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Biennial Report

of the Cooperative Forestry

Research Unit

Miscellaneous Report 321

June 1987

MAINE AGRICULTURAL EXPERIMENT STATION MISCELLANEOUS REPORT 321

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ADVISORY COMMITTEE CHAIRMAN'S REPORT

The years 1984 and 1985 have been productive for the Cooperative Forestry Research Unit (CFRU). The CFRU saw the successful completion of the second five -year research program, and began preparations for the third such period which begins in 1986. There were also some organizational changes during the past two years. Dr. Maxwell McCormac k was appointed CFRU Leader, a position created to provide administrative help for the Unit, as well as to furnish guidance and direction for future activities.

William Hepburn, a long -time member of the Advisory Committee, representing hardwood interests, retired in 1985. Mr. Hepburn has been replaced by Michael Partridge. Henry Saunders, a staunch supporter of CFRU's hardwood research program, has stepped down from his active role. Benjamin Haug is now leading the organized hardwood interests. Dwight Newm an also retired freer, the Advisory Committee in 1985. The snail woodland owner interests are now represented by our newest member, Edward Cnase. The CFRU thanks Bill, Henri' anc Dwight for their contribution, and welcomes Mike and Ed to their new assignme nts. The Maine Bureau of Public Lands was welcomed as a cooperator in 1985, and Director Robert Gardiner will represent the Bureau on the Advisory Committee.

A field tour of research projects in September 1984 marked the beginning of preparations for the next five-year period. The two-day tour in the Greenville and Squaw Mountain areas was well -attended by current CFRU cooperators, potential cooperators and other interested parties. The tour provided excellent insight into the variety and depth of CFRU research activities

The CFRU Staff and Advisory Committee have been actively pursuing members for the third five-year period. A new membership and funding structure was established this past fall. A comprehensive promotional brochure describing CFRU resear ch activities was completed in December 1985. New guidelines for outside funding support have also been established. The Staff and Advisory Committee are working jointly to determine research directions and priorities for the coming five-year period.

The A dvisory Committee, on behalf of the membership, wishes to thank Dr. Gregory Brown, Director of the CFRU, and Maxwell McCormack, as CFRU Leader, for their administrative support and direction over the past two years. We are proud of the research accomplishr nents of the staff scientists over the past decade, and look forward with anticipation to continued progress in forestry research for the next five -year period.

Robert V. Vithrow, Chairman
CFRU Advisory Committee

DEAN'S REPORT

The Cooperative Forestry Research Unit has had two highly successful years. I continue to be pleased in my association as Director of the Unit.

Many research accomplishments were made by the CFRU faculty and staff. Many of these accomplishments are discussed throughout this Biennial Report. I would like to highlight the following contributions:

1. Removal of whole trees (rather than boles only) in spruce-fir harvest increased nutrient removals (3 x N, 4 x P, 2 x K, 2 x Ca, 2.4 x Mg);
2. Information was gained on harvesting production and stand damage from thinning overstocked, small-diameter, hardwood stands with biomass systems;
3. Planting site factors were identified which significantly influence the seedling debarking weevil (i.e., site preparation methods, duff quantity around seedling bases, time since cutting, and location within a plantation).

I would like to recognize Robert Lawrence and Paul Messier who left the CFRU staff during 1984, and thank them for their contributions to the Unit. I would also like to welcome Ronald Lemin, Jr. and Frank Spizuoco who joined the CFRU as Research Associates during 1984 and 1985, respectively.

During 1984, the CFRU was restructured, and Dr. Maxwell McCormack was formally named the CFRU Leader. He already has provided outstanding leadership in this role.

During 1984 the College reorganized into three departments –the Department of Forest Biology chaired by Floyd Newby; (now, Michael Greenwood) the Department of Forest Management chaired by David Field; and the Department of Wildlife chaired by Ray Owen.

John Bissonette (Cooperative Wildlife Research Unit) and David Leslie (Department of Wildlife) left the College of Forest Resources during 1985. We are fortunate in having added Michael Greenwood, Paul Risk, and Barry Goodell to the Department of Forest Biology, and James Philp to the Cooperative Extension Service during 1984. In 1985, Jody Goodell (Department of Forest Biology) Larry Gering (Department of Forest Management) Dennis Jorde, William Krohn and Mark McCullough (Department of Wildlife) and William Lilley (Cooperative Extension Service) joined our faculty.

During late September 1984, the CFRU sponsored a highly successful two -day field tour, visiting many of the Unit's research operations. The tour was well -attended by many forest landowners and representatives from the forest products industry. Also, during 1984 and 1985, the CFRU faculty and administrators presented several programs explaining the Unit's activities to the Eastern, Western and Northern Forest Forums and other groups throughout the State. A CFRU public relations and promotional brochure was completed and distributed in 1985. Another busy year is ahead for the CFRU faculty, staff and Advisory Committee as we continue our renewal effort for the third five -year period starting October 1, 1986 and continuing through September 30, 1991.

I would like to thank Bart Harvey, Chairman; Robert I. Cope, Vice Chairman; Harold KLaiber, Financial Officer; and Robert Withrow for having served as the CFRU Executive Committee during 1984. I would also like to thank Robert Withrow, Chairman; Clifford Swenson, Vice Chairman; Bart Harvey, Financial Officer; and Robert Gardiner for having served as the CFRU Executive Committee during 1985. These individuals did an outstanding job. Without their efforts, the CFRU would not have successfully moved ahead.

I would like to take this opportunity to also thank all CFRU Advisory Committee members, cooperators, faculty and staff for their service and performance during 1984 and 1985. Without your cooperation, the CFRU would not have continued its high -standing reputation in the field of forest management.

Gregory N. Brown, Dean
College of Forest Resources

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CFRU LEADER'S REPORT

CFRU Field Tour

A field tour of CFRU research operations was conducted on September 26 -28, 1984. Approximately 70 cooperators, guests and CFRU staff participated in this tour. The tour served two primary functions. First, it provided a technology transfer mechanism by which cooperators were brought up -to-date on research projects which they have funded over the past several years. Second, the tour provided an opportunity for formal and informal discussions which will be mo st helpful in developing new research priorities and program directions for the next five -year research period.

All CFRU research areas were represented in the tour, with field stops highlighting the following projects:

1. Biology of seed and cone insects of larch and spruce, and seed and cone insect survey results in Charleston;

2. Provenance tests of spruce, larch, and balsam fir in Dover-Foxcroft;

3. Density control in young spruce -fir stands, control of competing hardwood vegetation with herbicides, and hardwood tree quality and vigor assessment using the Shigometer® in Mayf ield;

4. Fertilization of spruce near Kbkadjo;

5. Regeneration weevil biology, trapping systems and influences of various planting site characteristics, understory vegetation control with herbicides, thinning spruce - fir stands, and harvesting spruce -fir in thinnings using a portable radio -controlled winch, near Rowell Brook.

