CFRU Information Report 20

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RESEARCH UNIT

COLLEGE OF FOREST RESOURCES

MAINE AGRICULTURAL EXPERIMENT STATION

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ADVISORY COMMITTEE CHAIRMAN'S REPORT

The Cooperative Forestry Research Unit is one of the best forestry cooperatives in the nation. The professionalism and commitment of the scientists and research staff, plus the active participation of the cooperators through the CFRU Advisory Committee is the key to providing this excellence.

The CFRU has undergone an evolutionary process during the more than a decade of its existence. As the cooperator's priorities have changed, CFRU has responded by redirecting its resources and talents. This process was evidenced this year in the hiring of Dr. Russell Briggs from the State University of New York at Syracuse to replace Dr. Seymour, who filled the Curtis Hutchins Chair of Quantitative Silviculture within the College of Forest Resources. Dr. Briggs is striking off into a new direction for CFRU - that of site classification. His research will provide a framework to permit integration of site/species/productivity/response information and relationships. He has gotten off to a great start this year and has already pulled together some very useful information. We welcome Dr. Briggs to the CFRU.

An improved financial position at the end of 1987 allowed the Advisory Committee to increase badly needed operating funds to ongoing projects. The planned increase of one-half cent per acre, effective October 1, 1988 will continue to allow projects to be adequately funded. Further, the activities of the Funding Mechanism Subcommittee has provided a dues structure for a new class of membership from logging contractors and wood fired electrical generating companies. MarkeTree, Inc. was contracted by CFRU to determine the interest of these types of companies in joining CFRU, and the response has been positive. H. O. Bouchard, E. J. Carrier, Inc., Fairfield Energy Venture, Irland Group, F. A. Madden, Inc., Lloyd Poland Chipping, Resource Conservation Services, Thermo Electron Energy Systems, United Bank, and Rodney H. Wales & Sons, Inc., have already responded by joining as affiliated members. Additionally, several other companies have expressed an interest in joining in 1989. We welcome these companies to the CFRU.

The strength and excellence of CFRU would not be possible without the strong commitment of the staff to both the program and to good science. While this commitment is primarily the result of the quality of scientists within the program, opportunities for professional development are essential. As a part of an overall review of CFRU's Policies and Procedures, the Advisory Committee implemented a sabbatical leave policy to enhance professional development for the Research Professors.

The synergism resulting from the cooperation between the staff and the cooperators has provided a research program that is dynamic in its ability to provide timely solutions to the cooperators evolving and ever changing problems. As we look to 1989 and into our fourth five-year planning period there are new opportunities and challenges to be undertaken. As I talk to our cooperators, I not only hear discussion about important on-going projects, but also about need of additional research in the areas of potential forest productivity, biomass harvesting, ash and sludge disposal and so forth. This indicates to me that we have our eyes to the future and that the vitality of CFRU continues to remain strong.

Michael S. Coffman, Chairman
CFRU Advisory Committee

DEAN'S REPORT

The Cooperative Forestry Research Unit has completed another productive year for the benefit of the membership and the forests of Maine. We are on target in meeting the long-term mission of the Cooperative; the accomplishments reported here speak clearly to this point.

We were very fortunate in our choice of the newest scientist for the CFRU. Dr. Briggs came to us with very strong recommendations, and all of these strong statements seem to be supported by his first-year activities. I hope all of you will become acquainted with this energetic young scientist. He is full of ideas and is committed to doing an outstanding job for all cooperators.

The Cooperative functions best with self-starters who will do outstanding work on projects approved by the Advisory Committee. We have top scientists who know how to plan research projects, can budget effectively, will seek advice when needed and will do top quality work with a minimum of supervision. Dr. McCormack and Dr. Ostrofsky have proven to all of us that they are outstanding scientists. Other faculty with special projects; Dr. Carter, Dr. Greenwood, Dr. Seymour, Dr. Shepard, and Dr. White have provided answers to high priority questions that required their special expertise. The remainder of this report tells the story.

During 1989 we will be commencing the process of developing priorities for the CFRU in our next five-year work cycle, commencing on October 1, 1991. Less than three years remain on the current cycle which ends on September 30, 1991. I hope all cooperators will be thinking about this and will be ready to make inputs to the planning process when requested to do so by the Advisory Committee.

The summary of our expenditures and income for the past year are presented on the next page. We have done well to balance the income and expenditures and our 1989 budget should do equally well. Please note that we have succeeded again in holding our reserve at a level approximately equal to a years operating costs. This policy was established the first year that CFRU was developed. It provides the needed security to protect the employees and cooperators against an economic disaster. Research cannot be shut off on a moments notice without severe losses for everyone involved.

The CFRU is healthy in all aspects through the efforts of its supporters and its scientists, and as a result of its productivity. We are ready for another outstanding year in 1989.

Fred B. Knight Dean and
Director, CFRU

BALANCE SHEET

1987-88 Period 10/01/87-
9/30/88

Balance Forward September 30, 1987		$517,186.82	
Contributions 1987 Received After 09/30/87		15,923.00	
Contributions 1988 Received 10/01/87-9/30/88		412,553.50	
Investments 10/01/87-09/30/88		36,160.32	
Total Assets:		$981,823.64	

Expenses:

Administration	Knight	$ 42,614.22	
Champion	White	2,268.25	
Energy Res.	MarkeTree	14,667.00	
Silviculture	McCormack	145,691.76	
Soil Site	Briggs	99,459.57	
Timber Quality	Ostrofsky	78,108.14	
Growth & Yield	Seymour	13,610.21	
Tree Improvement	Greenwood	10,000.00	
Fertilization	Shepard	9,040.26	
Tree Improvement	Carter	30,408.10	
Herbicide	McCormack	10,500.00	

Total Expenses 10/01/87-9/30/88	$456,367.51
Less Account Balances Carried Forward	6,083.44*
Balance on Hand 9/30/88	$519,372.69

***5-6-42800-A**	**$1,431.75**
5-6-42804	**2,910.79**
5-5-38079	**1,740.90**

SILVICULTURE
Dr. Maxwell L. McCormack, Jr.

Forestry undergraduates Karl Stuart and David Spicer along with M.S. candidate Tian-Ting Shih and Mount Holyoke undergraduate Kirsten Kenerson carried out a major plot measurement effort during the 1988 field season. During the year, Patrick Strauch completed his M.S. requirements and his thesis is ready for final editing. G. R. Schaertl continued his Ph.D. program on vegetation management and R. A. Lautenschlager was employed full-time as Assistant Scientist in the silviculture program while he worked on the final stages of his Ph.D. research on red raspberry.

In addition to the technology transfer activities listed later in this report, Dr. McCormack participated on the Search Committee to fill the CFRU Research Professorship in site productivity/site classification. He presided at the 42nd Annual Meeting of the Northeastern Weed Science Society in January, and then served as Past-President through 1988. Also, he is the Leader, Silviculture Working Group, New England Society of American Foresters and, during the fall semester, he is substituting as instructor for the undergraduate course on artificial regeneration of forests.

The silviculture project continues to provide maintenance and supervision of the CFRU trailer at the Telos Operation of Great Northern Paper. Housing and support was provided for a variety of CFRU field studies and for several graduate students and cooperating scientists from other organizations. Continuing maintenance and coordination of use of the CFRU building on the University Forest was also provided.

Intensive Forest Harvesting

The Weymouth Point, T4R12 WELS, paired watershed study continued. The ninth year of soil solution and stream water sampling was completed. Evaluations of nutrient cycle dynamics, as well as vegetation responses to the 1985 aerial application of triclopyr, were carried out through well-established cooperation with C. W. Martin and J. W. Hornbeck of the USDA Forest Service, Durham, N.H. and C. T. Smith, Jr., of the University of New Hampshire. The support and cooperation from Great Northern Paper continues to be invaluable. At Weymouth Point, temporary summer labor expended a total of 18 worker days on maintenance of the study site installations and grid system plus ten worker days measuring the permanent vegetation plots. This total of 28 worker days was approximately six percent of the summer field work effort.

Watershed losses of triclopyr (Smith and McCormack 1988) and changes in nutrient cycling following the herbicide application (Smith, Hornbeck and McCormack 1988) have been reported. Results indicate that applications of triclopyr at levels of 2 lb ai/ac to regenerating clearcuts that contain streams in the spruce-fir type result in small amounts of triclopyr in stream water. Peak concentrations of 56 ppb were observed in stream water immediately after application due to direct application to the stream channel. A second pulse of 48 ppb occurred following a 0.4 in rain event on the sixth day after application. Below a 1475 ft streamside buffer strip, the highest concentration observed was 11 ppb. Total losses of triclopyr from the watershed for a 113-day period after treatment were estimated from triclopyr concentrations and stream volumes predicted by the hydrologic simulation model BROOK. These losses were estimated to be 0.02% of the applied triclopyr. Subsurface leaching of the herbicide appeared to be negligible in this study. The buffer strip of uncut trees was effective in minimizing changes in stream water quality after both the harvesting and herbicide treatments at Weymouth Point.

Nitrate and calcium concentrations increased in the soil solution of moderately well drained soils and in stream water draining the Weymouth Point watershed in the two growing seasons following herbicide application. The nitrate concentrations did not exceed health standards for drinking water during the two years following treatment. The nitrate-nitrogen losses from the watershed were somewhat smaller than the losses following clearcutting, but of a similar order of magnitude. The losses are considered a minor reduction in soil nitrogen compared with the magnitude of whole-tree harvesting removals.

Development of Spruce-Fir Regeneration

M. S. graduate student, P. Strauch, completed his investigation of early stand development of spruce-fir natural regeneration. Though limited in scope, his conclusions verify the value of his micro-measuring technique for understanding the origin of natural regeneration. Seedlings in the examined stands primarily were established in the understory of the mature stand prior to harvesting.

Measurements of height and root collar diameter indicated that dominance of balsam fir trees may be expressed early in the seedling stage of development. There was a strong positive relationship between seedling release age and height growth response. Patterns of growth from seedling to sapling were very similar for red spruce and balsam fir. The characteristically lower proportion of red spruce in Maine's spruce-fir forests may be due, in part, to factors in the establishment stage of development.

Precommerclal Thinning

The aerial strip thinning treatments applied with the THRU VALVE BOOM™ (TVB™) in June 1987 were evaluated. Sample plots were measured across all treatments tested on the International Paper Co. and Great Northern Paper sites. Generation of fines and the ill-defined spray patterns at the Scott Paper Co. site resulted in treatments which were not suited for evaluation. Measurements were taken to evaluate strip patterns, target biomass of conifers, and efficacy in killing conifers within the sprayed strips. At the Great Northern site there were 312 plots taken across five different treatments and at the International Paper Company site there were 447 plots across seven treatments. These measurements required 40 worker days of field work and six days of data processing and analysis. The 46 worker days comprised ten percent of the total summer field work. Target conifer condition was recorded in three categories; (1) dead, (2) injured, but not dead, and (3) alive and less than 25% injured. Counts of dead stems gave estimates of percent reduction of conifers. A comparison of selected results is shown in Figure 1.

Direct comparisons of efficacy between different treatments, or the same treatment on different sites, is difficult because of different amounts of target conifer biomass within the strips. The total spray volumes and basic chemical treatments applied in the 1987 tests yielded results consistent with those of previous trials. Results from the lower spray volume of 16 gal/ac were encouraging. Treatment bands of 8 to 10 ft with narrow residual strips of 3 to 5 ft appear to be defined most consistently. Formulated picloram + 2,4-D is the most consistent and effective single treatment. Combinations of picloram + 2,4-D + dicamba continue to be very effective. The highest mortality level of target softwoods, 70%, was achieved with 1.25 + 5 lb ai/ac treated of picloram + 2,4-D, respectively, in a total spray volume of 16 gal/ac.

The sensitivity of the TVB™ presented practical problems during the trials which interfered with the definition of the treatment strips. Though additional testing of delivery technology is being considered, a resumption of use of the Microfoil Boom™ appears to be the most practical means to achieve acceptable operational results. Recent examination of the 1984 tests, combined with results of the 1987 treatments which were applied after the boom was properly adjusted, are a basis for further work with this technique. To augment operational applications, plans for spring 1989 trials with a navigation system are underway.

Thinning Spruce and Spruce-Fir Stands

The long-term thinning study has been in place for ten growing seasons. The Scott Brook site, T5R15 WELS, in cooperation with Great Northern Paper and the Clayton Lake site, T11R16 WELS, in cooperation with International Paper Company were remeasured during the summer. The field crew spent a total of 46 worker days, ten percent of the summer field work, on these two sites. The remaining long-term study sites, described in the 1987 Annual Report, will be measured prior to the 1989 growing season.

