-sib families from the same seed parent.

TREE IMPROVEMENT

Dr. Katherine K. Carter

Introduction

Two older genetic test plantations, established in 1976 and 1977, were remeasured in preparation for thinning this year. Both plantations, one each of balsam fir and exotic larch, have reached a size at which commercial thinning could be carried out. Data for diameter growth and volume for each test plantation are presented in the following paragraphs.

Balsam Fir

This 1976 plantation is a half-sib family test of balsam fir from New England, consisting of progeny from balsam fir parent trees selected for volume production during the 1960s and 1970s by the Spruce-Fir committee, with some additional Christmas tree selections from Nova Scotia.

Bareroot seedlings (2-2 stock) were planted in 1976 on an old field site near Dover-Foxcroft, on a 6x6-foot spacing. A portion of the plantation was thinned for Christmas trees at age 8, leaving the remaining trees to grow on a 6xl2-foot spacing. After 16 years in the field, the average dbh of trees at the closer spacing was 4.8 in., and average dbh at the wider spacing was 5.5 in. The plantation as a whole is estimated to have an average volume of 16 cords/acre, or an average yearly volume growth of 1.0 cord/acre/year.

There are also significant differences in dbh among the various families in this plantation (Table 5). The largest average dbh is 5.9 in. for family 32 from Bradley, Maine. Even though balsam fir is not often used for the establishment of forest plantations, this test demonstrates that it is capable of rapid early growth and good volume production. Differences among families indicate that selection for increased growth rate could be successful.

Larches

This plantation was established on a 7xl4-foot spacing using 1-year-old containerized stock in 1977, and planted on a good-quality old field site near Milo, Maine. Several separate seedlots (provenances) represented each of the following species: European larch, Japanese larch, and European x Japanese hybrid larch. After 15 years, hybrid larch had the

Table 5. Average dbh for 16-year-old half-sib families in a balsam fir plantation near Dover-Foxcroft, Maine.

UM Family #	1992 Dbh (inches)	Origin
5	5.4	Ammonoosuc R.D., NH
7	5.3	Ammonoosuc R.D., NH
7v	4.3	Folly Lake, NS
8	5.3	Ammonoosuc R.D.. NH
8v	4.4	Folly Lake, NS
9	5.1	Androscoggin R.D., NH
10	5.3	Androscoggin R.D., NH
lOv	4.6	Lynn Mtn., NS
llv	4.3	Lynn Mtn., NS
12	5.4	Weston, VT
12v	2.6	Cape Breton, NS
32	5.9	Bradley, ME
33	5.7	Calais, VT
35	4.6	T6 R8, ME
38	5.5	Eustis, ME
53	4.4	T4 R18, ME
61	4.8	Albany, NH
70	4.9	Milton Twp., ME
74	4.8	Old Town, ME
77	4.6	T12 R14, ME
79	5.4	Til R14, ME
81	4.4	T6 R19, ME

largest dbh (8.2 in.), followed by European larch (6.7 in.) and Japanese larch (6.4 in.). Volume production for the plantation as a whole was approximately 1.6 cords/acre/year through age 15. Unextracted wood specific gravity was also tested for 5 seedlots of each species. There were differences in average specific gravity among the various seedlots, although the means for each species were similar (Table 6).

Table 6. Average height, dbh, and wood specific gravity for 15-year-old seedlots of European larch, Japanese larch, and hybrid larch growing near Milo, Maine.

Species and Seedlot #	Height (ft)	Dbh (in.)	Sp. grav.
European			
400	41	6.4	0.39
407	43	6.0	0.39
408	50	7.6	
409	44	6.9	
410	46	7.1	
411	41	6.2	
635	44	6.7	0.36
636	42	6.4	
637	45	6.8	
641	48	7.0	0.36
647	43	7.1	0.40
European mean:	**44**	**6.7**	**0.38**
Hybrid			
638	49 41	8.7 8.0	0.38
640	47 53	8.4 8.8	0.37
643	47	7.4	0.40
645			0.38
646	47	**8.2**	0.40
Hybrid mean:			**0.38**
	44 39	6.9 6.3	
Japanese	42 40	6.6 5.4	
401	39 40	6.0 6.6	0.37
402	41 37	6.5 5.1	
403	41 38	7.2 6.1	
404	39 39	6.4 5.9	
405	43 38	6.4 6.6	
406	44 41	7.6 6.2	0.36
413	46 44	7.3 6.4	
414	44 42	6.9 6.2	
415			0.37
416	**41**	**6.4**	
417			0.39
418			
419			
420			0.37
421			
422			
423			
639			
642			
644			
Japanese mean:			**0.37**

GROWTH AND YIELD

Dr. Robert S. Seymour

Growth and Yield Prediction of Managed Northern Conifer Forests

During the fall semester, 1991, I spent a sabbatical leave working with Dr. Kenneth Mitchell and his colleagues of the British Columbia Ministry of Forests, Forest Productivity Group, learning to use their outstanding system of growth prediction models and studying the potential application to Maine conifers. Two models were acquired: the powerful Tree and Stand Simulator (TASS), a distance-dependent simulation model that has been formulated for the six major conifer species of B.C.; and The Interpolation Program for Stand Yields (TIPSY), a very flexible and compact program that uses TASS results to generate custom yield tables for any silvicultural regime. These will be used as the software platforms for my new program to develop growth equations for Maine conifer species, funded jointly by CFRU and the Maine Agricultural Experiment Station with Mclntire-Stennis funds.