6. Impact of whole-tree harvesting on watershed dynamics at Weymouth Point; and

7. Adjustment in density of stocking in spruce-fir regeneration using a strip method of aerial application of herbicides in T5R12.

Evening sessions were devoted to informal discussions which centered around poster displays of ongoing research projects which were not on the tour route. The tour was a cooperative effort, with the CFRU staff and industry personnel involved in its planning and execution. Several students from the College of Forest Resources at the University of Maine also provided project assistance.

Members of the tour committee were Dr. Maxwell McCormack, Dr. Barton Blum, Mr. Ron Lovaglio and Mr. Oscar Selin. Great Northern Paper, International Paper Company and Scott Paper Company supported and cooperated in this effort by allowing parts of the tour to be conducted on their forest lands.

Maxwell McCormack, Leader
Cooperative Forestry Research Unit

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FOREST PROTECTION

Mark W. Houseweart

Regeneration Weevil

In the spring of 1984, M.S. graduate student Celeste Velty completed her thesis entitled "Site Influences on Hylobius congener–a seedling debarking weevil in conifer plantations in Maine." The site influences and seasonal abundance portions of her thesis results have been published (Welty and Houseweart 1985).

The results on host susceptibility are being prepared for publication and are discussed in field and greenhous e experiments on host susceptibility to this regeneration weevil.

Results from field experiments indicate that black spruce, Norway spruce, eastern larch, and white spruce were debarked more frequently than white pine and Japanese larch, while red spruce, jack pine, and red pine were debarked the least in the Glenwood Township field tests.

In the greenhouse experiments, where weevils were confined in cages with trees (Fig. 1), no consistent pattern was found in host susceptibility when data from all tests were used (i.e., tests of all nine species combined in June and July, and tests of species in a single genus in June, July and September). Among the general trends observed, using all nine species in two separate experiments in June and July, red pi ne seems to be the least susceptible of the pine species to debarking damage (Table 1). Japanese larch is less susceptible than eastern larch. Red spruce may be the least susceptible of the spruces although there was great variability among the spruce species.

Figure 1. Host susceptibility tests for regeneration weevil in the greenhouse.

Table 1. Relative susceptibility of nine host species (from most to least susceptible), based on ranked incremental debarking damage caused by IL congener in greenhouse experiments, 1983.

June		July	
Red spruce	a*	White spruce	a
White pine	ab	White pine	ab
Black spruce	abc	Eastern larch	abc
White spruce	abed	Red spruce	bed
Jack pine	bed	Norway spruce	bed
Red pine	cd	Jack pine	cde
Norway spruce	cd	Red pine	cde
Eastern larch	de	Black spruce	de
Japanese larch	e	Japanese larch	e

Species within a column, followed by different letters, have mean ranked incremental damage significantly different at P =0.05, using Duncan's multiple range test.

White Pine Weevil

Lise Anne McGaillard, a M.S. graduate student in forest entomology, comple ted her research on fall application of insecticides for suppression of the white pine weevil in August 1985 (McGaillard 1985). Initial reductions in the weevil population following treatment applications in the fall of 1983 were as follows: Pydrin (100 percent), hand pruning (97 percent), Dursban (93 percent), and Sumithion (87 percent). Because control plots had to be located in the same plantation as the treatments, the reinfestation rates in the summer of 1984 were quite high, thu s modifying the initial ranking of treatments (Table 2).

Data from cone traps used to monitor adult weevil emergence in the spring of 1984 showed that significantly more weevils (P = 0.05) emerged from the control plots than from treatment plots. This supp orts the hypothesis that the reinfestation of treatment plots was due, in part, to population of weevils remaining in the control plots.

Table 2. Ranked percentages of white pine weevil infestation levels, 1983 -1984 by treatments (based on weeviled -leader assessments).

Rank[3]	Treatment	1983	1984	Difference
		– (% infestation) –		
Most	Pounce	48.8	25.5	-23.3
.	Pydrin	55.7	35.0	-20.7
.	Methoxychlor	59.2	39.6	-19.6
•	Sumithion	42.4	24.8	-17.6
.	Pruning	53.3	40.1	-13.2
.	Dursban	47.6	35.2	-12.4
Least	Control	43.7	50.1	+ 6.4

f/ Most to least effective treatment for population suppression.

Seed and Cone Insects

Cone Damage Survey

Results of the 1983 Statewide cone survey (Table 3) indicated that balsam fir, hemlock, and tamarack cones suffered the greatest damage with over 80 percent seed loss per cone. For example, of the 83.3 percent total seed damage on balsam fir, 27.7 percent was obviously insect damaged; specifically 18.5 percent was internal insect damage; 0.1 percent was external insect damage; and 9.2 percent of the seeds had insects in the seed. An additional 55.3 percent of the seeds were shrun ken. Only 0.3 percent of the seeds were hollow. The cause of the shrunken seeds remains unknown, but it is possible that these seeds had been fed upon by true plant bugs. This survey, the first since 1954 by the USFS, gives direction to future research priorities for CFRU protection and identifies problem areas for forest and seed orchard managers interested in artificial regeneration.

Intensive Studies on Tamarack

A. Lee Eavy, Ph.D. graduate student, has continued his investigations into the ecological factors affecting tamarack seed production

Table 3. Mean percentage of seeds on longitudinal slice of cone in each category by tree species for the 1983 cone and seed survey for Maine.

Species	Cones (n)	Total Filled Seeds	Dissection Categories: Damaged Seeds	Hollow	Shrunken	Insect In Seed	Insect Damaged	Aborted
White spruce	56	23.6	71.4	4.7	47.2	3.5	15.1	0.9
Red spruce	74	31.4	68.5	4.0	48.7	0.5	14.9	0.4
Black spurce	53	34.9	62.4	1.3	50.5	0.0	10.6	0.0
Balsam fir	51	16.6	83.3	0.3	55.3	9.2	18.5	0.0
Exotic larch	42	47.3	52.4	0.3	47.7	0.0	3.9	0.5
Tamarack	54	16.1	83.9	0.2	37.5	0.2	45.2	0.8
White pine	24	68.5	29.2	1.0	12.5	0.2	4.2	11.3
Red pine	42	56.8	41.0	1.9	12.4	0.3	10.4	16.0
Jack pine	6	78.8	21.2	0.0	19.4	0.0	1.8	0.0
Hemlock	12	13.8	86.2	0.0	86.2	0.0	0.0	0.0

during 1984 and 1985. Results of the pollen dispersal study were reported at the Northeastern Forest Tree Improvement Conference in Morgantown, West Virginia (Eavy et al. 1985).