There is a general lack of dramatic responses to the thinning treatments. Possibly, this is the result of (1) spruce budworm impacts during the early years of the study, (2) an inadequate reduction of tree stems occupying the sites, or (3) too late an entry in the older stands. The data base is composed of individual study tree measurements, rather than stand data. Therefore, further evaluation

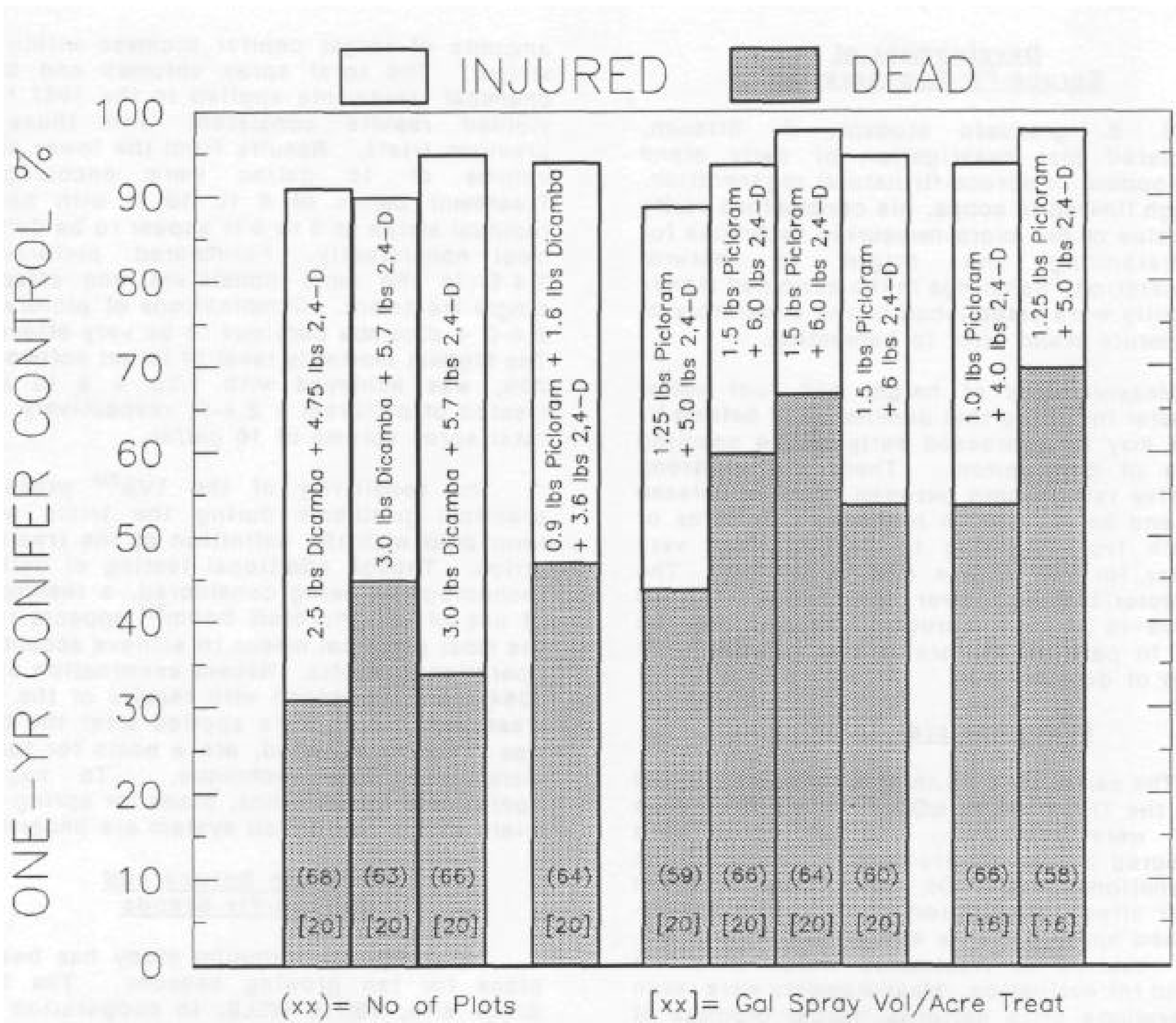


Figure 1. Average conifer control by aerially applied strips for precommercial thinning. These are selected from study areas with similar volumes of target conifer biomass. Treatments are shown as active ingredients per acre of treated strips.

of the ten-yr data may provide some understanding of individual tree responses based on the variable number of competing trees incorporated into this study. A thorough evaluation of the ten growing season responses will be a basis.for deciding the future of the thinning plots.

The lack of visual differences in height growth between crop trees thinned to different levels of competitors is illustrated in Figure 2. The two study sites measured showed the most promise for positive responses to the thinning treatments. However, except for slight improvements through the second five-yr period, there are no apparent differences. The radial growth responses on these two sites are relatively uniform across the different levels of thinning. Though the response data are disappointing, they will be thoroughly evaluated on a tree-by-tree basis in an effort to identify any meaningful trends.

Management of Undesirable Vegetation with Herbicides

The 1988 season was primarily devoted to follow-up observations and data collection from the broad array of aerial treatments applied in 1987. Approximately 50% (225 worker days) of

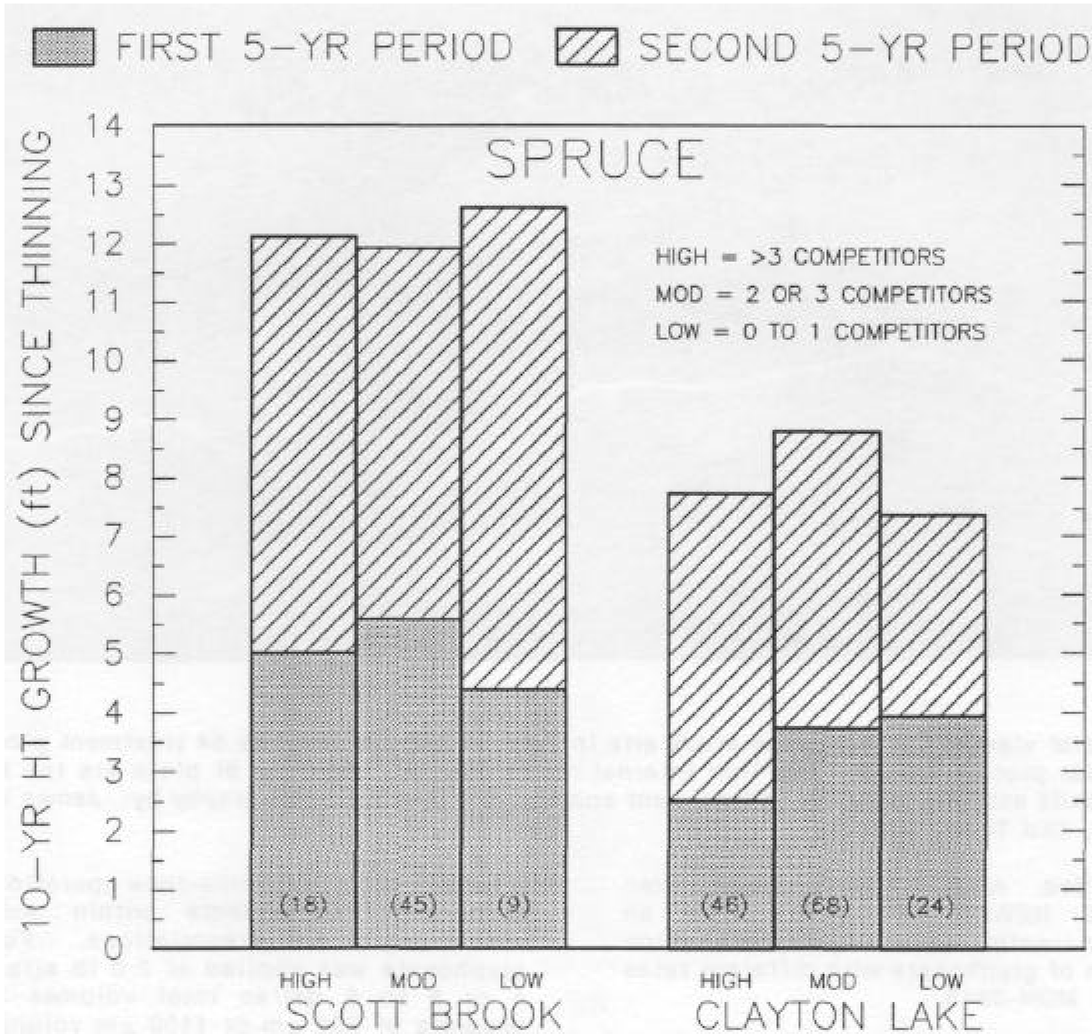


Figure 2. Average spruce study tree height growth, in 5-yr increments, for the period following thinning treatment. They are grouped according to the number of competing trees based on touching crowns. Numbers in parentheses indicate study trees measured in each category.

the field effort was devoted to evaluating treatments and establishing 162 permanent measurement subplots across the 54 main treatment plots in Twp. 34 MD. These permanent subplots are part of the comprehensive study established on land of Champion International which was reported in the 1987 Annual Report (Figs. 3 and 4). The subplots were monumented and measured twice to provide pretreatment and first-year post-treatment vegetation data. A formal update on this project is planned for the 43rd Annual Meeting of the Northeastern Weed Science Society (NEWSS). The most effective reductions of shrubs and hardwoods occurred on plots treated with glyphosate and imazapyr. However, MON-8709, glyphosate with a lower level of surfactant, does not seem as effective as the commercially formulated glyphosate. Sulfometuron appears to be effective as a residual herbicide when used in tank mixtures. Varying levels of conifer injury were observed in imazapyr treatments and where glyphosate was applied with surfactants MON-8166 and MON-8191.

A companion study to the Twp. 34 MD treatments on land of Boise-Cascade was also evaluated during the summer field season. Twenty-five worker days were employed to collect data from 33 subplots distributed across 11 treatment plots. Data analysis will be carried out over the winter for this investigation of tank mixes of glyphosate with

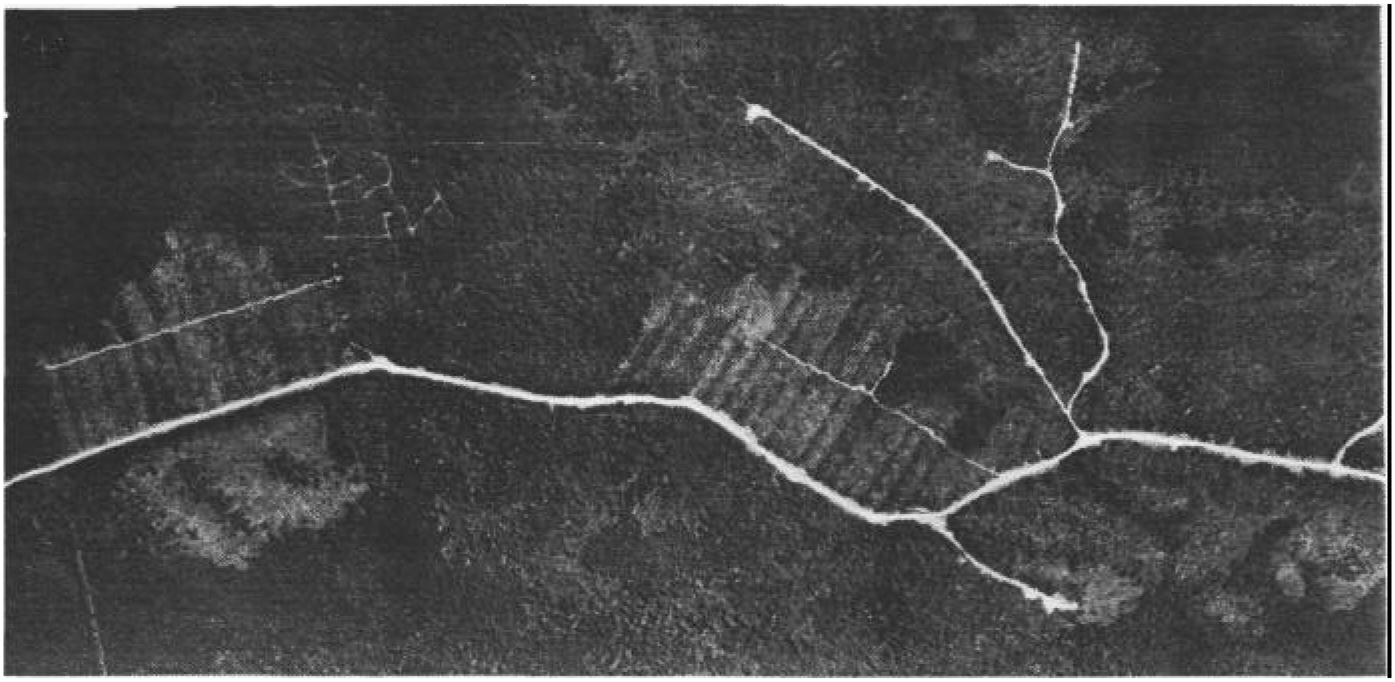


Figure 3. Aerial view of the herbicide study site in Twp. 34 MD showing the 54 treatment plots. Each rectangular plot is 1.5 ac. The thin internal roads dividing the tiers of plots are the bulldozer access roads established prior to treatment application. (Aerial photography by: James W. Sewall Company, Old Town, Maine).

other herbicides. Also, a report will be given at the 43rd NEWSS on results from an additional ten treatment plots for the evaluation of interaction of glyphosate with different rates of surfactant MON-0818.

Balsam fir transplants were furnished by Western Maine Forest Nursery, Fryeburg, Maine for a potted-seedling study designed by G. R. Schaertl to evaluate physiological and phenological responses to glyphosate, triclopyr, metsulfuron and imazapyr. The planting stock was transplanted to 1-gal greenhouse pots and arranged in five randomized complete blocks of 50 trees each. Delays have resulted from procedural problems with excessive temperatures caused by the high intensity light during measurements. Following simulated aerial applications to be made in August 1989, rates of photosynthesis, respiration and transpiration will be monitored.

Results of a spray volume delivery/droplet size study with aerially applied glyphosate were reported (Schaertl *et al*. 1988). Field data emphasize the importance of considering spray volumes delivered and, especially, droplet size of spray patterns. This work is part of an intensified effort to fine-tune operational spray technology components within established active ingredient prescriptions. Formulated glyphosate was applied at 2.0 Ib ai/ac in 3 to 4 or 5 to 6 gal/ac total volumes by spray droplets of 700 *nm* or 1100 /im volume median diameter. These treatments represented a low and high delivery volume by small and large spray droplets. This study was conducted in cooperation with Scott Paper Co. Small diameter spray droplets were more efficacious than large droplets at either delivery volume. Efficacy of large droplets improved at the high volume rate, while small droplet efficacy was better at the low volume. Some differences in off-site deposition occurred at 100 ft downwind from the plot boundaries.