Field work to develop the basic database for this modelling effort began during summer of 1992. Daniel Gilmore, a recent M.S. graduate working on European larch site index and volume equations, began Ph.D. studies on this project under my direction. Several permanent plots were established and measured, and a highly detailed stem analysis and crown dissection was completed on 11 balsam fir trees for the purpose of developing equations to modify TASS. Field procedures were reviewed for the cooperators during the summer field meeting at the Penobscot Experimental Forest, where much of the research is being carried out.

Wood Supply Analysis

Modifications of the ForMAINE wood supply model (Version 2.0) were completed, and a User's Manual was published as Information Report 30. In addition to simulating partial cutting, the model now has the added capability to formulate harvest strategies based on area regulation as well as volume regulation, in any combination over time. This important addition makes the model extremely flexible in its ability to replicate virtually any "real-world" harvest scenario.

Sensitivity analyses of the previously completed timber supply projections for Maine were completed in 1991, and a final internal report was submitted to the Maine Department of Conservation. A bulletin describing the 136 empirical yield curves used in this statewide analysis was also completed in 1991 and published as CFRU Research Bulletin 8. This work brings to a close my research effort on this subject within CFRU, and allows me to place a new emphasis on growth prediction of managed conifer stands.

Stand Development

Former Ph.D. students Xiandong Meng and Mary Ann Fajvan have completed their dissertations, and publications are in various stages of completion. Meng"s results on stand development and biomass production of young spruce-fir stands as influenced by drainage class were published as listed in the publication section of the annual report. A second manuscript on the subject of drainage-induced vegetation differences in herbicide-released stands is in review by New Forests. In April 1992, Dr. Fajvan accepted the position of Assistant Professor of Silviculture at West Virginia University. Two publications from her dissertation (submitted to the Canadian Journal of Forest Research and Forest Science) on the subject of stand development and productivity of mixed pine-spruce-hemlock stands are currently under revision.

Review Articles

Dr. Malcolm Hunter, Jr. and I were invited to present a review of "New Forestry" in eastern spruce-fir forests at the 1991 National Convention of the Society of American Foresters, Forest Ecology Working Group. This review was enlarged and subsequently published through the Maine Agricultural Experiment Station and distributed to all CFRU Cooperators. This discussion paper outlines some principles and the rationale associated with New Forestry in our region, then outlines silvicultural and landscape-level practices that would be expanded under New-Forestry-type management. The concept of a land allocation "triad" is proposed, in which ecological reserves, high-yield production forestry, and New Forestry would co-exist throughout the northern forest region.

A comprehensive review of natural disturbance patterns and silvicultural practices in Maine's spruce-fir forests, presented originally at the retirement symposium of David M. Smith at Yale University in 1990, was published as part of a book on the Ecology and Silviculture of Mixed-species Forests. This paper includes an extensive review of historical literature on the original, presettlement condition of the red spruce forest, and discusses how this forest has changed through more than a century of harvesting and management activities.

SLUDGE AND ASH

Dr. Robert K. Shepard, Jr.

Introduction

This report presents results from two studies in which a pronounced effect of the residual(s) on seedling growth and foliar nutrient concentrations has occurred. Also included are pretreatment soils data from one study showing differences between disturbed and undisturbed areas. Some of the work in which I am involved is being done cooperatively with Dr. Ostrofsky. Several studies have reached the state of completion at which sampling will be done every other year rather than every year.

Study 1

Overview

This study was started in October 1987, on land owned by Great Northern Paper. One hundred eight plots were established in a clearcut planted to black spruce in April 1986. Plots were treated with a combination of papermill secondary sludge (20% dry weight) and wood ash (80% dry weight). Application of materials to plots was by hand. Treatments consisted of four application rates (0, 2.4, 4.8, and 9.6 dry tons per acre), three application times (late May, late July, and late September), and one, two, or three years in succession. In this report, treatment rates are designated 0, 1, 2, and 3, which correspond to 0, 2.4, 4.8, and 9.6 dry tons per acre. The root collar diameter and height of all seedlings were measured before the treatments were applied and after each growing season through 1991. Foliage samples were taken after the 1988, 1989, 1990, and 1991 growing seasons. The 1991 growing season measurements were not made until May 1992, and are not included in the results presented here.

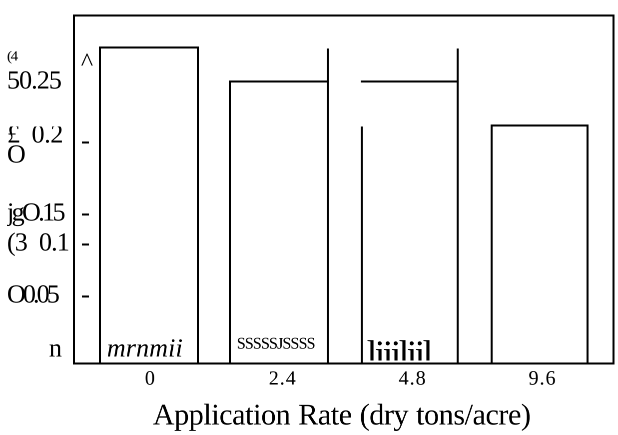

Figure 26. Three-year (1988 through 1990) root collar cross-section growth of black spruce seedlings treated with a combination of papermill secondary sludge and wood ash at four rates.