Studies of seed -feeding insects continued during 1984 while taxo nomic identifications and verifications, and data analysis were the primary efforts in 1985. Field experiments to determine seed insect identifications, life cycles, attack times, and damage levels on tamarack cones and seeds were completed during 1984, an d are being analyzed. Preliminary results indicate that 1983 damage levels were higher than 1984, but lower than 1982 (Fig. 2). The primary seed -damaging insects in 1984 as in 1983, were the larch cone maggot and the small larch seed midge. These results and research methods were presented in field demonstrations to participants of the CFRU Research Field Tour in September 1984.

Reliability of Ethanol Flotation for Testing Tamarack Seed

As part of our study of seed production problems in tamarack, we needed precise seed set rates for accurate assessment of several experimental treatments. Many researchers and forest improvement technical personnel use 95 percent ethanol flotation to remove the empty seed from seed lots. It is generally assumed that seeds which float are empty or inviable, while those that sink are full and supposedly viable. However, since the literature gave no indication of the reliabili ty of this method for separating full and empty tamarack seed, we used both radiography and germination trials to test the flotation results.

The ethanol seed flotation trials (n = 37,740 seeds) showed that over 80 percent of tamarack seeds float, and woul d, under prevailing assumptions, have been considered empty seed and discarded. Only about 18 percent of all seed sank. An x -ray analysis of 18,344 seeds showed that about 97 percent of the sinkers were full, while about 14 percent of the floaters were als o evaluated as full. Germination results also indicate serious problems with the assumption that floaters are empty. Over 17 percent of the floaters germinated, thus making a significant contribution to the total viable seed. Of the total germinants, over half of all seedlings originated from floater seed lots, and would normally have been discarded.

Ethanol flotation consistently separated chalcid-infested seed from non-infested sunken

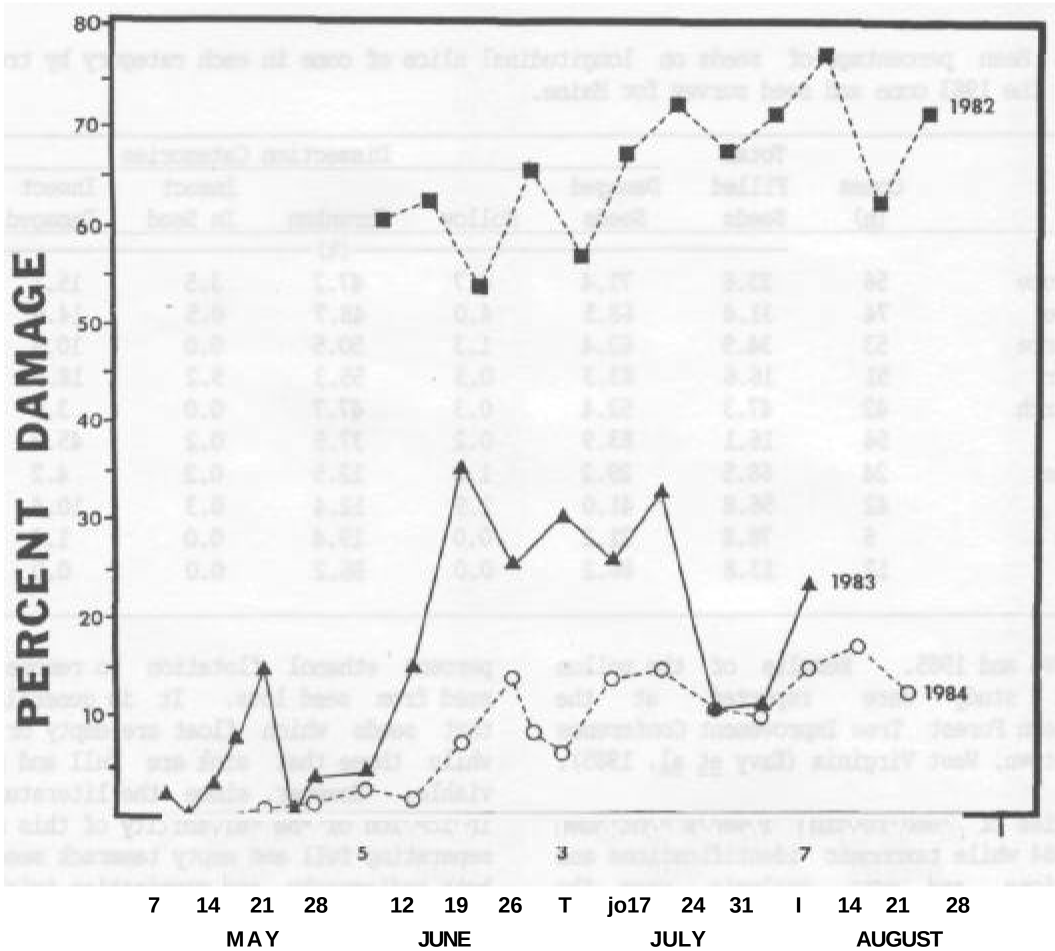


Figure 2. Percentage of tamarack cones damaged at Old Town, Maine sites for 1982-84.

seed. Using this method to identify infested seed could help prevent dispersal of the pest insect with the seed. This is an important consideration in the future for tree improvement work with tamarack.

Depending on the objectives for using this method, ethanol flotation may or may not produce the desirable results. For example: if a commercial seed laboratory wants to remove all bad seed, this procedure may be quite acceptable because ethanol flotation removes up to 99 percent of the bad seed. For research objectives that require precise counts of full or viable seed (i.e., inbreeding coefficients and full seed-set rates), ethanol flotation is unacceptable.

HARDWOOD SILVICULTURE

Dr. William D. Ostrofsky

Modified Shelterwood System

Plots at the shelterwood study site at Lambert Lake, Maine, were remeasured in 1984 and 1985. This study involves the preharvest treatment of advance beech reproduction, and large, defective beech with an herbicide application. Herbicide treatment was then followed with the seed cut of a shelte rwood sequence.

Data were collected and summarized on first- and second -year regeneration establishment, beech sprouting, and herbicide efficacy. Both glyphosate (Roundup^) and triclopyr (Garlon© 3A) were effective in reducing the amount of advance beech reproduction, and beech root and stump sprouting (Table 4). An average of 7,000 germinants and seedlings per acre of desirable species (sugar maple, red maple, yellow birch and paper birch) had become established two years after harvest. A manuscript detai ling the study procedure and early results will appear in the Northern Journal of Applied Forestry later in 1986.