Approximately half of a planned stem injection study was carried out on land provided by International Paper Company. Treatment installation on 828 trees for spring and summer injections was completed. Collected data and observations for these trees are under review. Unfortunately, the injection system did not hold up and perform satisfactorily under our operational conditions for testing. Also, the chemical formulations

Figure 4. Calibration of equipment and checking of individual nozzle flow rates in preparation for applying the multiple herbicide treatments at the Twp. 34 MD study site.

which were used are under review by Monsanto. These developments have resulted in this project being placed in an inactive status.

Research on factors affecting germination, establishment, and competitive potential of common red raspberry with white spruce seedlings was continued by R. A. Lautenschlager. His greenhouse experiment indicated that raspberries respond to moisture, nutrients and light in complex and sometimes unexpected ways. For instance, although heavy (73%) shade reduced raspberry biomass production and expansion potential (shoot production), and tended to increase the amount of above-ground biomass in relation to root biomass, 30% shade had little effect. In addition the negative effect of heavy shade was offset by the addition of nutrients and moisture. These results coupled with field experiments should help to explain the positive response of raspberries to forest disturbance, including forest gap creation, and why raspberries often develop after even fairly light thinning operations.

A second field experiment was designed to examine effects of shade, nitrogen, and competition on the establishment and dry matter production of raspberry and white spruce seedlings. Harvesting of plant material was completed during autumn 1988 (Fig. 5). Approximately 2200 individual and multiple stem samples were collected. These represented above- and below-ground portions of raspberry and spruce seedlings grown at varying densities in circular Nelder plots. The samples have been dried and weighed. Data analyses will be carried out through the winter.

Data collection from Lautenschlager's field experiment in the Telos area was completed in August 1988. This experiment was designed to determine: 1) the competitive potential of red raspberry, grasses and sedges, hardwood brush and herbaceous weeds on planted white spruce; 2) if the competitive potential of these species and competitive groups changes with site; and 3) if bare-root transplant (2-2) white spruce stock tolerates competition better than smaller paper-pot seedling white spruce. Data collection consisted of measuring total height, diameter at the root collar, leader length, and caliper at the base of the leader of each planted tree. In addition, the estimated percent cover (0-100%) of each competitive

Figure 5. R. A. Lautenschlager harvesting raspberry and spruce seedling biomass from the circular Nelder plots.

species or group within a radius of 0.5 m of each planted tree was estimated. Data that was collected on 960 trees is now being analyzed.

SITE QUALITY

Dr. Russell D. Briggs

Introduction

A proposal to begin a productivity-oriented research program for evaluation of spruce-fir site quality in Maine (Briggs 1988) was accepted by the Advisory Committee in April, 1988. The primary objective was to develop a classification system for evaluating sites according to their inherent capacity for spruce-fir production. A major goal of the initial field sampling was to extend the soil-site data base collected by graduate students under the direction of Dr. Ralph Griffin at the University of Maine. Field work was initiated in June 1988. Personnel involved in the field work included Dr. Russell Briggs, Asst. Res. Professor, Mr. Ronald Lemin, Asst. Scientist and Mr. James Steinman, Ph.D. candidate in Forest Management.

Approach

Classification of forest land according to its inherent spruce-fir production capacity requires empirical development of the relationship between measures of aboveground productivity and site (soil and topographic) variables. In order to detect and quantify the influence of site variables on stand productivity, the differential effects of stocking and age must be minimized. Sample plots used to define the relationship between stand productivity and site factors were restricted to even-aged, fully-stocked stands. This constraint made it particularly difficult to distribute sample plots over a wide range of soil and topographic conditions.

Field Procedures

During the summer of 1988, fully stocked even-aged spruce-fir stands were located in the northern half of Piscataquis County (Fig. 6). The study area was restricted to a limited geographic area in order to minimize the differential effects of climate on spruce-fir growth. Delineation of climatological zones, based on analysis of Maine weather station data collected during the past 30 years, has not yet been completed.

Potential stands were identified on forest type maps and inspected in the field. Stands

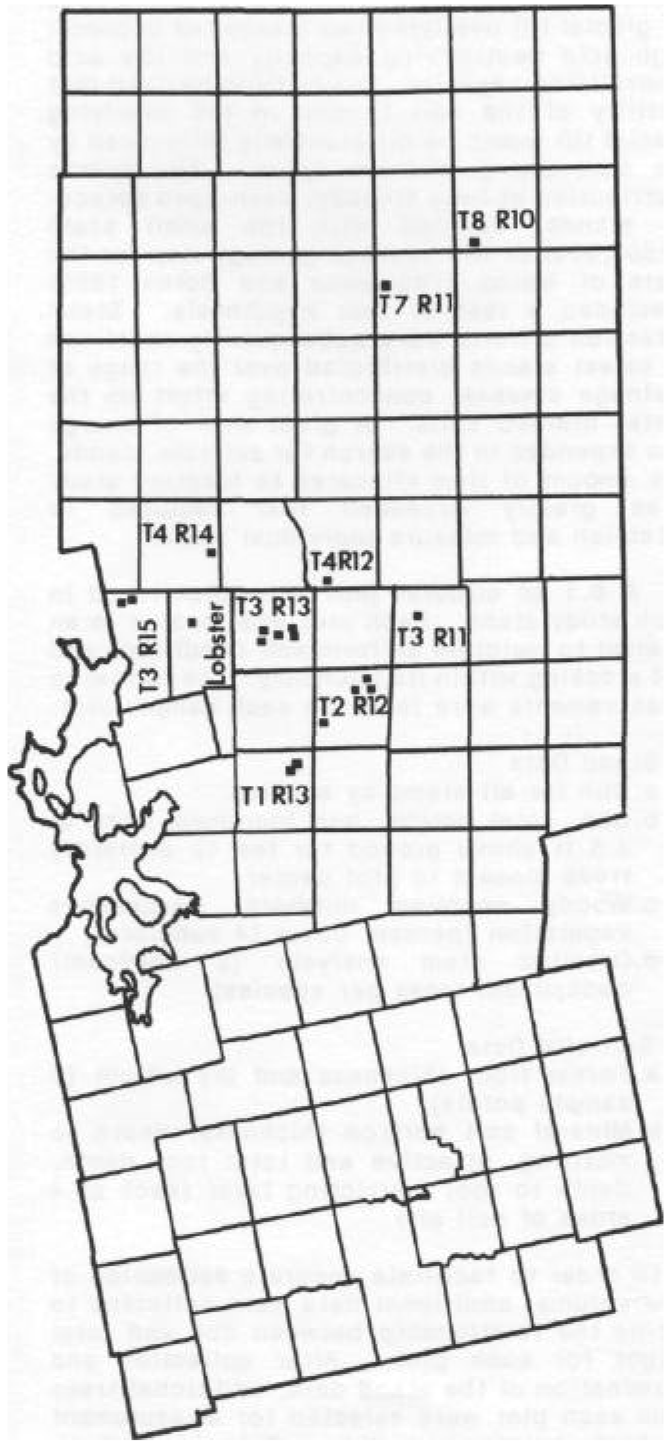


Figure 6. Map of Piscataquis County, Maine, illustrating locations for the 19 sample plots established during 1988.

exhibiting apparent insect and disease problems or cultural intervention were rejected. Initially, an attempt was made to locate stands on glacial till overlying two classes of bedrock: high acid neutralizing capacity and low acid neutralizing capacity. It was hypothesized that fertility of the soil formed in the overlying glacial till would be differentially influenced by the contrasting bedrock types. The sparse distribution of fully stocked, even-aged spruce-fir stands, coupled with the small scale (1:500,000) of the bedrock geology map for the state of Maine (Thompson and Borns 1985) precluded a test of that hypothesis. Stand selection criteria were subsequently redefined to select stands distributed over the range of drainage classes, concentrating effort on the better drained soils. A great deal of energy was expended in the search for suitable stands. The amount of time allocated to locating study sites greatly exceeded that required to establish and measure individual plots.

A 0.1 ac circular plot was established in each study stand. Each plot was located in an attempt to maintain uniform soil conditions and full stocking within its boundary. The following measurements were taken on each sample plot:

I. Stand Data
   a. Dbh for all stems by species
   b. Dbh, total height, and increment core at 4.5 ft above ground for the 10 overstory trees closest to plot center
   c. Woody seedling numbers, herbaceous vegetation [percent cover (4 subplots)]
   d. Detailed stem analysis (2 dominant/codominant trees per species)

II. Soil-site Data
   a. Forest floor thickness and dry weight (8 sample points)
   b. Mineral soil horizon thickness, depth to mottling, effective and total root depth, depth to root restricting layer (each of 4 sides of soil pit)

In order to facilitate accurate estimation of tree volume, additional data were collected to define the relationship between dbh and total height for each plot. After collection and examination of the stand data, additional trees from each plot were selected for measurement of both height and dbh. This insured an adequate data base (distributed over the range of tree sizes on each plot) to define the relationship between dbh and total height.

Individual total tree volumes, computed for all live trees, overstory trees, and merchantable trees (greater than 3.5 in dbh), were summed for each plot and expressed on an area basis. The equations of Reams and Brann (1981) were used to calculate spruce and fir volume, whereas white pine volume was calculated using the equation of Honer (1965). Site index, defined as the height of the dominant/codominant trees at 50 years (breast height age), was obtained directly from each stem analysis sample tree. Average site index values for spruce, fir and combined spruce-fir were computed for each plot.

At the present time, data processing is continuing and soil samples are being prepared for laboratory analysis. A brief summary of the data that have been analyzed is presented below.

Stand Data

Total age of the 19 sample stands ranged from 70 to 120 years, averaging 17 years to reach breast height (Table 1). Total and

Table 1. Mensurational summary for the 19 stands sampled during the summer of 1988.[a]

Stand Variable	Mean	Range
Total age	88	70-120
Breast height age	71	59-106
Basal area (ft^2/ac)	167	123-242
Stems (No./ac)	651	370-920
Mean stand diameter (in)	7.0	5.7-9.3
Site index (ft)		
Balsam fir	45	35-55
Red spruce	49	40-65
Volume m.a.i. (ft^3/ac/yr)		
Overstory trees	56.1	30.0-90.8
Merchantable trees	52.0	26.9-86.7
Free growth volume m.a.i. (ft^3/ac/yr)		
Overstory trees	68.7	45.1-97.0
Merchantable trees	63.6	40.5-92.6

Data exclude suppressed treelTSite index defined as total height attained at 50-years breast height age. Spruce-fir volumes estimated using equations of Reams and Brann (1981), and white pine volume estimated using equation of Honer (1965). Volume m.a.i. = total volume/stump age. Free growth volume m.a.i. = total volume/breast height age.