Root Collar Growth

The first significant ($P < 0.05$) treatment effect on root collar cross-section growth occurred during the 1989 growing season, and was a decrease relative to growth of the rate 0 plots. The only significant treatment was application rate. A similar trend occurred in 1990 and for the 3-year period 1988 through 1990 (Fig. 26). As in 1989, the time of application and the number of years of application were not significant for either 1990 or the 1988 through 1990 period. It is not possible to state whether other treatment effects will materialize in the future.

The reduced growth of seedlings in the plots to which the material was applied is attributed to more intense competition from herbaceous vegetation, growth of which was dramatically stimulated by the sludge-ash treatment. Although there was *a* significant reduction in root collar growth, the mean 3-year difference between the rate 0 plots and the rate 3 plots was only 0.15 in. diameter. In practical terms, this is inconsequential.

Foliar Nutrient Concentrations

The most pronounced effects on foliar nutrient concentrations occurred for those elements whose availability for uptake is a function of soil pH. This is evident for foliar concentrations of aluminum (Fig. 27) and manganese (Fig. 28), both of which decreased significantly ($P \leq 0.05$) with increasing application rate. This would be expected because uptake of these elements decreases as soil pH rises, and the data indicate an increase, although relatively small, in soil pH with increasing residual application rate. Concentrations in foliage from seedlings from the

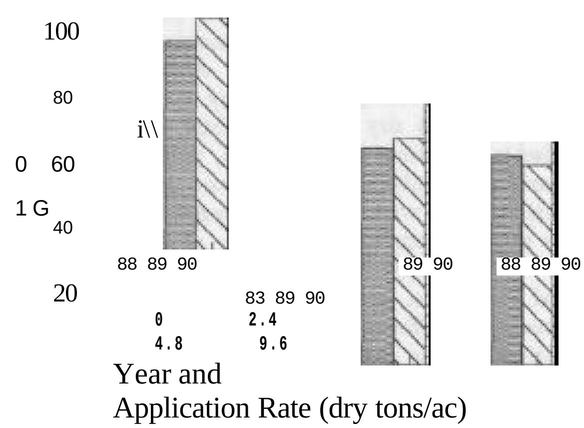

Figure 27. Concentrations of aluminum in current year foliage of black spruce seedlings treated with a combination of papermill secondary sludge and wood ash at four rates.

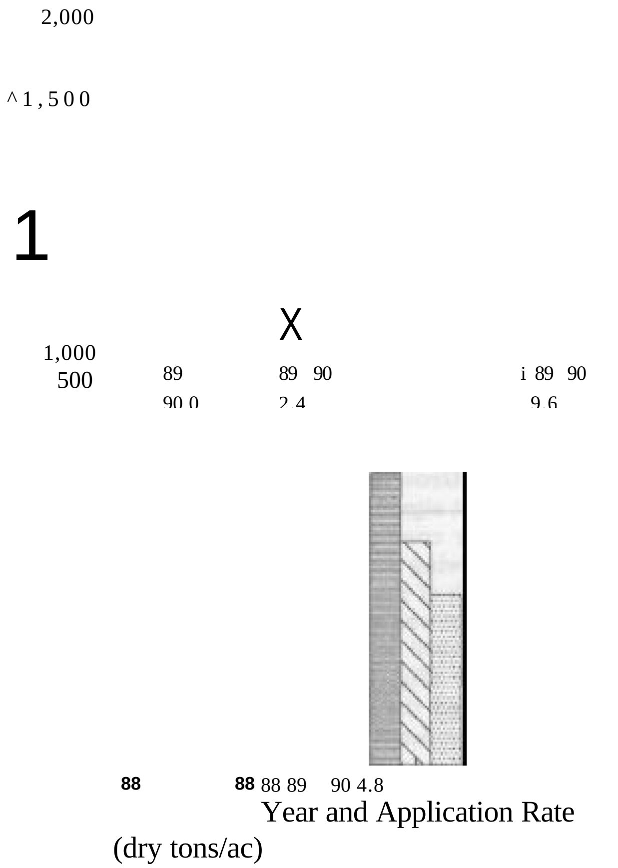

Figure 28. Concentrations of manganese in current year foliage of black spruce seedlings treated with a combination of papermill secondary sludge and wood ash at four rates.

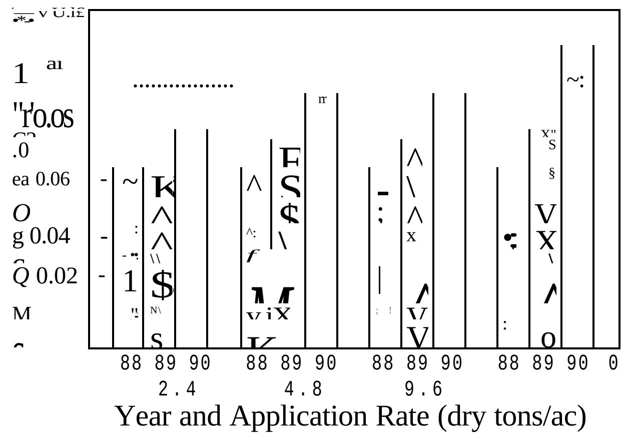

Figure 29. Concentrations of magnesium in current year foliage of black spruce seedlings treated with a combination of papermill secondary sludge and wood ash at four rates.

rates 1, 2, and 3 plots displayed a gradual decrease over time relative to seedlings from the rate 0 plots. There is a trend toward lower concentrations at higher rates.

All elements exhibited rather large fluctuations in concentration from year to year. The concentrations of most nutrients were generally not limiting to growth, based on established criteria for black spruce. The possible exception was magnesium, which exhibited highly significant ($P < 0.01$) elevated levels in foliage from treated plots (Fig. 29).