Table 4. Number of beech sprouts developing within one (1984) and two (1985) years after herbicide treatment at the Lambert Lake study site*''

Treatment	Plot NO.	Number of Beech Sprouts 1984	1985
Triclopyr	1	0 3	1
	2	2 4	7 5
Glyphosate	4	15	4
	5	13	42
Control	3		18
	6		

[a]/ Values represent the total number of beet sprouts in ten milacre subplots.

Paper Birch Defects

The Maine Agricultural Experiment Station is currently funding a project on the biology of canker-rot fungi of paper and yellow birch. The project, initiated in October of 1985, is providing data on the distribution of canker - rot fungi within individual s tems, and within young and old stands of birch. The project is also addressing the effect these pathogens may have on growth and development of the wood and bark of affected trees. Final results will help foresters assess the defect status of birch stands, and will lead to the development of appropriate management strategies for reducing the impacts of these pathogens.

Evaluation of Red Spruce Vigor

In 1985, the Maine Forest Service funded a research projec t designed to test the applicability of the Shigcmetei®, a field ohmmeter, for assessing vigor of red spruce stands that had sustained different levels of spruce budworm defoliation. The method was compared with an ocular rating technique and with a budcou nting technique developed by the Maine Forest Service.

A comparison of these methods indicated that the Shigometei® provided a better estimate of tree vigor than did counts of terminal and/or lateral buds. In addition, the Shigometer® method is less subjec tive than ocular rating techniques. This information will be useful in developing a spruce budworm hazard rating system for red spruce stands. The technique is also useful for comparing growth and relative vigor of stands within larger forest management units.

Thinning Hardwood Stands Using Whole-Tree Harvesting Technology

This project was undertaken to assess the economic and biological impacts of whole -tree harvesting for biomass in hardwood stands of western Maine. The study was done in cooperation with the Boise Cascade Corporation and the S.D. Warren Division of Scott Paper Company. Robert Seymour is co -investigator and Ron Lenrin is providing assistance with data collection.

The two sites selected and compared were located in Grafton Township (a 45-year old stand of paper birch) and South Bridgton (an uneven - aged stand composed of red oak, beec h, bigtooth aspen, and white pine). Both stands were overstocked, had a large proportion of small stems, and were slated for thinning using biomass harvesting technology. The following harvesting treatments were applied to the stands:

Grafton Twp. Site
1. Mechanical harvest; 1-chain spacing of skid trails;
2. Mechanical harvest; 2-chain spacing of skid trails;
3. Chainsaw felling; bunching with winch (Radio horse 9); 2-chain spacing of skid trails;
4. Mechanical harvest; no trail layout (operator judgement); and
5. Contro (unthinned).

South Bridgton Site
1. Mechanical harvest; 2-chain spacing of skid trails;
2. Mechanical harvest; no trail layout (operator judgement; and
3. Control (unthinned).

Mechanical harvesting using Morbell ® or Hydro-A3^ feller -bunchers was done in all treatments except for the chainsaw/winch - treatment and the unthinned area. The Hydro -A$> was used primarily for cutting skid trails.

Low quality stems, small steins and undesirable species were designated for removal by marking the residual crop trees. All treatments involved whole -tree felling, bunching and skidding. All harvested material was delivered to on -site chippers by grapple skidders. Plots 0.1 ac (1 -chain spaci ng) and 0.2 ac (all other treatments) were established for the determination of pre - and post -harvest stand conditions and for measuring the effect of treatments on residual crop tree quality (Fig. 3).

Differences in forest stand types accounted for signif icant differences in damage to residual crop trees. Fifty-two percent (52%) of

Figure 3. Crop tree damage after thinning for biomass using whole -tree harvesting techniques.

the residual trees in the birch stand, were injured in the 2 -chain trail spacing treatment compared with 21 percent in the oak -beech stand (Table 5). Designation of skid trails resulted in fewer injuries to crop trees in the oak -beech stand, and reduced the number of crop trees which had to be cut f or access in the birch stand. Designation of skid trails is, therefore, economically and biologically advantageous.

The Shigometei® was used to measure vigor of the selected crop trees in all plots on both sites. To obtain a standard curve of paper birch v igor at the Grafton site, over 1,100 codominant trees were measured. The data indicated a mean cambial electrical resistance (CER) of 15.3 for the stand (Fig. 4). Response of crop trees to treatments will be compared with the standard curve over the next s everal years.

The Shigometei® was also used to select high-vigor trees as crop trees in the chainsaw/winch treatment. Trees with a CER of less than 13 were classed as high vigor trees; those with a CER of more than 16 as low -vigor trees. Trees with a CER of 13 to 15 were classed as moderately vigorous (Fig. 4). This technique of crop tree selection will be compared with conventional visual methods. Change in cambial electrical resistance of trees on both sites will be used as a measure of tree response to treatment.

Table 5. Stand stocking and damage to residual crop trees after thinning with biomass harvesting systems.

	Grafton Twp.				South Bridgton	
	Mechanical Fell & Bunch			Chainsaw/ Winch	Mechanical Fell & Bunch	
	1-chain Trail Spacing	2-chain Trail Spacing	No Trail Layout	2-chain Trail Spacing	2-chain Trail Spacing	No Trail Layout
Planned Residual Stand	279	159	203	263	124	142
Crop Trees Cut:						
In trails	71 (25)	12 (7)	38 (19)	7 (3)	0 (0)	2 (1)
In stands	44 (15)	8 (5)	34 (17)	19 (7)	3 (2)	2 (1)
Actual Residual Stand	167 (60)	139 (87)	131 (64)	238 (98)	121 (96)	138 (97)
Tree Damage:^ Bole only	21 (7)	15 (10)	20 (10)	27 (10)	12 (10)	34 (24)
Root only	17 (6)	31 (19)	30 (15)	28 (11)	9 (7)	12 (9)
Root and bole	25 (9)	38 (24)	42 (21)	19 (7)	6 (5)	12 (9)
Total Damage*-'	62 (22) x	44 (53)y	92 (45)x	74 (28) x	27 (22) x	58 (41) y
Undamaged	104 (37)	55 (35)	40 (18)	164 (62)	94 (76)	80 (57)

Severity classes 2 and 3 (bark broken, wood exposed or damaged).