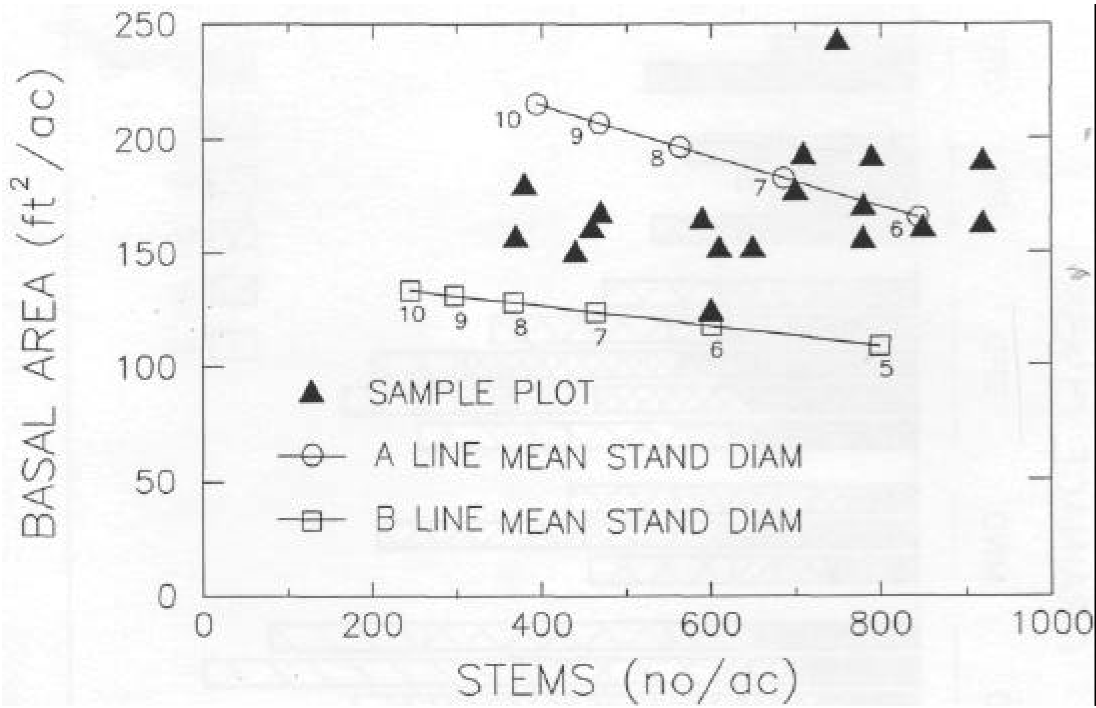


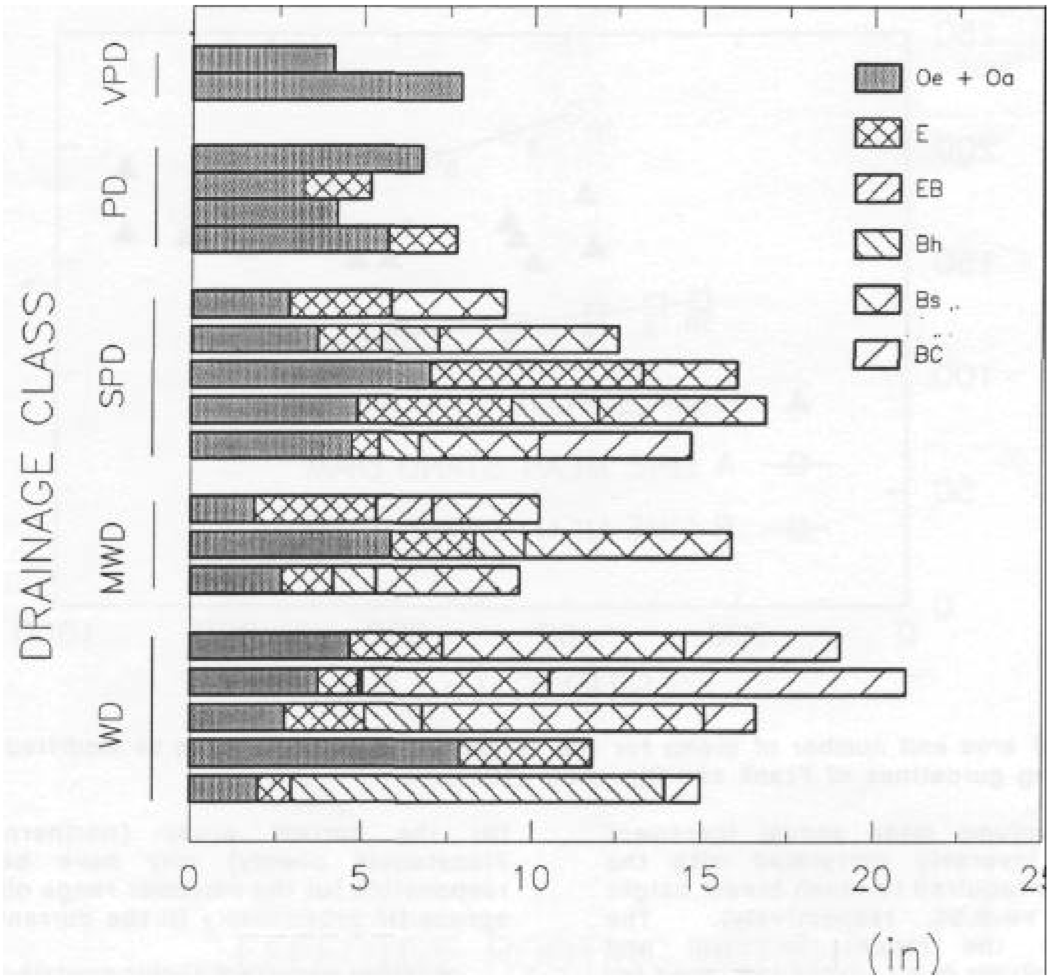
Figure 7. Basal area and number of stems for the 19 sample plots in relation to modified A- and 13-line stocking guidelines of Frank and Bjorkbom (1973).

merchantable volume mean annual increment (m.a.i.) were inversely correlated with the number of years required to reach breast height (r=-0.55 and r=-0.58, respectively). The magnitudes of the ranges in total and merchantable volume m.a.i. exceeded those for spruce and fir site index.

According to the stocking guides developed by Frank and Bjorkbom (1973) and later modified by Solomon ef a/. (1987), sample plots for the current study were well stocked. The A- and B-lines from the stocking guide were superimposed on the graph of basal area versus number of trees in the main canopy for the 19 sample stands (Fig. 7). Eight of the plots were above the A-line, with the remaining plots falling between the A- and B-lines. The ranges in spruce site index (base age 50 years) and total volume m.a.i. observed for the plots sampled in the summer of 1988 (Table 1) were narrower than those reported by Allen (1978) (29.6 - 69.5 ft and 18.6 - 202.6 ft^3/ac/yr, respectively). Allen (1978) analyzed soil-site data collected from 65 plots established in even-aged spruce-fir stands distributed over the northern and western portions of Aroostook county as well as the northern half of Piscataquis county. The smaller sampling area for the current study (northern half of Piscataquis county) may have been partly responsible for the narrower range observed for spruce-fir productivity in the current study.

Another important factor contributing to the narrower range in spruce-fir productivity for the current study was the mid-1970's spruce budworm epidemic. Many potential sample stands, particularly those with a significant fir component, were decimated by the budworm and were not suitable for inclusion into this study. Some of those stands may have been on the better sites. Although stands that were sampled did not exhibit apparent evidence of budworm damage, stem analysis revealed that all of the stands experienced significant reductions in height growth coincident with the mid 1970's budworm epidemic.

In spite of the negative impacts of the budworm, site index data from the 19 sampled stands are reliable. In all cases, the height of the sample trees at 50 years past breast height occurred prior to the budworm outbreak. It may be necessary to evaluate stand volume m.a.i. at the height and age just prior to the budworm attack.



EFFECTIVE ROOTING DEPTH

Figure 8. Effective rooting depth distribution by drainage class and horizon for the 19 sample plots. Drainage classes were: VPD = very poorly drained, PD = poorly drained, SPD = somewhat poorly drained, MWP = moderately well drained, and WD = well drained.

Soil Data

The influence of drainage class on effective rooting depth, defined as the depth within which 95% of the roots were contained, was readily apparent (Fig. 8). Roots were confined to the forest floor of the poorly drained soils, penetrating only a few inches (if at all) into the mineral soil. In contrast, effective rooting depth was greatest in the well drained soils, extending as deep as 17 in into mineral soil. Effective rooting depth was highly correlated with depth to mottling (r=0.80) and with maximum rooting depth (r = .89).

Within drainage classes, there was considerable variation in effective rooting depth. Rooting depths in moderately well and well drained soils were sometimes limited by bedrock or high coarse fragment content.

Contrary to expectations, thickness of the organic (Oe + Oa) horizons did not differ by drainage class (Fig. 8). One possible explanation may be the high variability associated with forest floor thickness within an individual plot. Sample sizes required to estimate forest floor thickness within ten percent of the mean value 95% of the time ranged from 4 to 56.

A significant proportion of the effective rooting depth was accounted for by the organic horizons (Fig. 8). These results coupled with Kraske's (1988) findings that red spruce seedlings exhibited substantially better growth rates in organic relative to mineral soil, emphasize the importance of the forest floor to spruce-fir roots. Analysis of nutrient exchange chemistry for both organic and mineral soil horizons may increase our understanding of the relationship between spruce-fir productivity and site factors.

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SILVICULTURAL TECHNIQUES FOR THE IMPROVEMENT OF TIMBER QUALITY

Dr. William D. Ostrofsky

Partial Cutting In Northern Hardwoods - Evaluation of a Mechanical Harvesting System

As part of a project to study the long-term impact of harvesting techniques on productivity of partially cut stands, Mary Hennessey, M.S. candidate, studied the effects of two harvesting methods on the quantity and quality of trees in the residual stand. Objectives of the study were to (1) evaluate the performance of a mechanical harvesting system (2) compare the mechanical harvesting system with a conventional system (chainsaw - cable skidder), and (3) determine the effect of intensity of harvest (residual basal area) on damage to the residual stand. The mechanical harvesting equipment used was a Caterpillar 205 tracked excavator with a swing-to-bunch, long reach boom equipped with a 15 in shear head (Fig. 9). Machine track width was 8 ft.

The study site is located on Georgia-Pacific Corp. land in Orient Township. The selected hardwood stand represented those which will be harvested over the next few decades with respect to species composition, stem size, and stand density. The stand is composed of sugar maple, beech, yellow birch, ash, and red maple. The mean preharvest basal area was 90 ft^2/ac in stems greater than 5 in dbh. Field plots were established and the stand harvested during the summer of 1988. Peter Caron, CFRU Research Technician, and Univ. New Hampshire forestry student Christina Malitz assisted with the field work. Robert Chandler, Georgia-Pacific Corp., assisted in stand selection and made the harvesting arrangements with appropriate contractors.

Two 5 ac blocks within the stand were selected at random. Sixteen 0.5 X 1.0 chain subplots were established within each block. Each of four subplots in each block represented a marked residual basal area of 40 ft^2/ac or 60 ft^2/ac to be harvested either mechanically or conventionally. The location of each tree greater than 0.5 in dbh in all subplots was mapped prior to harvesting. Milacre plots were established within each subplot to measure advance regeneration.

Harvesting began in early June and was

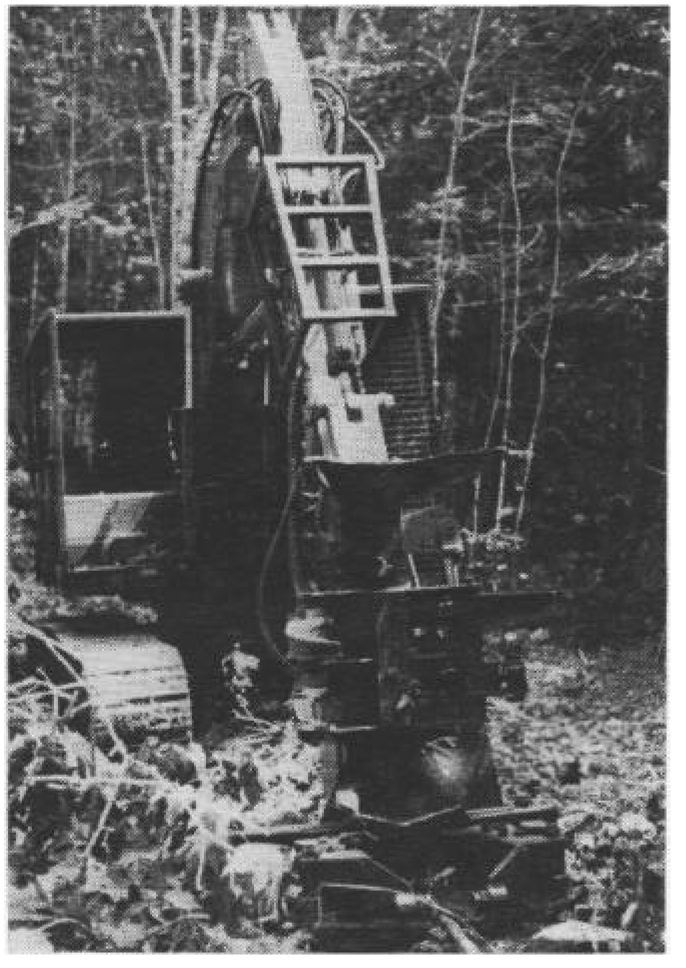

Figure 9. Mechanical feller-buncher used for partial cutting of the northern hardwood stand in Orient Township, Maine.

completed by early August. After harvesting was completed, residual trees were measured for damage, and residual trees, harvested trees, and equipment trail locations were mapped on all subplots (Figs. 10 and 11.). Preliminary data on stand characteristics and damage are shown in Table 2. Complete data analysis is underway, but early results suggest that with lower residual densities, the swing-to-bunch mechanical harvesting system results in substantially less damage to the residual stand than does conventional harvesting. The mechanical system also offers obvious productivity advantages, especially in stands managed primarily for fiber.

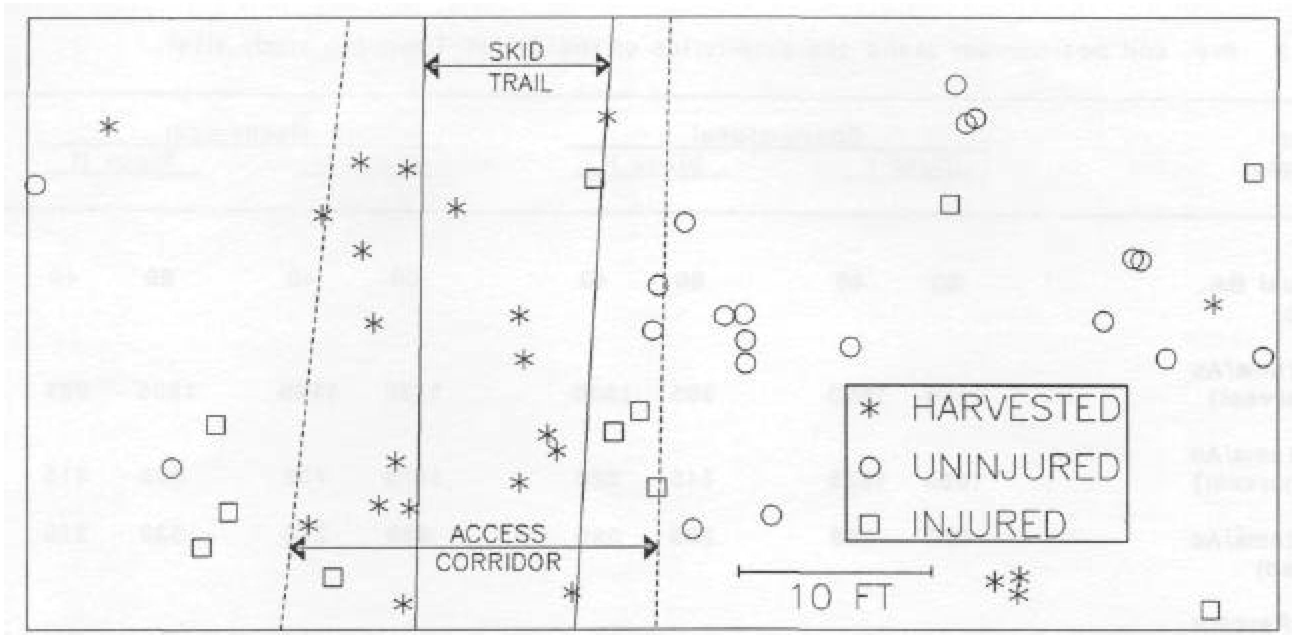

Figure 10. Typical subplot diagram from the mechanical treatment with 40 ft^2/ac of basal area, showing residual, damaged, and harvested stems.