Study 2

Overview

A mixture of primary (80% dry weight) and secondary (20% dry weight) papermill sludge was applied to a clearcut in Township E in western Maine, in early September 1989. Although the target application rate was 20 dry tons per acre, actual rates ranged from 0 to slightly over 100 dry tons per acre. Dr. Charles Kraske, presently with International Paper Co., established plots in this clearcut to study the effects of clearcutting and sludge application on the chemistry of the soil and the soil solution.

To assess possible effects of sludge on growth of planted red pine seedlings, individual seedlings were selected in May 1990 for subsequent stem diameter and height measurements. The seedlings were divided into two groups, untreated and treated. There were approximately 90 seedlings in each group. Treated seedlings were further subdivided into three groups based on the application rate immediately around the seedlings. These application rates were

< 15 dry tons per acre, >. 15 < 30 dry tons per acre, and > 30 dry tons per acre. These rates were estimated based upon the appearances of the sludge on Dr. Kraske's plots and his information on sludge application rates to his plots. Stem diameter at 1 ft above the ground and total height of all seedlings were measured when the seedlings were selected, and after the 1990, 1991, and 1992 growing seasons. Samples of current year foliage were taken from 10 seedlings in each application rate category after the 1990, 1991, and 1992 growing seasons.

Stem Diameter Growth

The pattern of stem diameter growth observed in this study (Fig. 5) is similar to that in the previous study, a decrease in growth with increasing application rate. Three-year (1990 through 1992) growth of seedlings at the maximum rate was 0.37 in. less than growth of the controls, which was significant ($P < 0.01$) Also, as in the previous study, the growth reduction appears to result from increased competition, primarily from raspberry. Although the amount of raspberry was not quantified, it was readily apparent that a close relationship existed between the amount of raspberry surrounding a seedling and the weight of sludge received by the seedling. Seedling mortality was not affected by sludge application rate.

Height Growth

In contrast to stem diameter growth, height growth over time does not show the same marked relationship to application rate that stem diameter growth does (Fig. 31). Although seedlings that received the highest rate grew less in height than the remaining seedlings, the difference was not statistically significant. Thus, it seems that the effect of treatment was more pronounced on diameter growth than on height growth.

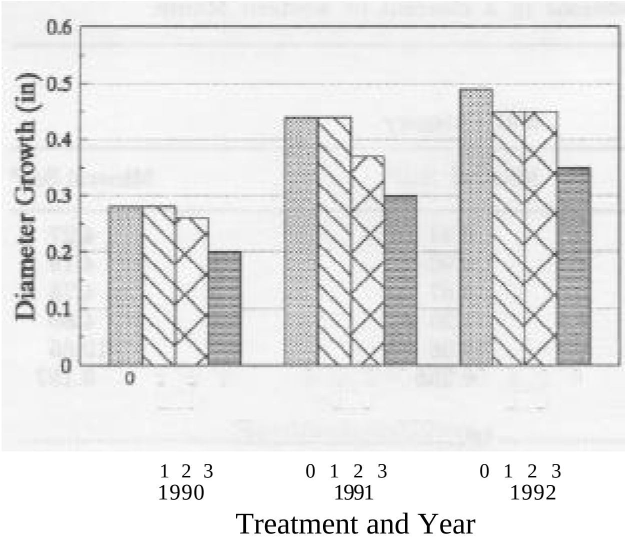

Figure 30. Diameter growth of red pine seedlings treated with a mixture of primary and secondary papermill sludge. 0, 1, 2, and 3 correspond to 0, < 15, >_ 15 < 30, and >_ 30 dry tons per acre. Measurements were made at 1 ft above ground.

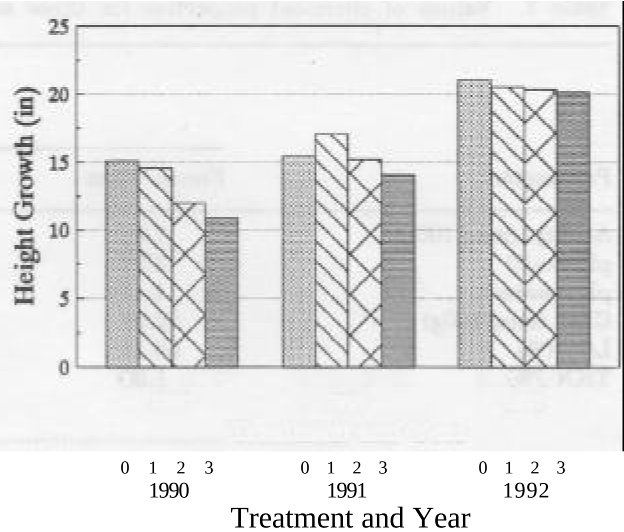

Figure 31. Height growth of red pine seedlings treated with a mixture of primary and secondary papermill sludge. 0, 1, 2, and 3 correspond to 0, < 15, > 15 < 30, and >_ 30 dry tons per acre.

Foliar Nutrient Concentrations

Analyses of 1991 foliage showed that magnesium concentrations for all treatments in which sludge was applied were significantly ($P < 0.05$) greater than concentrations in the control seedlings. This was the only element that showed a significant increase. Aluminum and manganese did not exhibit the same pattern of concentration decline with increasing application rate as was observed in the black spruce seedlings in Study Area 1. Overall, the effect of the sludge on foliar nutrient concentrations in the red pine in this clearcut was relatively small.