Numbers followed by the same letter, vrithin sites, are not significantly different (P = 0.05)

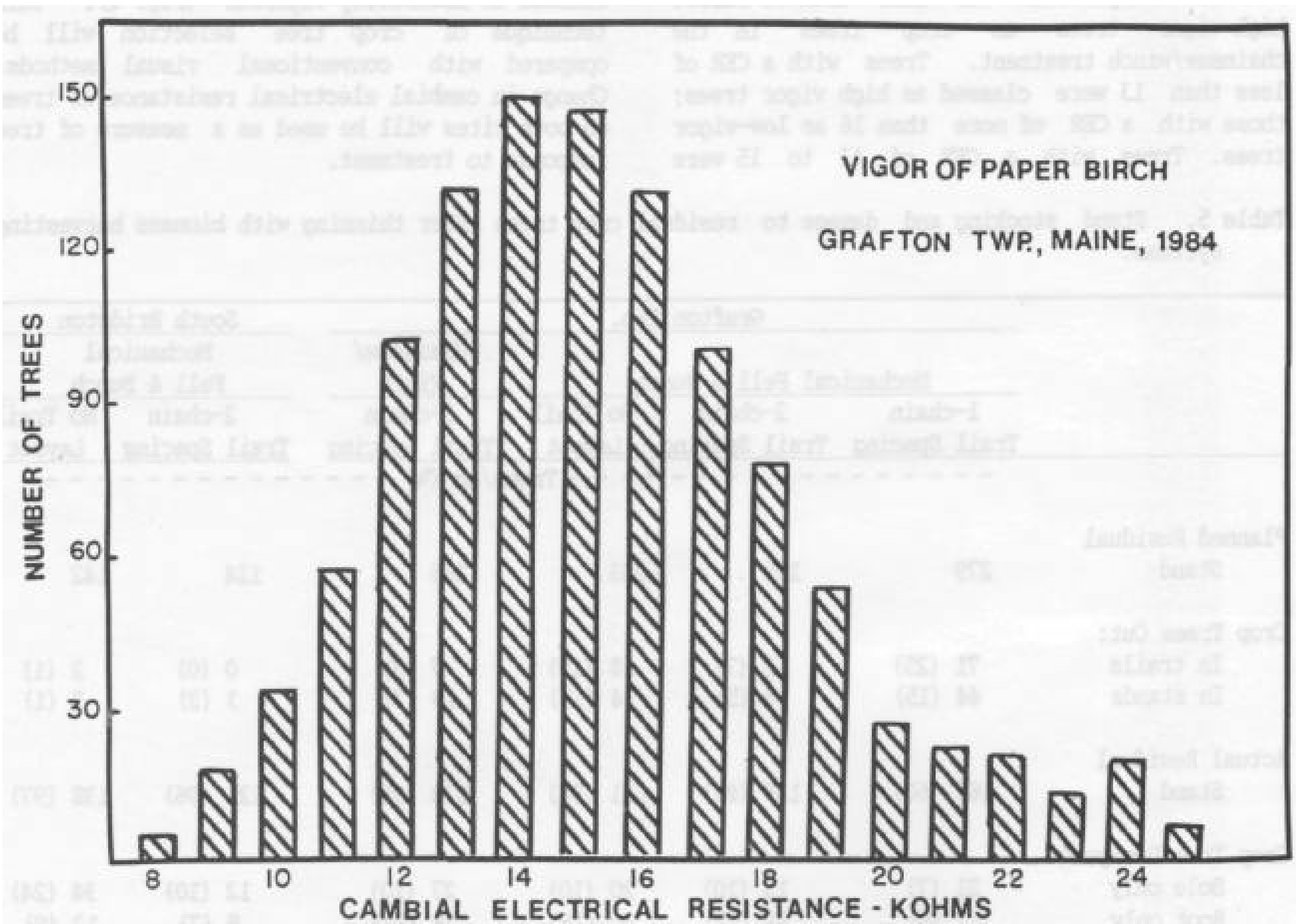


Figure 4. Cambial electrical resistance (CER) of paper birch at the Grafton Township site.

TIMBER MANAGEMENT AND HARVESTING

Dr. Robert S. Seymour

Commercial Thinning Systems for Small-Diameter Stands

Biomass Operations in Hardwoods

A major study of whole -tree chipping operations for thinning small -diameter hardwood stands in western Maine was undertaken with Dr. William Ostrofsky during the 1984 field season. Study objectives, methods and preliminary stand damage results are summarized in the preceding section of this Biennial Report. The Morbel]® feller-buncher and grapple skidders (Fig. 5) were time-studied at the Grafton Township site (Fig. 6). Regression analysis will be used to develop equations that predict thinning production and cost as a function of tree size (1 to 14 inches dbh) for variou s skid-trail patterns.

Ccmaercial Thinning in Spruce-Fir

Permanent plots were remeasured in November 1984 to assess stand response to the thinning treatments performed in 1982. Early results were somewhat discouraging. Scattered mortality from wind breaka ge, uprooting and spruce budworm defoliation has been greater than accretion of surviving trees, resulting in negative net growth rates for the 2 -year period (Table 6}. Despite continuous spruce budworm protection every year since thinning, residual spruce s still have only a partial complement of foliage and are in fair condition at best. Stand response appears to be unrelated to the thinning treatments.

A comprehensive summary of the production and cost results of this study was completed and

Figure 5. Grapple skidder yarding a turn of small hardwood bicnass to the chipper.

Figure 6. CFRU suraner student, Stephen Pinkham, timing the Morbell® feller-buncher.

Table 6. Two-year response of a 75-year old spruce-fir stand (T12R6, Maine) to ccranercial thinning from below (trees 4.6 inches dbh and larger).

	Spruce		Fir		Otherf/	
	Trees/ac	BA (ft^2/ac)	Trees/ac	BA (ft^2/ac)	Trees/ac	BA (ft^2/ac)
Residual stand (1982)	200	89.9	26	5.9	17	10.3
Mortality (1983-84)						
Budworm, suppression	4	1.8	4	0.7	0.2	0.1
other standing dead Broken	4	1.2	3	0.7	0.7	0.2
Uprooted	5	2.1	5	1.2	1.0	0.4
Total	13	5Z	12	2J5	L9	0?7
Survivor growth (1983-84)	—	2.5	—	0.1	—	0.4
Stand (1984)	187	87.4	14	3.4	15	10.0

*/ Mostly paper birch and northern white-cedar.

published as CFRU Research Bulletin 6 (Seymour and Gadzik, 1985b).

Density Control in Young Spruce-Fir

Production and Cost

Production results from the study of the Hydro-Aj© swath cutter and brush saw workers for spacing young spruce-fir stands, carried out in cooperation with Scott Paper Company during the 1983 field season, were published as CFRU Research Note 14 (Seymour, Ebeling and Gadzik, 1984). A method for estimating the cost of motormanual brush -saw spacing, using simple graphical techniques, was also developed (Seymour and Gadzik, 1985a). The nomogram (Fig. 7) can be used to predict costs for any combination of stand density, prior mechanical swath treatment, and hourly labor cost.