Assessment of Partially Cut Stands - 1987 Survey

Data from the 1987 survey of stands which had been partially cut 10 to 25 years ago was analyzed using the USDA Forest Service model FIBER. Several harvesting (thinning) regimes were tested where residual basal area, species composition and harvesting intervals were varied. Four of the hardwood stands had initial densities between 80 and 110 ft^2/ac, and the two softwood stands contained approximately 104 ft^2/ac.

The model indicated that all the hardwood stands examined could be harvested on a 30-year cutting cycle (60-year rotation) if cut to a basal area of between 40 and 50 ft^2/ac. That is, growth over 30 years will be nearly equal to removals from stands as presently structured. However, volumes removed could be approaching the economic limits, depending on the harvesting system used.

Residual stand density limits for the two softwood stands would be approximately 80 ft^2/ac if a 30 year cutting cycle were desired. The softwood stands, however, were heavily damaged by spruce budworm, so the model is likely overestimating their future growth rates. Both softwood stands were composed primarily of spruce and hemlock. Spruce apparently

Figure 11. Appearance of the stand after the mechanical harvest, 40 ft^2/ac Orient Township, Maine.

Table 2. Pre- and postharvest stand characteristics of the Orient Township study site[3].

Stand Parameter	Conventional				Mechanical			
	Block I		Block II		Block I		Block II	
Residual BA (ft^2/ac)	60	40	60	40	60	40	60	40
No. Stems/Ac (preharvest)	1180	1530	995	1330	1730	1190	1335	925
No. Stems/Ac (postharvest)	1055	1235	845	920	1075	735	635	515
No. Stems/Ac (injured)	190	600	285	595	330	260	330	210
Mean Percent Damaged	16	39	29	45	19	22	25	23

[a] Includes all stems 0.5 in dbh or larger.

recovers from defoliation stress quite slowly. Three general observations were made during the study. First, under some circumstances an acceptable species composition will be difficult to maintain by the partial cutting practice described above. This will be especially true for stands already damaged by spruce budworm, beech bark disease, or other agents. Second, the sustainable harvesting described may not optimize stand productivity. Finally, harvesting systems for softwood and mixedwood stands which minimize the risk from windthrow are needed. Recent experiences with narrow strip cutting in hardwood stands indicates that this system may be well adapted to partial cuts in mixedwood and conifer stands as well.

Lambert Lake Shelterwood Study - Fifth-Year Remeasurement

A regeneration assessment was made of the Lambert Lake shelterwood study established in 1983 on Georgia-Pacific Corp. land. The study is testing the effectiveness of pre- and post-harvest understory herbicide treatments for rehabilitation of northern hardwood stands severely damaged by beech bark disease.

The preharvest treatment included a mist blower application of herbicides to the advance beech regeneration and a frill application to defective beech marked for harvest. The seed cut of the shelterwood harvest was conducted in the fall of 1983. The postharvest treatment included a mist blower application of herbicides to advance beech regeneration and to developing beech root sprouts in 1985, two growing seasons after the seed cut.

Both treatments were successful in establishing adequate desirable regeneration (paper birch, yellow birch, sugar maple, and red maple) and in removing most if not all of the disease-susceptible beech. A comparison of the regeneration of beech to that of desirable species for the preharvest treatment is shown in Figure 12. Regeneration in the postharvest treatment is slightly less, and considerably smaller (because it is two years younger). However, competition from raspberry and other herbaceous weeds is substantially different between treatments. Such competition is greatly reduced in the postharvest treatment compared with that in the preharvest treatment (Figs. 13 and 14). Additional sprout regeneration of desirable species will also be added to the stocking in both treatments after the removal harvest of overstory trees, planned for the winter of 1989-90.

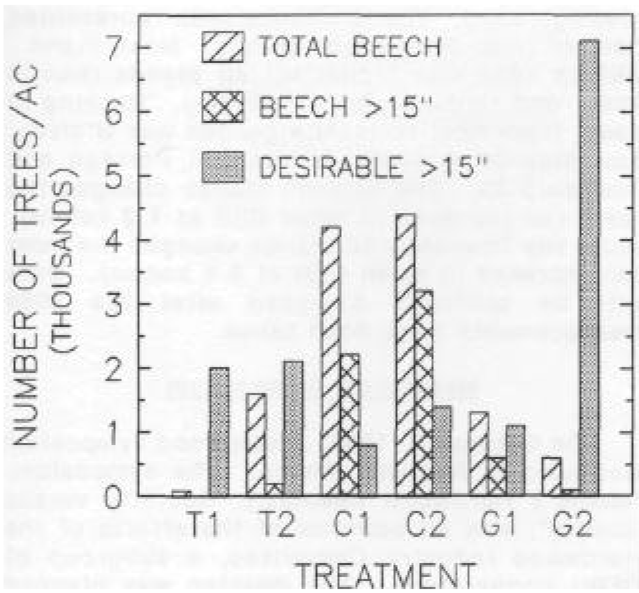

Figure 12. Regeneration five years after preharvest application of herbicides to a northern hardwood stand, Lambert Lake, Maine. Triclopyr treatments = T, Glyphosate treatments = G, Control (no treatment) = C. Replicates indicated by numbers after treatment letters.

This study has demonstrated the advantages of both treatments. Application of herbicides prior to harvesting allows new regeneration to become established quickly. Seedbed conditions at this time are likely to be optimal, especially for the desirable species intermediate in shade tolerance. Advantages of postharvest application of herbicides includes reduced competition from raspberry, elimination of the frill application procedure, and increased ease of maneuvering spray equipment within the harvested stand.

Shlgometer™ Studies

Whole-tree Harvested Sites

Cambial electrical resistance (CER) measurements were again taken on all residual crop trees in permanent plots at the Grafton and South Bridgton whole-tree harvested study sites established in 1984. A total of 540 trees (primarily yellow and paper birch) at the Grafton site, and 275 trees (primarily beech and red oak) at the South Bridgton site have been measured annually since project initiation. A complete analysis of the CER data is planned after the 1989 measurements have been taken.

Figure 13. Milacre plot showing typical regeneration conditions five years after preharvest treatment with glyphosate, Lambert Lake, Maine.

Figure 14. Milacre plot showing typical regeneration conditions three years after postharvest treatment with glyphosate, Lambert Lake, Maine.

This year, mortality was encountered in the plots for the first time (excepting windthrow which occurred soon after the thinning). At Grafton, five trees (0.92%) had died since last year; three yellow birch and 2 paper birch.

None of the trees were in the unthinned control plots. While data are too few for adequate analysis, three of the trees had a 1987 CER of slightly more than twice their 1984 (preharvest) CER. In addition to the mortality, numerous trees had noticeable branch dieback, as well. No mortality or crown dieback symptoms were encountered on study trees at the South Bridgton site.

Red Spruce Vigor

CER measurements were also taken on over 1500 red spruce from twelve different stands representing six different locations. The CER measurements will be used to determine rate of stand recovery and/or decline resulting from different levels of defoliation damage caused by the spruce budworm. Little or no defoliation has occurred in these stands since 1985, when chemical control applications were last used. All trees have been measured annually for CER since 1985.

In 1985, the stands were ranked in the following order by CER, from most to least vigorous: Township-30, Grafton, Kossuth, Portage, Beddington, and Township-36. Three levels of vigor could be statistically distinguished. The Grafton stands represented control (non-defoliated) stands. Mean stand CER in 1988 was higher for all stands than in 1985, and ranking shifted slightly. Ranking in 1988, from most to least vigorous was Grafton, Township-30, Kossuth, Beddington, Portage, and Township-36. The Grafton stands changed the least (an increase in mean CER of 1.2 kohms), while the Township-36 stands changed the most (an increase in mean CER of 3.8 kohms). Data will be critically analyzed after the 1989 measurements have been taken.

Hardwood Symposium

On October 6, 1987, a hardwood symposium was held in Augusta, Maine. The symposium, "Maine's Hardwood Resource: Quantity versus Quality", was an outcome of the efforts of the Hardwood Industry Committee, a subgroup of CFRU cooperators. The meeting was planned and conducted with the assistance of Dr. Chris Murdoch of the Professional Development Office, College of Forest Resources. Nine papers were presented, followed by a brief summary from each of five state and forest industry representatives. Approximately 150 people attended the conference.

TREE IMPROVEMENT

Dr. Michael S. Greenwood and Dr. Katherine K. Carter

Larch Breeding Program

In its early years, tamarack is the fastest growing conifer in the Northeast, and there are indications that exotic larch species (Japanese and European) and hybrids (Japanese X European) grow even faster on good sites. Larches are, therefore, prime candidates for short rotation conifer plantations in Maine. A larch breeding program is currently under way at the University of Maine.

Scions from 6 select tamarack, 6 select Japanese and 6 select European larch were grafted onto rootstock in February, 1987. The selections were provided by International Paper Corp., Scott Paper Co., and the Univ. of Maine. These trees (a total of 60) form an indoor, potted breeding orchard. Information from one of our prototype indoor tamarack orchards shows that flowering can be expected three years from grafting. The first crosses both intra- and interspecies will be made in 1990.

Progeny tests will subsequently be established, including an indoor, accelerated test as well as traditional outdoor tests at several locations. The seedlings will first be vegetatively multiplied, providing clones for use in tests and eliminating genetic differences between test locations. The goal will be to identify single-species and hybrid families, or even specific individuals, that show exceptional growth characteristics. Wood properties and frost hardiness will also be considered. These progeny tests will not only yield genetic information but will also provide an opportunity to refine vegetative propagation and early plantation management techniques. The improved stock, along with the knowledge acquired, will then be available as a "package" to those interested in fast growing, uniform plantations. Depending on the success of and continued interest in the larch breeding program, it can be continued to advanced generations. It may also be expanded to include more selections and new species such as Siberian and Western larch.

Breeding and Seed Collection

Some preliminary experiments in larch breeding were carried out in the spring of 1988. A total of 77 crosses were made in the prototype indoor breeding orchard. Pollen was also collected from tamarack, Japanese larch and Japanese X European hybrid larch and used to make several intra- and interspecies crosses outdoors, including Tamarack X Japanese, Tamarack X Hybrid, and Japanese X Hybrid back-cross. Open pollinated seed from tamarack, Japanese and hybrid larches was collected in the fall of 1988. Seed from Siberian and Western larch was also obtained. Seed from all these seedlots will be germinated in November of 1988 and a field test planted in the Penobscot Experimental Forest in the spring of 1989.

Flower Stimulation

In any tree breeding program, the time from grafting to flowering to selection should be shortened as much as possible. To facilitate this, a flower induction experiment was carried out on the indoor tamarack orchard and repeated in a young tamarack plantation consisting of two to three-year old seedlings, rooted cuttings and grafts of the same families that are in the indoor orchard.

Gibberellins effectively stimulate flowering in conifers and are often used in conjunction with other treatments such as drought, root pruning, and greenhouse culture to promote early flowering in breeding orchards. Gibberellin (GA 4/7) was applied as a foliar spray every two weeks, starting at two different times (approx. four and eight weeks after bud burst indoors, four and six weeks outdoors) and continuing for three different periods of duration (8, 12 and 16 weeks). The GA concentration was 200 mg/l. and the foliage was sprayed until wet using a hand-held mister. Individual branches, were sprayed, so that individual trees serve as blocks in a randomized complete block design. In addition to this, half of the potted trees were root pruned in early June. A third population, consisting of three-year-old potted tamarack grafts kept outside, received a single stem injection of approximately 100 mg of GA 4/7 per tree on July 3, 1988. Flower buds will be counted in spring of 1989. Results will help determine whether and/or how gibberellin will be applied to the breeding orchard in 1989.

GROWTH AND YIELD PROGRAM

Dr. Robert S. Seymour

Site Index-Stand Development of Red Spruce

Mary Ann Fajvan, Ph. D. student, completed the second season of field work in a study of the relationship of site index and soil quality with the development and yield of mixed conifer stands in eastern Maine. This study is funded by a special grant from Champion International. The objectives are:

1. Analyze the effect of soil quality, stand development history, and spruce budworm defoliation on site index of red spruce;

2. Derive empirical yield relationships for red spruce as influenced by soil-site characteristics; and

3. Assess the validity of the TWIGS growth model (Northeast version 1.0) in predicting development of the sampled stands.

Data were obtained during the 1987-88 field seasons from 367 permanent growth plots that were established on Champion timberlands in 1977 and remeasured in 1983. At each plot, breast height increment cores were taken from three dominant red spruce; total heights were also measured. Trees with no history of growth suppression were preferred; if no such trees were available, the most dominant stems were sampled regardless of their growth history. Balsam fir were selected where no suitable spruce were available. Soil quality was assigned to one of three classes (good, fair or poor) by visual assessment of the soil profile; soil drainage, rooting depth, and thickness of the organic horizon were the main criteria. Increment cores were measured in the laboratory to determine age and growth history. Heights and ages were then used to calculate site index using USDA Forest Service equations (Scott and Voorhis 1986). Average stand volumes from the 1977 and 1983 measurements were plotted over stand ages (as derived from the increment cores) to produce empirical yield curves for the red spruce component of the sampled stands. On a subsample of these plots, 106 spruce, 23 fir and 20 hemlock trees were stem-analyzed at 5-ft intervals to characterize height-development patterns, check the validity of the site index equations, and estimate growth reduction from the recent spruce budworm outbreak.

Analysis of information from the stem-analyzed trees is underway. Preliminary results from the increment core and soils data for red spruce are:

1. Although calculated site indices are significantly higher on "good" soils than "poor" ones, the practical difference is small. Much variation in site index exists within each soil group (Table 3).

2. Stand development history makes surprisingly little difference in site index estimates obtained from dominant stems. Trees with various histories of growth suppression (as evidenced by narrow rings on the increment cores) had site indices that averaged virtually the same as those of trees that grew freely since reaching breast height (Table 4).