Study 3

Overview

Two important questions surrounding ash application to forest lands are the extent to which disturbance modifies the effect(s) of ash materials, and how changes caused by disturbance compare with those caused by ash. Sixteen plots were established for a sludge-ash study in a clearcut in King and Bartlett Township in western Maine. Disturbance to the forest floor, due to both harvesting and subsequent windrowing, was considerable. Over large areas, the forest floor and various amounts of the upper B horizon were absent. Soil samples were taken at six points in each plot. At four points where the forest floor was present a sample was taken of both the forest floor and the upper four inches of the B horizon. The forest floor and variable depths of mineral soil had been removed at the remaining two sample points, and only the upper four inches of the mineral soil were sampled at those points. Pretreatment soil samples were collected in June 1991. The plots were treated with sludge ash in early July 1991.

Chemical **Characteristics of the Soil**

The chemical characteristics of the forest floor, undisturbed mineral soil (top four inches of B horizon where forest floor present), and disturbed mineral soil (top four inches of B horizon where forest floor absent) are presented in Table 7. There are large differences between disturbed and undisturbed mineral soil. Mean differences for all properties were either significant ($P <. 0.05$) or highly significant ($P < 0.01$). There were also large differences for most properties between the mineral soil and the forest floor.

The importance of the forest floor as a source of nutrients is evident. Care should be taken to minimize removal of the forest floor and the upper B horizon, which is also relatively high in nutrients.

The current Maine DEP guidelines for operational spreading of wood ash and sludge ash allow a maximum rate of three tons per acre of calcium carbonate equivalent. The difference in pH (water) between disturbed and undisturbed mineral soil at the King and Bartlett study site was 0.18 unit, highly significant ($P <. 0.01$). In contrast, the difference in undisturbed mineral soil pH between plots treated with wood ash at three tons of calcium carbonate equivalent per acre and untreated plots was 0.15 pH units (0.438 vs. 0.453), with the treated plots having the higher pH. This difference was not significant ($P < 0.05$). Other differences between disturbed and undisturbed areas at the King and Bartlett site were comparable to those between treated and untreated plots at the undisturbed site, except that the direction of the differences was reversed.

liable 7. Values of chemical properties for three soil conditions in a clearcut in western Maine.

	Soil Category		
Parameter	Forest Floor	Mineral Soil[1]	Mineral Soil[2]
Acidity (meq/lOOg)	7.86	6.34	4.27
pH (salt)	3.77	3.96	4.18
pH (water)	4.45	4.57	4.75
CEC (meq/lOOg)	22.52	7.26	4.80
LOI (%)	66.18	14.66	10.66
TKN (%)	1.39	0.255	0.157
	, (ppm).		
Ca	2312.60	107.44	59.69
K	331.18	75.93	57.69
Mg	235.94	17.67	9.60
Na	70.54	6.22	5.29
Al	410.65	458.64	301.55
Fe	18.82	21.97	10.47
Mn	254.85	14.42	8.00
P	655.51	11.72	6.22

[1] Forest floor present
[2] Forest floor absent

HERBICIDE EFFECTS ON HABITAT AND NUTRITIONAL ECOLOGY OF MOOSE AND DEER IN MAINE

William Eschholz, Kevin Raymond
and Dr. Frederick Servello

Introduction

In 1992, the second year of field and laboratory work was completed on this 3-year project. The work is on schedule and there have been no major problems. Kevin Raymond and Bill Eschholz (M.S. graduate students) are conducting the moose research, and Justin Vreeland (Honors student) is conducting the deer research. Dr. William Krohn is co-advising Bill Eschholz to provide additional expertise on the moose habitat studies. Also, Dr. Brad Griffith, an original co-principal investigator on this project but now with the U.S. Fish and Wildlife Service in Alaska, continues to provide advice on design and analysis.

This report presents some of the major results of the first two years of the project. The first year (1991) consisted entirely of studies of moose habitat use, food availability, and diet quality on experimental sites prior to treatment with glyphosate. In 1992, similar studies were conducted on both treated and untreated sites in winter (moose research) and summer (deer research). Major data analyses are in progress; therefore, we can not address objectives in much detail at this time. We caution that these are preliminary results and are subject to change as the review process proceeds.

Objectives

The objectives of the project are

1. to determine the effects of glyphosate on winter browse availability and digestible energy and protein availability for moose, 1-2 and 7-10 years post-treatment;
2. to determine the effects of glyphosate on winter browse utilization and diet quality for moose, 1-2 and 7-10 years post-treatment;
3. to determine if intensity of stand use by moose differs between glyphosate-treated and untreated stands;
4. to determine the effects of landscape-scale habitat characteristics on moose use of glyphosate-treated and untreated stands;
5. to determine the effects of browse availability and stand characteristics (cover) on moose use of glyphosate-treated and untreated stands; and
6. to determine effects of glyphosate on food availability for deer in summer, 1-2 and 7-10 years post-treatment.

Moose Habitat Use

We measured moose activity on 31 study sites in winter 1992. Six sites had been treated with glyphosate in August 1991 and six similar untreated sites served as controls (short-term effects study). Fourteen other sites had been treated 7-10 years prior to the start of this study and five similar-aged sites served as untreated controls (long-term effects study). Activity was measured 6-7 times on each site using transect surveys to count moose track aggregates, pellet groups, and beds. Transect surveys totaled 469 km during 1992. Track aggregates also were classified as foraging or non-foraging activity if possible. Activity data collected in 1992 could not be directly compared to 1991 data (pretreatment) for short-term sites because earlier surveys were done by aircraft. However, based on aerial survey data, there was no difference ($P>0.10$) in moose activity between treated and untreated sites prior to treatment.