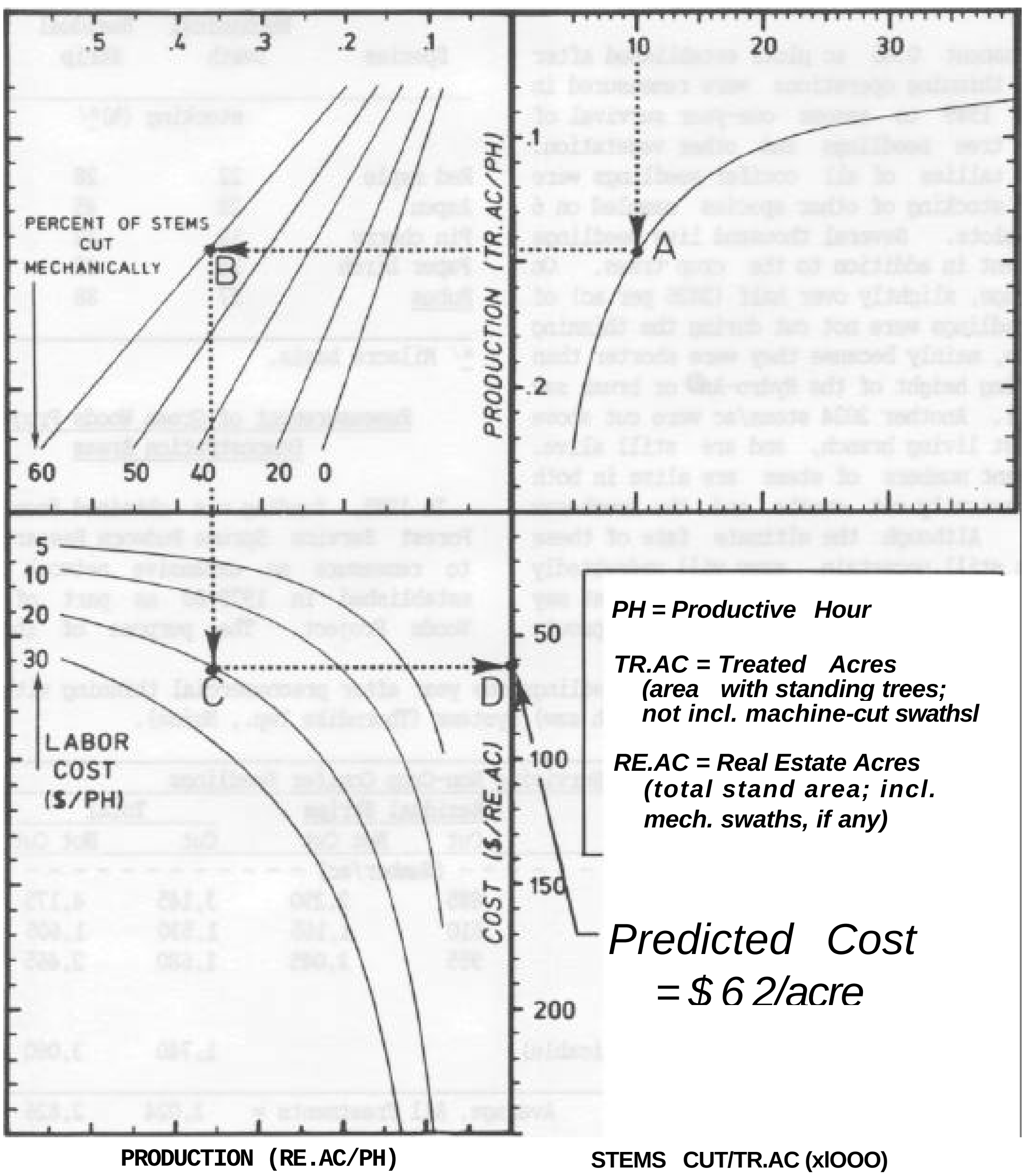


Figure 7. Monogram for predicting precorrmercial thinning costs in overstocked spruce-fir stands using brush saws.

Robert Ebeling, former CFRU Graduate Research Assistant, completed his master's thesis in May 1985 (Ebeling, 1985). Monograms to predict mechanical thinning costs were developed, and analyses of various combinations of mechanical and brush -saw thinning completed. The optimum combination of mechanical and motormanual operations appears to be insensitive to changing stand conditions but is strongly influenced by the hourly labor cost.

Stand Response

Permanent 0.05 ac plots established after the 1983 thinning operations were remeasured in May-June 1985 to assess one -year survival of noncrop tree seedlings and other vegetation. Complete tallies of all conifer seedlings were made and stocking of other species sampled on 6 milacre plots. Several thousand live seedlings are present in addition to the crop trees. On the average, slightly over half (2826 per ac) of these seedlings were not cut during the thinning operation, mainly because they were shorter than the cutting height of the Hydro -Aj© or brush saw (Table 7). Another 2024 stems/ac were cut above the lowest living branch, and are still alive. Significant numbers of stems are alive in both the mechanically cut swaths and the brush -saw strips. Although the ultimate fate of these trees is still uncertain, many will undoubtedly remain alive and form an understory that may eventually compete with the crop trees. Sprouts of brush species are also well -distributed throughout the residual stand. Stocking of aspen, birch, and pin cherry appears to be higher in the brushsaw treated strips than in the mechanically cut swaths (Table 8).

Table 8. Survival of brush species one year after precommercial thinning with various mechanical-motormanual (Hydro -A^ and brush saw) systems (Thorndike Twp., Maine).

Species	Survival: Mechanical Swath	Survival: Residual Strip	Average Height inches
	stocking		
Red maple	22	28	19
Aspen	28	45	28
Pin cherry	14	32	15
Paper birch	14	32	20
Rubus	97	88	~™

f/ Milacre basis.

Remeasurement of Green Woods Project Demonstration Areas

In 1985, funding was obtained from the Maine Forest Service Spruce Budworm Research Program to remeasure an extensive network of plots established in 1979 -80 as part of the Green Woods Project. The purpose of these plots

Table 7. Survival of non-crop conifer seedlings one year after precommercial thinning with various mechanical-motormanual (Hydro-Aj© and brush saw) systems (Thorndike Twp. , Maine) .