3. Yields of red spruce exhibited the expected increasing pattern from ages 25 through 85 (Fig. 15). After age 85, volumes per acre showed an apparent decline, contrary to the actual growth of the plots which was positive in all age classes. Average growth rates also varied widely within age classes, but were surprisingly similar over the range in age.

Early Development of Released Spruce-Fir Stands

Xiandong Meng, Ph.D. student, has completed field work in a comprehensive study of the growth and development of young, even-aged spruce-fir. Twelve study sites were located on Great Northern Paper timberlands in the Telos area in stands that originated after clearcutting from 1974-76 and were treated with herbicide in 1982-83. Sites were equally distributed between well drained and poorly drained soils to quantify the effects of soil drainage on vegetation development and productivity. Drainage was initially classified by visual assessment of the profile and was confirmed by weekly monitoring of soil wells throughout the 1988 growing season. All above-ground vegetation was measured on ten

Table 3. Site index (SI) of free-growing red spruce and balsam fir by soil quality.

Species	Soil Quality: Good	Fair	Poor
Red Spruce			
Mean SI[a], ± SE	42.3 ± 1.24	40.7 ± 0.4	38.6 ± 0.52
No. Obser.	35	193	110
Range	29.0 - 59.0	21.0 - 57.0	24.0 - 55.0
Balsam Fir			
Mean SI[a], ± SE	53.4 t 2.7	48.8 ± 1.65	0.6 ± 3.0
No. Obser.	18	48	14
Range	32.0 - 86.0	23.0 - 84.0	30.0 - 68.0

[a] Height in feet at a total age of 50, as calculated from the equations of Scott and Voorhis (1986). SE = Standard error.

Table 4. Site index (SI) of red spruce according to stand development history ("Fair" soils only; total ages of suppressed trees adjusted to free-growth equivalents).

Growth History	Mean SI (± 1 SE)	No. Observ.
Free Growing	40.7 ± 0.4	193
Suppression during 1912-20 spruce budworm outbreak only	41.1 ± 0.6	45
Initially suppressed followed by free growth	41.1 ± 1.2	27
More than one period of growth suppression	38.9 ± 0.8	37

0.001 hectare plots per site; ten plots on each drainage class were then destructively sampled to determine above-ground biomass by component, age structure, and early growth patterns. Samples are currently being weighed and analyzed; preliminary summaries show the distribution of sampled trees by height and basal diameter on each drainage class (Fig. 16).

Regional Cooperative Project on Quantitative Silviculture

A proposal to establish a regional cooperative in quantitative silviculture was completed by regional committee NEC-71 which I have chaired since its inception in June, 1987. This proposal (currently in review) is the outgrowth of the successful workshop held in January, 1987 (Seymour and Leak 1987). If approved, the proposal would establish a cooperative that includes scientists from eight State experiment stations, the USDA Forest Service, industrial timberland owners (through the CFRU), and public agencies throughout the Northeast. The initial goals of the 3-year project are to thoroughly test, validate, and modify as needed, two recently released stand development simulation models: FIBER (a stand-table projection model developed by Dale Solomon of the USDA Forest Service) and NE-TWIGS (a distance-independent, individual-tree model developed originally in the Lake States and modified for the Northeast by Don Hilt of the USDA Forest Service). The cooperative is also designed to serve as the clearinghouse for growth and yield data via a new staff position to be created at the University of Maine.

Timber Supply Modelling and Analysis

The analysis of Maine's future timber supplies, carried out with funding from the

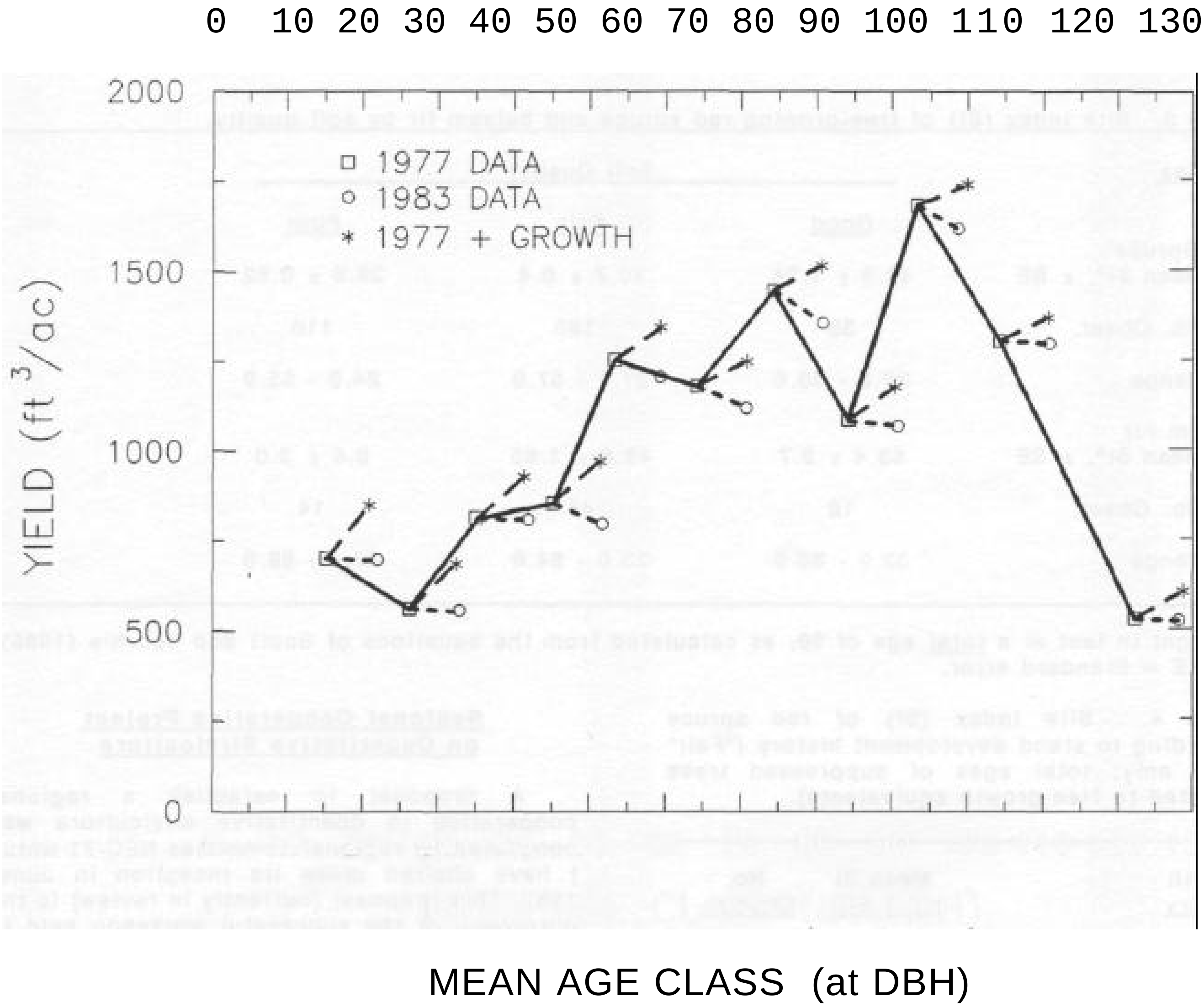

Figure 15. Empirical yield curves for red spruce derived from two successive measurements (1977 and 1983) compared to the next six-year growth of the original (1977) sample.

Maine Department of Conservation's Forest For the Future Program, was completed and presented to several groups. The publication describing the results is currently in press, and should be available late in 1988. I also completed an analysis of the structure and development of Maine's northern hardwood resource, which was presented as the keynote address at the conference "Conflicting consequences of practicing northern hardwood silviculture" in Durham, N.H. during June, 1988.

This paper will appear in the meeting proceedings, which are also currently in press.

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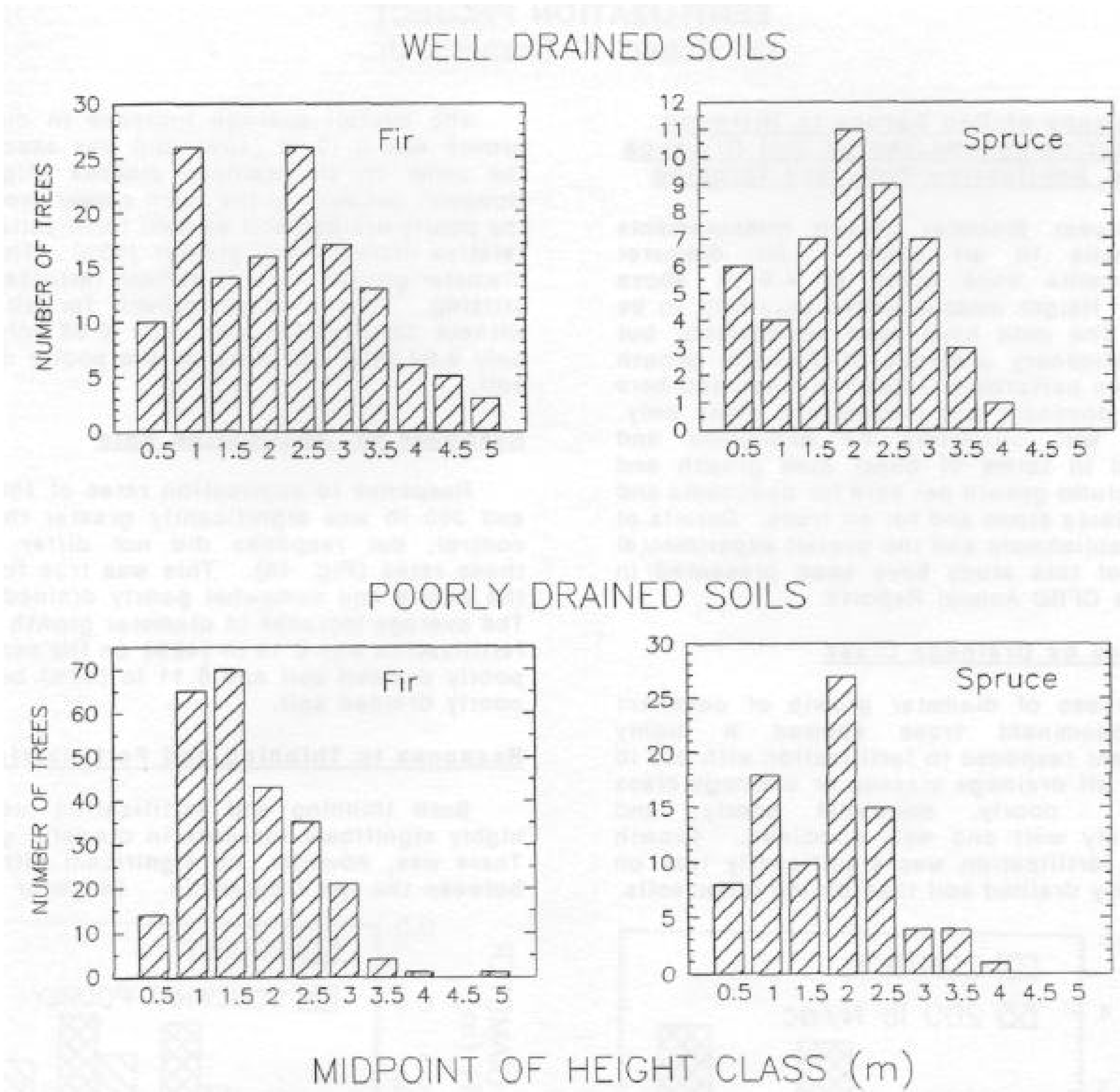


Figure 16. Comparison in height distribution of balsam fir and red spruce sample trees between well drained and poorly drained soils (10-12 year-old stands in northcentral Maine released by an herbicide treatment of competing brush at age 5-7).

FERTILIZATION PROJECT

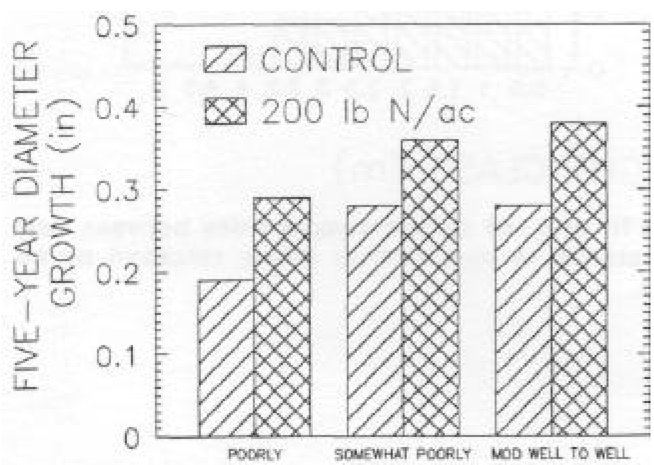
Dr. Robert K. Shepard, Jr.

Response of Red Spruce to Nitrogen Fertilization as Affected by Soil Drainage Class. Application Rate, and Thinning

Five-year diameter growth measurements were made in all plots. All diameter measurements were taken at 4.5 ft above ground. Height measurements were still to be made. The data have been summarized, but only preliminary analyses of diameter growth have been performed. Results presented here are for dominant and codominant trees only. Results will ultimately be expressed and analyzed in terms of basal area growth and cubic volume growth per acre for dominants and codominants alone and for all trees. Details of plot establishment and the overall experimental design of this study have been presented in previous CFRU Annual Reports.

Response by Drainage Class

Analyses of diameter growth of dominant and codominant trees showed a highly significant response to fertilization with 200 Ib N/ac on all drainage classes or drainage class groups: poorly, somewhat poorly, and moderately well and well combined. Growth without fertilization was significantly less on the poorly drained soil than on the other soils.



DRAINAGE CLASS

Figure 17. Diameter growth at breast height of dominant-and codominant red spruce in stands on three drainage classes treated with nitrogen.