Glyphosate treatment did not affect ($P>0.10$) any measured aspect of moose activity in 1992 (Table 8). However, on the treated short-term sites we observed that much of the deciduous vegetation was not dead by winter 1992, although it was visibly stressed. Also, moose foraging patterns and use of specific sites in winter may be largely established in late summer and early fall. Because treatment effects on the short-term sites would have been minimal in fall, normal use of sites may have carried over into the winter to some degree. Given these two potential factors, the full effect of the initial glyphosate treatment on moose activity may not occur until the second winter post-treatment (winter 1993 of this study).

Sites that had been treated with glyphosate 7-10 years ago may receive more use than similar-aged untreated sites; however, at this point moose activity in treated and untreated sites was not statistically different ($P>0.10$, Table 8). The highest recorded track counts did occur on sites that were treated 7-10 years earlier which indicates that these sites can receive high use. Two factors influence comparisons of treated and untreated long-term study sites. First, there appears to be a clear difference in the level of moose activity between the Moosehead (Jackman to Roach Pond) and the Telos regions. We suspect that this is due to either regional differences in average moose densities or differences in food abundance on the sites. Food abundance may vary due to treatment variation or forest type differences. Second, moose activity was highly variable in the long-term untreated stands. Sites with uniform closed canopies had relatively low use, but some contained a mosaic of small openings that appeared to be maintained by heavy moose browsing each winter.

Table 8. Moose activity (counts per km of transect) on glyphosate-treated and untreated clearcuts 1 year (short-term effects) and 7-10 years (long-term effects) after treatment. Long-term treated sites were located in two different regions.

	Short-term				Long-term					
					Treated					
	Treated[1] (n=6)		Untreated[1] (n=6)		Telos (n=8)		Moosehead (n=6)		Untreated[1] (n=5)	
Counts	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Total Tracks	1.57	0.48	2.55	0 59	2.81	0.55	5.27	0.96	3.38	1.30
Foraging	0.44	0.16	1.02	0 20	0.75	0.30	2.10	0.51	1.14	0.51
Non-Foraging	1.01	0.36	1.23	0 ,37	1.82	0.34	2.52	0.36	1.82	0.64
Pellets	0.11	0.05	0.18	0.08	0.20	0.07	0.77	0.41	0.49	0.25
Beds	0.03	0.01	0.13	0.08	0.09	0.03	0.35	0.08	0.31	0.15

[1] Located in Moosehead Lake region.

Total tracks, beds, and pellet group counts were greater (P<0.10) on long-term sites than short-term sites (Table 8). The greater height and development of the vegetation on the older sites may be more attractive to moose for cover.

We measured the proportion of stand types and other landscape features in areas surrounding each study site to confirm that differences between treatments or stand age were not influenced by the surrounding landscape. These data have not been statistically analyzed; however, mean values for treated and untreated short-term sites were similar (Table 9). The long-term treated and untreated sites were also generally similar except that the treated sites in the Telos region tended to have more softwood cover than treated sites in the Moosehead region. This may explain the differences in moose activity we observed between regions.

Moose activity data will be collected on all sites in 1993. These results will allow us to describe the short-term effects of treatment after the full initial effects of glyphosate have occurred (16 months post-spray). On long-term sites, a second field season will double sample sizes which should help to clarify some apparent effects. Vegetation data also have been collected on these sites for the purpose of examining cover characteristics relative to glyphosate treatment, but these data have not been analyzed. Our ultimate goal is to determine the relative importance of cover (physical nature of the sites) and food availability and quality (described below) on moose activity relative to glyphosate treatment during early stand development.

Food Availability and Quality For Moose

Browse biomass and utilization were measured by species on the 12 short-term study sites in winter 1992 (Year 1 post-treatment) and on 8 long-term treated sites and 3 long-term control sites. We modified our sampling design in 1992 because of high variability in the 1991 data. We increased the number of sample plots from 24 to 40 per site and established permanent plots on the short-term study sites. In 1993, the short-term study sites and additional long-term sites will be sampled.

Browse biomass availability varied substantially (high standard error values) among individual sites (Table 10). However, repeated (annual) measurements on the short-term study sites should allow adequate statistical power to detect treatment differences. Data analyses are in progress. In general, it appears that the reduction in browse biomass in the first winter after treatment is low (25%) relative to control sites. This was consistent with our field observations that much of the vegetation was visibly stressed but not dead. We expect browse biomass to decline further by the next winter. Browse biomass appears to be lower on the long-term treatment and control sites than on the short-term sites. The apparent preference for older sites by moose (described in the previous section) may therefore be related more to the well-developed physical cover on these sites rather than food.

We will be examining effects of glyphosate treatment on the availability of individual browse species and relating these data to species preference

Table 9. Mean composition (%) of habitats' surrounding glyphosate-treated and untreated clearcuts, 1 year (short-term effects) and 7-10 years (long-term effects) after treatment. Long-term treated sites were located in two different regions.