Treatment Residual Strip Width (ft)	Surviving Non-Crop Conifer Seedlings: Mechanical Oat Swath Cut	Mechanical Oat Swath Not Cut	Residual Strips Cut	Residual Strips Not Cut	Total Cut	Total Not Cut	Crop Trees
Narrow (4-5)	2,340	1 885		:r/ac)	3,145	4, 175	763
Average (8-12)	920	, 440	— (Numbs 885 610	-2,290	1,530	1, 605	890
Wide (15-25)	725	420	955	1,165 [illegible]	1,680	2, 465	883
Motormanual (Brush-saw only)	(Not Applicable)				1,740	3,060	1,005
Average, All Treatments					2,024	2,826	886
Total					4,850		

was to assess long -term response of various stand types to spruce budworm protection and fir-only partial cutting. In the partial cutting trials, mortality has been much greater than expected, ranging between 33 and 48 percent of the 1980 residual stand (Table 9). Much of this mortality was residual fir that never recovered from early defoliat ion, even though residual stands were protected repeatedly after 1980. A significant number of fir and spruce trees also were lost to windthrow and breakage.

Research Associate Hired During the summer of 1984, a national search was conducted to fill a res earch support position vacancy created when Charles J. Gadzik left the Unit late in 1983 to become Forest Manager for the Baskahegan Company. In August 1984, Ronald C. Lenin, Jr. was hired. Ron brings to the Unit a strong background in quantitative analysi s, computer programming and field techniques from his education at Penn State University (B.S. 1979) and Virginia Polytechnic Institute (M.S. 1981), and experience as Research Assistant for the Virginia Growth and Yield Cooperative and the Orono Research Unit of the USDA Forest Service.

Table 9. Five-year response of four stands harvested by a variety of fir-only cutting prescriptions (T14R16, T15R15, Maine).

	Stand F Spruce	Fir	Stand II Spruce	Fir	Stand III Spruce	Fir	Stand IV Spruce	Fir
			------ BA (ftVac)-					
Residual stand (1990)	**47.8**	**42.2**	96.7	25.0	21.4	47.2	29.5	46.3
Old mortality (1981-82)	—	4.4	5.0	—	—	5.7	3.7	17.9
Standing Down		1.1				2.9		1.6
New mortality (1983-85)								
Standing	1.1	7.8	3.3	10.0	4.3	5.7	2.6	6.
Down	6.7	18.9	8.3	1.7	1.4	12.9	4.8	4.
Total mortality	7.8	32.2	16.6	11.7	5.7	27.2	11.1	30.0
Survivor growth	3.0	0.5	4.5	0.5	0.8	2.6	0.7	1. 1
Surviving stand (1985)	43.0	10.6	84.5	13.8	16.5	22.6	19.1	17.4

•/ Stand I: marked residual firs; harvested with winch and forwarder shortwood system.
Stand II: marked residual firs; harvested with winch and skidder tree-length system.
Stand III: marked residual firs; harvested with conventional skidder operation.
Stand IV: 8-inch diameter limit on fir; harvested with conventional skidder operation.
^J_ Stand I and II were harvested in 1981.

FOREST FERTTTiT7ATION

Dr. Robert K. Shepard

The fertilization project consists of two major parts. One part involves studies of primarily red spruce, and the other, studies of eastern white pine. Additional work deals with the effect of intensive management on wood properties. Alt hough not part of the fertilization project, work on wood properties is closely related and is described here.

Spruce Soil Drainage Class -

Fertilization Response

Increment cores were taken from trees in each of two plots in four unthinned stands on moderately-well and well -drained soils, three unthinned stands on somewhat -poorly-drained soils, and four unthinned stands on poorly - drained soils. One plot had been treated with 200 Ib nitrogen/acre (Ib N/ac) in June 1981. The remaining plot served as a c ontrol. The total growth for five growing seasons preceding treatment as well as the annual growth for five growing seasons after treatment was measured on each plot. Increases in growth at all locations ranged from 30 to 50 percent but, overall, there appears to be no difference in increases among drainage classes.

Additionally, increment cores were taken from 90 plots that have completed two growing seasons since treatment. These plots are in stands on the same drainage classes as the plots described abov e. The plots are distributed among studies of: (1) response to thinning plus fertilization; and (2) response to nitrogen application rates of 0, 100, 200 and 300 Ib/ac. Growth measurements have not yet been completed on these cores.

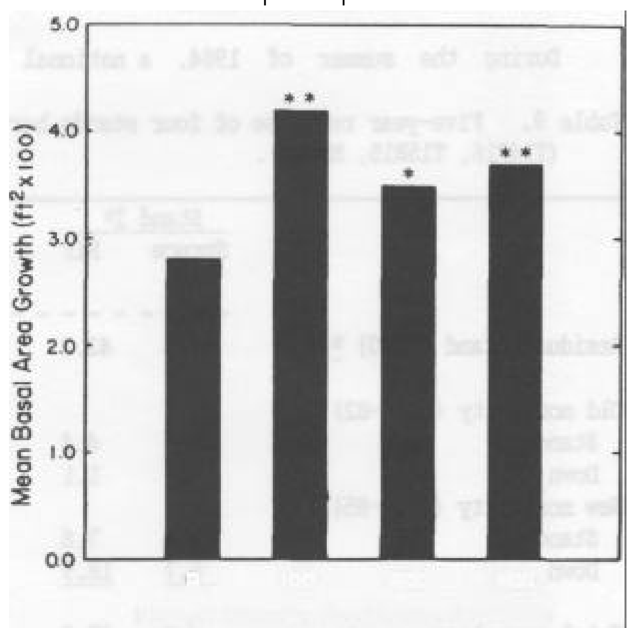
Thinned Old-Field Plantations

Measurements from thinned white spruce plantation trees that have completed three or five growing seasons since fertilization with varying rates of nitrogen were analyzed. Response did not increase as application rate increased from 100 to 400 Ib/ac (Fig. 8). Nevertheless, a significant response in sawlog plantations or managed sawlog stands could make

0 IOO 200 400

Rote of Nitrogen Application (Ib p«r A)

Figure 8. Mean basal area growth of trees in a thinned white spruce plantation fertilized



with four rates of nitrogen (N) (rates are Ib/ac).

less an

fertilization at a rate of 100 Ib/ac or attractive practice in such stands.

White Pine

Treatment Results

Measurements were made in 11 stands that have completed four growing seasons since treatment and in 13 stands that have completed two growing seasons since treatment. Analysis of measurements in seven stands that by 1984 had completed the fourth growing season since treatment showed 100 Ib of nitrogen/acre was the best treatment in both western and central Maine (Table 10). Good returns on the investment in fertilization could be expected from these volume gains, especially in stands of high quality and with a real increase in stumpage price during the investment period (Table 11).

Measurements taken in 20 stands (14 in western Maine and 6 in eastern Maine) two growing seasons after treatment were analyzed for fertilization effects on growth and differences in response to fertilization between the two regions. Although fertilization resulted in increased growth (Table 12) differences between the two regions for individual treatments were not significant. It does appear, however, that differences between the two regions may be developing for treatment rates of 50 and 200 Ib/ac.