The overall average increase in diameter growth was 0.10 in (40%) and was essentially the same on all drainage classes (Fig. 17). However, because of the much slower growth on the poorly drained soil without fertilization, the relative increase was greater (53%). The poor diameter growth, with or without fertilization is striking. The average growth for all plots without fertilization was only 0.05 in/yr and only 0.04 in/yr for plots on the poorly drained soil.

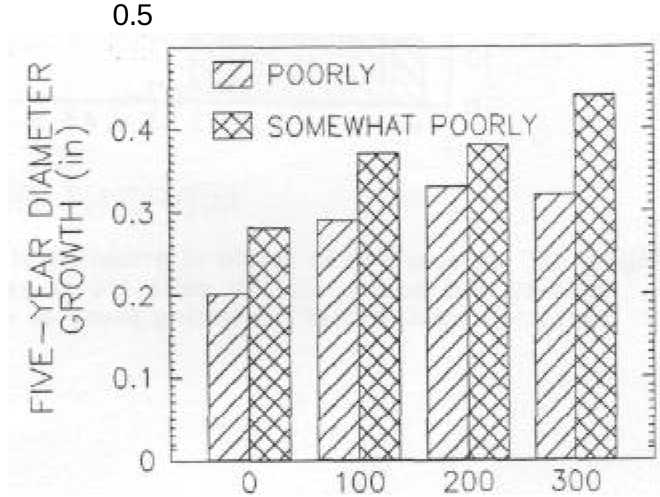
Response vs. Application Rate

Response to application rates of 100, 200, and 300 Ib was significantly greater than the control, but response did not differ among those rates (Fig. 18). This was true for both the poorly and somewhat poorly drained soils. The average increase in diameter growth due to fertilization was 0.12 in (42%) on the somewhat poorly drained soil and 0.11 in (58%) on the poorly drained soil.

Response to Thinning and Fertilization

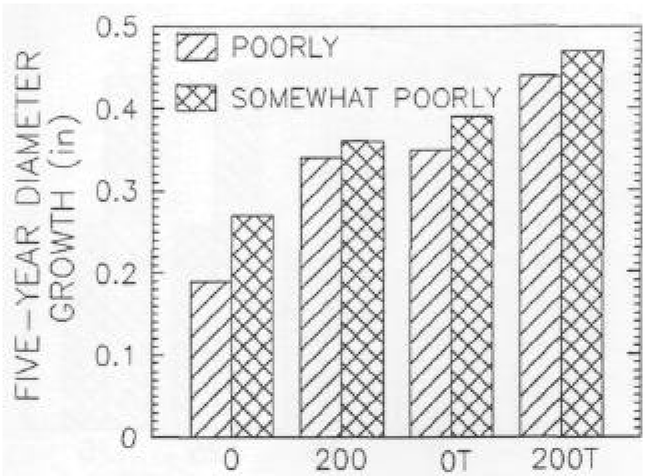
Both thinning and fertilization led to a highly significant increase in diameter growth. There was, however, no significant difference between the two treatments. Diameter growth

0.5



TREATMENT (Ib N/ac)

Figure 18. Diameter growth at breast height of dominant and codominant red spruce in stands on two drainage classes treated with nitrogen.



TREATMENT (lb N/ac) Figure 19. Diameter growth at breast height of dominant and codominant red spruce in stands subjected to fertilization and thinning on two soil drainage classes (0 = 0 lb N/ac; 200= 200 lb N/ac; T= thinned).

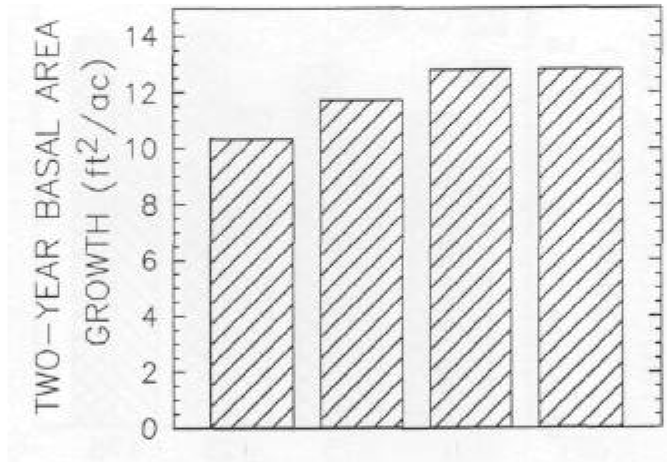
of dominants and codominants treated with 200 lb N/ac was virtually the same as that of trees from the thinned plots (Fig. 19). The combination of thinning plus fertilization was better than either treatment alone but was not equal to the sum of the increases caused by each of the treatments.

Response of Eastern White Pine to Nitrogen Fertilization as Affected by Application Rate. Soils, and Stand Category (Poletlmber vs. Sawtimber)

Analyses of two-year diameter measurements made in 1987 were completed and four-year measurements were made in 12 stands. All diameter measurements were taken at 4.5 ft above ground. Height measurements were made in some of those stands. Results presented here are from analyses of the two-year measurements.

Response vs. Application Rate

The effect of nitrogen on two-year basal area growth was highly significant. Response to 75 lb/ac was significantly greater than the control. Response to both 125 and 175 lb/ac was significantly greater than response to 75 lb/ac, but the difference between the two was not significant. The general relationship between response and application rate was curvilinear (Fig. 20).



0 75 125 175

TREATMENT (lb N/ac)

Figure 20. Basal area growth of white pine stands treated with nitrogen.

Response on Different Soils

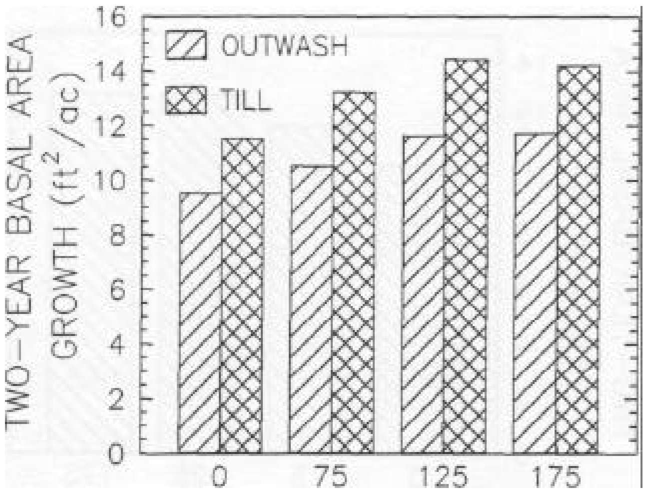
The difference between response on till soils and outwash soils was not significant, although response was somewhat greater on the till soils (Fig. 21). However, growth overall was significantly greater in stands on the till soils (13.3 ft^2/ac vs. 10.8 ft^2/ac).

Response by Stand Category

Growth was significantly greater in poletimber stands than in sawtimber stands (15.0 ft^2/ac vs. 8.7 ft^2/ac), but response between the two types of stands was not significantly different. It appears, however, that response may ultimately prove to be greater in the poletimber stands, especially at the higher application rates (Fig. 22). For example, in the poletimber stands growth at both 125 and 175 lb/ac was 3.0 ft^2/ac greater than at 0 lb/ac, whereas in the sawtimber stands growth at the same application rates was respectively, 2.1 and 2.2 ft^2/ac greater than the control.

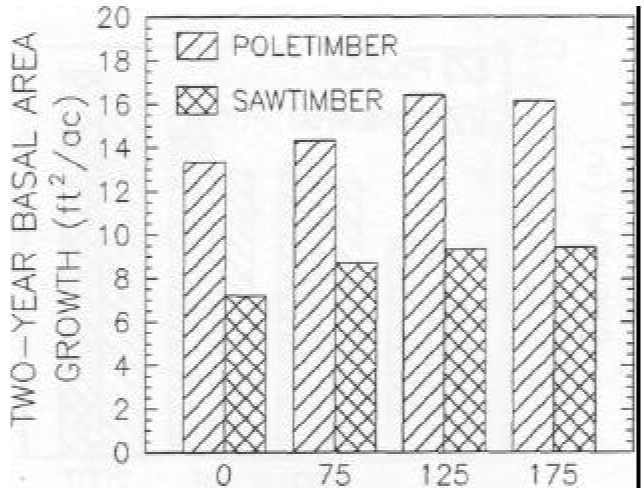
Sludge - Ash Work

Plots were established in two clearcut areas recently planted to black spruce. The primary objectives of this study are to determine the effects of:



TREATMENT (lb N/ac)

Figure 21. Basal area growth of white pine stands treated with nitrogen on till and outwash soils.



TREATMENT (lb N/ac)

Figure 22. Basal area growth of white pine poletimber and sawtimber stands treated with nitrogen.

1. Different application rates, and
2. Different times of application, and different numbers of successive years of application on:

   a. seedling growth,
   b. growth of competing vegetation,
   c. soil characteristics, and
   d. soil water (especially nitrate concentrations).

Treatments were applied during late May, early August, and early October. Growth measurements and sampling of competing vegetation were begun in plots treated in late May. Although statistical analyses of data from the first year of this study will not be completed for some time, measurements and field observations from plots treated in May suggest no positive effect on seedling growth and an increase in the amount of herbaceous vegetation as application rates increased. The early August and early October applications would not be expected to have any effect yet on either 1988 seedling growth or growth of competing vegetation.

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

Dr. Alan S. White

Introduction

Strip clearcutting has been used operationally in Maine for 20 years or more. Although this approach has often been successful in reducing harvesting costs, there have been problems with windthrow in the residual strips and with obtaining adequate regeneration in the cut strips. Most previous strip clearcutting was done with quite wide strips; consequently, little information is available for narrow strip clearcutting. This study, conceived and initiated by John Bryant and Michael Coffman of Champion International Corp., was based on the belief that narrow strips would minimize windthrow while resulting in successful regeneration of spruce and balsam fir.

The specific objectives of this project are to:

1. Determine if narrow (30 ft and 50 ft) strip clearcuts result in successful regeneration by red spruce and balsam fir.
2. Determine the effects of narrow strips on regeneration by other species, both commercially valuable species such as white pine and less valuable species such as red maple.
3. Monitor the amount of windthrow in residual strips (60 ft and 100 ft).

Materials and Methods

This study was installed on two mixed softwood pole stands on Champion International Corp. land in T30 MD. To reduce confounding of strip-width effects with site effects, the stands were chosen to meet the following guidelines:

a) spruce-fir basal area was >. 60%
b) softwood stand and size/density class were 3A (Champion classification)
c) sites were comparable in quality, aspect, and exposure
d) each stand was >. 40 acres

Harvesting was conducted uniformly on both sites to the following specifications:

a) strips had an east-west orientation
b) maximum harvest removal was 35%
c) harvesting was done with a feller-buncher, with delimbing at the yard
d) machine travel was restricted to the cut strips

Harvesting was conducted in May 1986 on Site 1 and in December 1986 on Site 2. Although the original intention was to harvest both sites at the same time, a fire which destroyed the original location for 30 ft cut strips resulted in a later harvest on Site 2. Thus, any comparisons between the two sites must be made with the recognition that time of harvest as well as strip cut width might be influencing results.

Sampling transects were established at 25 randomly chosen locations on each site. Transects started at the south edge of the cut strip and finished at the north edge of residual strips. Along each transect, permanent fixed radius mil-acre plots were established. On Site 1, nine such plots were established, four in the cut strip and five in the residual strip. On Site 2, which had the narrower cut (30 ft) and residual (60 ft) strips, only seven regeneration plots were established, three in the cut strip and four in the residual strip. All regeneration in each milacre plot was recorded by species and by height class (0-3.5 in, 3.6-6.5 in, 6.6-12.5 in, 12.6+ in) for each year of the study. The seedbed of each plot was characterized by its dominant (>. 50% coverage) feature in the first year: brush accumulation, standing water, rocks, bare mineral soil, or organic pad.

Two permanent fixed radius fiftieth-acre plots were established in the residual strips along each transect to monitor windthrow. On Site 1 these plots coincided with regeneration plots 6 and 8 whereas on Site 2 these plots were located to the north and to the south of the transect line. On each plot during the first year, all merchantable stems were numbered and recorded as to species, dbh, vigor (excellent, good, poor, and cull), and crown position (open-grown, dominant, codominant, intermediate, suppressed, oppressed). In subsequent years, the status of these trees were recorded by the following categories: no change, blown down, mortality (insect, wind-damaged, other), or other if applicable.

Progress

The original field work on this project, from harvesting through plot establishment and the first plot measurements, was conducted by personnel from Champion International Corp. My involvement began in September 1987, at which time student employees began collecting regeneration data and windthrow data. Data collection for 1987 was completed in early November whereas data collection in 1988 was completed in late September.

None of the data collected by Champion personnel had been put on the computer at the time I took over this project. After we collected the 1987 data, all the data (from regeneration plots and from windthrow plots for both years) were entered into Lotus 1-2-3 worksheets. This data will continue to be entered in the same format each year.

Because so little time has passed since the strips were harvested, it is premature to present results. Full statistical analyses will be done at the end of the project, after four years of data have been collected. At that time, tests will be run to determine how regeneration by species and size class have changed over time on cut and uncut strips. Windthrow data will be similarly analyzed.

1988 PUBLICATIONS RESULTING FROM RESEARCH SUPPORTED BY THE CFRU

Briggs, R. D., J. Porter and E. H. White. ____. Component biomass equations for *Acer rubrum* and *Fagus grandifolia.* Faculty of Forestry, Misc. Publication, SUNY College of Environmental Science and Forestry, Syracuse, New York, *in press.*

Carter, K. K., D. H. Dehayes, M. E. Demerrit, Jr., R. T. Eckert, P. W. Garrett, H. D. Gerhold, J. E. Kuser, and K. C. Steiner. _____. Tree improvement in the Northeast: Interim summary and recommendations for selected species. Maine Agric. Tech. Bull. 131, Univ. of Maine, Orono. *in press.*

Carter, K. K. 1988. Genetic differences among white spruce families. Plant Biology Letter No. 3, Fall 1988. Dept. of Botany & Plant Path., University of Maine, Orono, 2 pp.