	Short-term				Long-term					
					Treated					
	Treated[2] (n=6)		Untreated[2] (n=6)		Telos (n=8)		Moosehead (n=6)		Untreated[2] (n=5)	
Categories	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Roads	2.49	0.16	2.75	0.21	0.80	0.06	2.37	0.35	2.34	0.25
Cuts	27.48	3.62	29.79	4.38	48.07	7.69	54.83	4.61	37.31	7.69
Mixedwood	26.47	5.23	22.63	4.70	9.32	2.78	11.58	3.89	11.85	3.89
Mature softwood	8.33	1.59	5.86	1.28	22.30	4.38	5.56	1.11	10.56	0.71
Mature hardwood	11.99	3.15	13.00	4.38	3.74	1.21	10.28	3.10	15.95	2.47
Pole softwood	5.13	1.17	4.88	1.93	9.78	3.27	3.86	1.28	5.55	2.19
Total softwood	13.46	1.52	10.74	3.11	32.08	7.09	9.42	1.98	16.10	2.34

[1] Habitat composition was measured in a 8-km^2 circular area (mean home range of moose) centered on each site.

[2] Located in Moosehead Lake region.

Table 10. Mean browse biomass availability (kg/ha) for glyphosate-treated and untreated sites, 1 year (short-term effects) and 7-10 years (long-term effects) after treatment. Data for 1991 are prior to treatment.

	Short-term				Long-term			
	Treated (n=6)		Untreated (n=6)		Treated (n=8)		Untreated (n=3)	
Year	Mean	SE	Mean	SE	Mean	SE	Mean	SE
1991	141.2	34.5	159.7	34.5				
					42.6	9.4	64.1	16.1

(utilization). Moose were exhibiting clear preferences for some browse species on our study sites. Only by evaluating changes in browse species availability relative to food selection and preference by moose will we get a clear understanding of glyphosate effects on moose ecology. Analysis of the 1991 and 1992 browse utilization data is in progress. Preliminary results indicate that moose are eating up to 10-20% of the available browse biomass (current annual growth) on sites each winter.

Nutritional quality measurements (4 analyses) have been made on approximately 130 browse samples collected in winter 1991. Measurements are nearly complete on approximately 250 samples from 1992. These data will be combined with availability and preference data to evaluate the effects of glyphosate treatment on the quality of moose diets.

Food Availability and Quality For Deer

As described in the original project proposal, this work focused on deer ecology in the summer. From June to August 1992, food availability for deer was studied on 6 short-term treated sites, 6 short-term untreated sites, 5 long-term treated sites, and 5 long-term untreated sites. Cover measurements for woody and herbaceous species were used as an index of food availability. These data are currently being summarized. In general it appears that the sampling intensity and approach were satisfactory.

Samples of forage material were collected and nutritional quality analyses are in progress. These data will be used to evaluate the effects of changes in food availability relative to diet quality and deer nutrition.

Future Plans

All field work will be completed in winter 1993 (1992-93 season). The students anticipate thesis completion in 1993.

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ADDITIONAL TECHNOLOGY TRANSFER ACTIVITIES BY CFRU PERSONNEL

Briggs, R.D. Delineation of climatic regions in Maine. Maine Association of Practicing Soil Scientists Annual Meeting, Augusta, ME. March 3, 1992.

Briggs, R.D. and R.C. Lemin, Jr. Response of spruce and fir to precommercial thinning. Poster presented to the New England SAF, 1992 Annual Winter Meeting. Lowell, MA. March 11-13, 1992.

Briggs, R.D. Site quality assessment: interaction with response to spacing. Invited presentation to Bowater Woodlands Staff Meeting, Millinocket, ME. May 1, 1992.

—. Site quality and precommercial thinning. Vegetation Management Workshop. T34, ME. July 29, 1992.

--------. Site quality identification workshop. Invited presentation to Great Northern Division, Bowater. Millinocket, ME. August 12, 1992.

Briggs, R.D. and R. Krantz. Site quality identification workshop. Champion Int. Corp., Timberlands Field Workshop, Beddington, ME. September 23, 1992.

Eschholz, W. Herbicide-moose research project. Invited presentation to Georgia-Pacific Corporation, Woodland, ME. May, 1992.

Gilmore, D.W. and R.D. Briggs. Polymorphic site index curves for European larch *(Larix decidua* Miller) plantations in Maine. Poster presented to New England SAF, 1992 Annual Winter Meeting, Lowell, MA. March 11-13, 1992.

McCormack, M.L., Jr. Current European silvicultural perspectives. Seminar. College of Forest Resources, Univ. of Maine, Orono. January 31, 1992.

—. The importance of international and interdisciplinary cooperation in resolving current and future land use conflicts. Address to Eighth Grad. Student Conf. on Forestry, Environmental and Wildlife Sciences. Univ. of Maine, Orono. February 15, 1992.

—. The practice of clearcutting in the forests of northern Maine. Presentation to Limestone, ME Rotary Club, Limestone, ME. February 28, 1992.

—. Update on European silviculture. Presentation to Northern Forest Forum, Caribou, ME. March 9, 1992.

—. Veneer oak production in the Spessart Region of Germany. Poster presented to the New England SAF, 1992 Annual Winter Meeting. Lowell, MA. March 11-13, 1992.

McCormack, M.L., Jr. Christmas tree production and marketing practic es in northern Europe. Presentation to NH Christmas Tree Conf., W. Lebanon, NH. March 14, 1992.

—. European forestry observations. Seminar. Maritime Forest Ranger School, Fredericton, NB. April 6, 1992.

—. Forestry herbicides roundtable discussion for operational foresters. Organizer and facilitator. Maritime Forest Ranger School, Fredericton, NB. April 7-8, 1992.

—. Workshop on operational uses of forestry herbicide technology. Scott Paper Co., The Forks, ME. June 9-12, 1992.

—. Update on silvicultural practices in spruce-fir forests of Maine. Presentation to the Maine Forest Management Review, Champion International. Alamoosook Lake, ME. July 21, 1992.