Goodwin, A., and R. Shepard Season and drainage class effects on foliar nutrient concentrations of red spruce advance regeneration. Maine Agric. Expt. Stn. Misc. Rept. 329. 13 pp. *in press.*

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McCormack, M. L., Jr. 1988. Presidential address to the Northeastern Weed Science Society. Suppl. Proc. Northeast. Weed Sci. Soc. 42:6-10.

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McCormack, M. L., Jr. ___ . Silviculture sets the scene for the next forest stand of conifers. Proc. 31st Northeastern Forest Tree Improvement Conf. *in press.*

Newton, M., E. C. Cole, D. E. White, and M. L. McCormack, Jr. 1988. Long-term efficacy of herbicides for releasing spruce-fir. Weed Science Society of America 28:34. (Abstract No. 94).

Nowak, C. A., R. D. Briggs, E. H. White and H. A. I. Madgwick. 1988. Changes in weight-dimension relationships of *Pinus resinosa* over time. Faculty of Forestry, Misc. Publication ESF 88-005. SUNY College of Environmental Science and Forestry, Syracuse, New York. 18 pp.

Ostrofsky, W.D., T. Rumpf, D. Struble, and R. Bradbury. 1987. Incidence of white pine blister rust in Maine in areas with and without *Ribes* control. Phytopathology 77:1617-1618. (Abstract).

Ostrofsky, W. D. (ed.) 1988. Proceedings, Maine's Hardwood Resource: Quantity versus Quality, Markets - Management. Maine Agric. Expt. Stn. Misc. Rept. 327. 52 pp.

Ostrofsky, W. D. 1988. Improving tree quality and forest health by reducing logging injuries, pp. 29-35 *in* Proceedings, Maine's Hardwood Resource: Quantity versus Quality, Markets - Management. Maine Agric. Expt. Stn. Misc. Rept. 327. 52 pp.

Ostrofsky, W. D., T. Rumpf, D. Struble, and R. Bradbury. _____ . Incidence of white pine blister rust in Maine after seventy years of a *Ribes* eradication program. Plant Disease *in press.*

Ostrofsky, W. D. The health of northern hardwoods in relation to timber management practices, *in* Conflicting Consequences of Practicing Northern Hardwood Silviculture. Proc. SAF Regional Tech. Conf. June 9-10, 1988, Univ. N. H., Durham, *in press.*

Ostrofsky, W. D., and D. R. Houston. ________. Harvesting alternatives for stands damaged by the beech bark disease, *in* Proc., 1988 SAF National Convention, Oct. 16-19, Rochester, N.Y. *in press.*

Schaertl, G. R., D. I. Maass, and M. L. McCormack, Jr. 1988. Results from a volume delivery/droplet size study with aerially applied glyphosate. Suppl. Proc. Northeast. Weed Sci. Soc. 42:68-73

Seymour, R. S. and R. C. Lemin, Jr. 1988. Adapting FORMAN for timber supply analysis in Maine, pp. 896-903 *in* Forest Growth Modelling and Prediction (Vol. 2), Proc. IUFRO Conf. Aug. 23-27, 1987, Minneapolis, MN. USDA Forest Service Gen. Tech. Rep. NC-120. 1149 pp.

Seymour, R. S. and W. B. Leak, (eds). 1987. Proceedings of the New England Growth and Yield Workshop. Maine Agric. Expt. Stn. Misc. Rept. 325. 82 pp.

Seymour, R. S. . The northern hardwood resource: some silvicultural implications of its historical development and current structure, *in* Conflicting Consequences of Practicing Northern Hardwood Silviculture. Proc. SAF Regional Tech. Conf. June 9-10, 1988, Univ. N. H., Durham, *in press.*

Seymour, R. S. and R. C. Lemin, Jr. ________. Timber supply projections for Maine, 1980-2080. Maine Agric. Expt. Stn. Misc. Rept. *In press.*

Seymour, R. S. 1988. Silviculture and Maine's future forest, pp. 22-23 *In* The Maine Forester. 98 pp.

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Shepard, R., M. Blumenstock, and G. Reams 1988. Fertilization results in improved growth of white pine in Maine. Coop. Ext. Serv., Univ. Maine, Orono. 4 pp.

Smith, C. T., J. W. Hornbeck and M. L. McCormack, Jr. 1988. Changes in nutrient cycling following aerial application of triclopyr to release spruce-fir. Proc. Northeast. Weed Sci. Soc. 42:94-99.

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Steiner, K. C., M. W. Williams, D. H. DeHayes, R. B. Hall, R. LT. Eckert, W. T. Bagley, W. A. Lemmien, D. F. Karnosky, K. K. Carter, and F. C. Cech. 1988. Juvenile performance in a range-wide provenance test of *Fraxinus pennsylvanica* Marsh. Silvae Genet. 37:104-111.

White, A. S. 1988. Competition effects in hardwood stands. pp. 18-21 *in* Proceedings, Maine's Hardwood Resource: Quantity versus Quality, Markets-Management. Maine Agric. Expt. Stn. Misc. Rept. 327. 52 pp.

ADDITIONAL TECHNOLOGY TRANSFER ACTIVITIES BY CFRU PERSONNEL

Briggs, R. D. Site quality evaluation: a proposed research program for Maine. Seminar presentation, Great Northern Paper, Millinocket, ME. April 26, 1988.

______ Testing dependent variables for Allegheny hardwood soil-site evaluation. Seminar presentation, Plant and Soil Department, Univ. Maine, Orono, ME. April 27, 1988.

______ Estimating biomass and nutrient removals from whole-tree harvested sites by sampling chip trailers. Proposal submitted to: Office of Energy Resources, August, ME. May 16, 1988.

______ Site quality evaluation in Maine. Field tour for Maine Chapter SAP Summer Meeting. July 14, 1988.

Greenwood, M. S., and C. W. Murdoch. Symp. Coords., The effects of foreign competition on Maine's forest industries: State, University, and Industry concerns. January 7, 1988. Univ. Maine, Orono, ME. [College of Forest Resources Internal Rept., 18 pp.]

Jones, S. B., E. H. White and R. D. Briggs. 1988. Measuring productivity selection of appropriate dependent variables. Poster presented at 7th North American Forest Soils Conference, Vancouver, BC. July 24-28, 1988.

McCormack, M. L, Jr. Seminar. Forest management in the Federal Republic of Germany. Univ. of Maine, Orono, ME. January 26, 1988.

______ Chemical use for Christmas tree management. Forestry Seminar Series. Univ. of Maine at Machias. February 17, 1988.

______ Efficacy of herbicides. Assessment Workshop, Bangor, ME. February 25 & 26, 1988.

______ Growth responses from herbicide treatments at Austin Pond. Monsanto Herbicide Workshop. Sugarloaf, ME. March 7, 1988.

______ Report on chemical precommercial thinning. Monsanto Herbicide Workshop. Sugarloaf, ME. March 7, 1988.

______ Herbicide technology in forest management. Lecture, Forest Management Technology. Orono, ME. March 22, 1988.

______ Vegetation management with herbicides. Lecture, Silviculture Course. Orono, ME. April 5 & 6, 1988.

______ Silviculture on industrial forest lands in Maine. Field Tour, Forestry Summer Camp. Orono, ME. May 10 & 11, 1988.

______ Field Workshop. Logging roadside brush control. Howland, ME. June 8, 1988.

______ Herbicide uses for forest production. Seminar for Scott Maritimes Ltd., New Glasgow, N.S. June 15 & 16, 1988.

______ Silviculture Working Group, New England Society of American Foresters. Field Tour. Orono, ME. July 13-15, 1988.

______ Weed science for forest production. Rutgers graduate student field tour. July 28-30, 1988.

______ Moderator, Panel on Christmas tree production research. National Christmas Tree Convention. Bangor, ME. August 19, 1988.

______ Review of herbicide research and operational procedures. Field tour for representatives from the Auburn University Silvicultural Herbicide Cooperative. August 20 & 21, 1988.

Ostrofsky, W. D. Improving tree quality and forest health by reducing logging injuries. Symposium presentation, Augusta, ME. October 6, 1987.

______ Injuries to trees cost money, cause loss in value. pp. FP24-FP25, Bangor Daily News Forest Products Week Supplement. October 23, 1987.

Ostrofsky, W. D. NE-99 Reg. Tech. Comm. Chair, Vascular Diseases of Trees. King of Prussia PA. October 14-16 1987.

_______ Incidence of white pine blister rust in Maine in areas with and without *Ribes* control. Abstract presentation. Amer. Phytopath. Soc., Atlantic City, NJ. Nov. 5, 1987.

_______ Logging damage in thinned stands: Recent trends of an old problem. Invited lecture. Insect and Disease Problems of Southern New England Forests: A Workshop. Yankee Div., SAF. Springfield, Mass. Nov. 19, 1987.

_______ The influence of forest pathogens on forest development. Seminar presentation, Forest History Seminar. Orono, ME. Feb. 9, 1988.

_____A white pine blister rust update. Invited lecture and session moderator, Northeastern Forest Pest Council. Albany, NY. March 1, 1988.

Beech bark disease. Seminar presentation, Bot. 456. Orono, ME. March 3, 1988.

_____Forest pathology in forest practice. Seminar presentation and field tour, College of Forest Resources Summer Camp, Bridgton, ME. May 17, 1988.

_____The health of northern hardwood forests in relation to timber management practices. Invited lecture, Conflicting Consequences of Practicing Northern Hardwood Silviculture, SAF Reg. Tech. Conf. Durham, N.H. June 9.

_____Hardwood timber supply. Invited presentation. Forster Manufacturing, Wilton, ME. June 14, 1988.

_____Partial cutting practices in northern hardwoods. CFRU Advisory Committee Tour. Orient Township, ME. July 19, 1988.

_____Root injuries to trees. Invited presentation. Western Maine Chapter of SWOAM. Buckfield, ME. August 27, 1988.

______Ecological factors that affect stand quality. Invited presentation. Silviculture Education for Loggers Workshop. St. Johnsbury, Waterbury, and Peru VT. Sept. 27-29, 1988.

Seymour, R. S. Timber Supply Projections for Maine. Seminars presented to: Nutting Hall Noontime Series, Oct. 9, 1987; Eastern Maine Forest Forum, Oct. 12, 1987; Symposium on the Effects of Foreign Competition, Jan. 7, 1988; Monsanto Herbicide Workshop, March 7, 1988; Mainewatch Conference, June 17, 1988.

_______Stand Dynamics and Growth and Yield Models. Invited seminar presented to: Understanding and applications of forest stand dynamics; Winter, 1988, seminar series, Univ. Wash. College of Forest Resources. Seattle, WA, Jan. 21, 1988.

_____Member, Maine Forest Service midcycle resurvey technical review committee.

____Member, Maine Bureau of Public Lands Silvicultural Advisory Committee.

_______Member, Baxter Park Scientific Forest Management Area Advisory Committee.

_______Member and Chair, Maine Board of Licensure for Professional Foresters.

_______Participant, Maine Audubon Society Industrial/Environ. Forum on forest policy.

_______Scientific Advisor, Maine DOC review "Clearcutting as a management practice in Maine forests", by the Irland Group.

_______Advisor, Mainewatch Institute study on "Maine's forest economy: crises and opportunities'.

Shepard, R. K. Forest fertilization. Invited presentation at the Annual Meeting of the Pine Tree Chapter of the Soil and Water Conservation Society. Oct., 1987.

White, A. S. Competition effects in hardwood stands. Symposium presentation, Augusta, ME. October 6, 1987.

COOPERATIVE FORESTRY RESEARCH UNIT ADVISORY COMMITTEE

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The CFRU Advisory Committee sets priorities and reviews proposals for the Cooperative Forestry Research Unit. Members active during all, or part, of 1988 were:

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Keith Bowser, Fraser, Inc.
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Edward Chase, Chase Tree Farm
Pat Flood, Manager, Forest Management, International Paper Company
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(September 30, 1988)

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Maxwell L. McCormack, Jr., Research Professor of Forest Resources
Russell D. Briggs, Assistant Research Professor of Forest Resources
William D. Ostrofsky, Assistant Research Professor of Forest Resources
Michael S. Greenwood, Professor of Forest Resources
Katherine K. Carter, Associate Professor of Forest Resources
Robert S. Seymour, Associate Professor of Forest Resources
Robert K. Shepard, Jr., Associate Professor of Forest Resources
Alan S. White, Associate Professor of Forest Resources

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Ronald C. Lemin, Jr., Assistant Scientist (Site Quality)
Peter Caron, Research Technician (Tree Improvement)
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Seven Islands Land Co.
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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
Betula alleghaniensis Britt.	Yellow birch
Betula papyrifera Marsh.	Paper birch
Fagus grandifolia Ehrh.	American beech
Fraxinus spp.	Ash
Larix decidua Mill.	European larch
Larix laricina (DuRoi) K. Koch	Tamarack (Eastern larch)
Larix leptolepsis (Sieb. & Zucc.) Gord.	Japanese larch
Larix occidentalis Nutt.	Western larch
Larix siberica Ledeb.	Siberian larch
Larix spp.	Larch
Picea glauca (Moench) Voss	White spruce
P/cea *mariana* (Mill.) B.S.P.	Black spruce
Picea rubens Sarg.	Red spruce
P/cea spp.	Spruce
Pinus strobus L.	White pine
Quercus rubra L.	Red oak
Rubus idaeus L.	Common red raspberry
Tsuga canadensis (L.) Carr.	Hemlock