—. Characteristics of forestry herbicides. Workshop. Scott Paper Co., Greenville, ME. July 22, 1992.

—. Forest vegetation management workshop. Workshop tour leader. College of Forest Resources, Univ. of Maine, Orono. July 29, 1992.

—. Prescription development and operational uses of forestry herbicides. Lectures and discussion. Advanced Forestry Herbicides Course, Ontario Ministry of Natural Resources and Guelph University, Sault Ste. Marie, Ontario. September 27-29, 1992.

Ostrofsky, W.D. Cooperative Forestry Research Unit - Update and Review. Invited presentation to Georgia-Pacific Corp., Woodland, ME. December 11, 1991.

Ostrofsky, W.D., and R.K. Shepard, Jr. Effect of papermill sludge ash on black spruce growth and survival. Poster presented to New England SAP, 1992 Annual Winter Meeting. Lowell, MA. March 11-13, 1992.

Ostrofsky, W.D. Improving the quality of northern hardwoods. Invited presentation to Great Northern Paper, Inc., Millinocket, ME. May 1, 1992.

---------. Effects of papermill sludge ash on black spruce grown under greenhouse conditions. Invited presentation to International Paper Co., Jay, ME. May 7, 1992.

Pitcheralle, J.D. and R.D. Briggs. Foliar nutrient concentrations of precommercially thinned balsam fir: effects of site quality. Poster presented to New England SAF 1992 Annual Winter Meeting. Lowell, MA. March 13-15, 1992.

Raymond, K.S. Review of herbicide-moose research project. Maine Dept. Inland Fisheries and Wildlife Staff Meeting. June, 1992.

Schaertl, G.R. Comparison of herbicide effectiveness for vegetation management and spruce/fir growth (Twp. 34 MD Study). Forest Vegetation Management Workshop, Univ. Maine. July 29, 1992.

Seymour, R.S. Modification of the TASS simulation model for Maine conifers: a review of field research procedures. CFRU Advisory Committee summer field tour. Bradley, ME. July 28, 1992.

Servello, F.A. Effects of herbicides on wildlife habitat. Penobscot County Conservation Association. Brewer, ME. September 4, 1992.

COOPERATIVE FORESTRY RESEARCH UNIT ADVISORY COMMITTEE
1992 Membership

The CFRU Advisory Committee sets priorities and reviews proposals for the Cooperative Forestry Research Unit. Members active during all, or part, of 1992 were

Everett Deschenes, Fraser, Inc. (Chair)
Si Balch, Boise-Cascade Corporation (Vice Chair)
Thomas J. Colgan, Forestry Manager, Scott Paper Company (Financial Officer)
Thomas A. Morrison, Maine Bureau of Public Lands (Member at Large)
G. Bruce Wiersma, Dean, College of Forest Resources
Edward Chase, Chase Tree Farm
Robert Frank, USDA Forest Service
Dennis Gingles, International Paper Company
Russ Hewett, Pride Manufacturing Company
Peter Ludwig, Champion International Corporation
Ronald Mallett, Maine Power Services
Marcia McKeague, Great Northern Paper
Phil Sullivan, J.D. Irving, Limited
John D. Stowell, Timberlands, Inc.
Clifford L. Swenson, Seven Islands Land Company
Peter Triandafillou, James River Timber Corporation

Liaison to Forest Resources Advisory Committee

C. Edwin Meadows, Jr., Commissioner, Maine Department of Conservation

CFRU STAFF
(September 30, 1992)

Program Leaders

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Maxwell L. McCormack, Jr., Research Professor of Forest Resources Russell D. Briggs,
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Carter, Associate Professor of Forest Resources Robert S.
Seymour, Associate Professor of Forest Resources Robert K.
Shepard, Jr., Associate Professor of Forest Resources Frederick
Servello, Assistant Professor of Wildlife

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Haynes, H.C., Inc.
Huber, J.M. Corporation
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Pride Manufacturing Company
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Scott Paper Company
Seven Islands Land Company
Sewall, James W. Company
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Totman, General Clayton O.
Wales, R.H. & Son, Inc.
Western Maine Nurseries

OTHER ORGANIZATIONS PROVIDING SUPPORT FOR CFRU PROJECTS

DowElanco
E.I. du Pont de Nemours & Co.
Maine Agricultural Experiment Station
Maine Forest Service
Mclntire-Stennis
Monsanto Agricultural Products Company
USDA Northeastern Forest Experiment Station
USDA State & Private Forestry

APPENDIX

Terminology

SCIENTIFIC NAME	COMMON NAME
Abies balsamea (L.) Mill.	Balsam fir
Abies spp.	Fir
Acer rubrum L.	Red maple
Acer saccharum Marsh.	Sugar maple
Alces alces L.	Moose
Betula alleghaniensis Britton	Yellow birch
Betula papyrifera Marsh.	Paper birch
Dendroctonus simplex LeConte	Larch bark beetle
Fagus grandifolia Ehrh.	American beech
Fraxinus americana L.	White ash
Fraxinus nigra Marsh.	Black ash
Larix decidua Mill.	European larch
Larix leptolepis (Sieb. & Zucc.) Gord.	Japanese larch
Larix spp.	Larch
Odocoileus virginianus L.	White-tailed deer
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 spp.	Pine
Prunus pensylvanica L.	Pin cherry
Quercus spp.	Oak
Rubus idaeus L.	Common red raspberry
Sambucus spp.	Elder
Tsuga canadensis (L.) Carr.	Hemlock