Table 10. Change in volume growth from control for eastern white pine stands in Maine during the four years following fertilization with nitrogen.

Location	Nitrogen Application Rate (Ib/ac)		
	50	100	20
	(bd ft/ac)		
All stands	-50	1109	43
Western Maine[a]	-91	1106	32
Central Maine[b]	2	1110	58
			1

[a] Four stands. [b] Three stands.

Table 11. Approximate rates of return earned in white pine sawlog stands during the four years after fertilization with 100 Ib of Nitrogen/ac.

Stumpage Price (S/MBF)	Real Increase in Stumpage Price (%)		
	0	1	2
	12	13	14
90 100	15	16	17
	18	19	20

Table 12. Average increase in volume growth of white pine fertilized with nitrogen in western and eastern Maine.

Location[a]	Nitrogen Application Rate (Ib/ac)		
	50	100	200
	(bd ft/ac)		
Western Maine[b]	-94	609	511
Eastern Maine[c]	458	667	1184
All locations	72	627	714

[a] Two stands per location. [b] Seven locations. [c] Three stands.

Additional Plots Established and Fertilized

Plots in eight sawlog stands and six pole stands were treated in May 1985. Two of the sawlog stands are in eastern Maine. These stands were treated with nitrogen at rates of 0, 50, 100 and 200 Ib/ac. The remaining stands are in western Maine. Application rates in these stands were 0, 75, 125 and 175 Ib/ac. These rates were used to increase the total number of application rates and to provide a more complete data base from which to evaluate the relationship between growth response and application rate. Plots in seven stands were treated in September 1985. Application rates used were 0, 75, 125 and 175 Ib/ac.

In 1985, seventeen additional stands were selected for study. These stands are distributed among southern, western and eastern Maine and are the last stands to be included in the white pine fertilization study. Standard plots were established and data recorded {trees numbered, dbh, etc.,) for all trees.

Wood Properties

Ten trees were sampled from an 80-year-old red spruce stand, a thinned stand at age 50 years, and 10 from an unthinned 80-year-old red spruce stand. Micro-bending specimens were prepared and specific gravity, modulus of rupture, and modulus of elasticity were

determined for a range of ages and growth rates. Results show that: (1) wood of maximum specific gravity may not be produced until trees are as much as 70 years old; (2) modulus of rupture and modulus of elasticity attain maximum values 15 to 20 years before specific gravity; and (3) increased growth rates produced by thinning after wood properties have approached or reached maximum values do not adversely affect those properties {Table.13).

These results suggest that: (1) maximum amounts of dense, strong wood may be produced by thinning mature stands; and (2) shortened rotations (40 to 50 years) will likely lead to trees of lower specific gravity and strength than those presently being harvested from older stands.

Table 13. Comparison of specific gravity (SG), modulus of rupture (MOR) and modulus of elasticity (MOE) for juvenile and mature wood of red spruce between thinned and unthinned stands.

	Wood Property		
	SG	MOR (PsI)	MOB (PsI)
Thinned Stand			
Juvenile wood	0.381	5,898	864,544
Mature wood	0.414	7,114	1,102,783
Difference (%)	8	17	22
Unthinned Stand			
Juvenile wood	0.394	5,891	904,387
Mature wood	0.429	7,264	1,165,290
Difference (%)	8	19	22

TREE IMPROVEMENT

Dr. Katherine K. Carter

Progeny Test of White Spruce Plus-Trees

In 1984, an evaluation of an 11 -year old progeny test of white spruce plus -trees provided dramatic evidence of the gains in height growth that can be achieved by practicing plus -tree selection in this species. Trees for this study were selected during the 1960's and early 1970's by members of the Spruce-Fir Committee coordinated by Clyde Hunt of the USDA Forest Service. Selection was based primarily on growth rate, with one to three comparison trees in most cases.

Seed was collected from 23 plus -trees in Maine and New Hampshire for the establishment of this progeny test (Fig. 9). Bare -root seedlings were grown in the New Hampshire State nursery and out-planted as 3-0 stock on land owned by Scott Paper Co. near Moscow, Maine. Several "check" seedlots were also planted for comparison. These check seedlots included nursery-run white spruce from the New Hampshire and Maine State nurseries, red spruce from a Maine seed source, and Norway spruce.

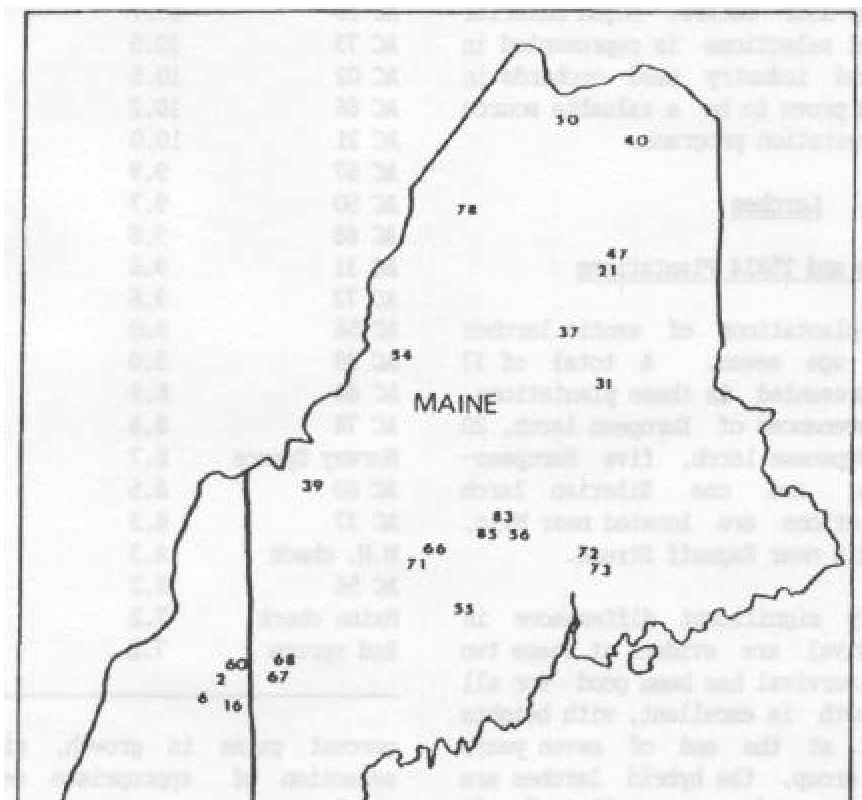


Figure 9. Location of white spruce plus-tree collections from Spruce-Fir Committee progeny represented in Moscow, Maine plantation.

Average height after 11 growing seasons at Moscow, Maine, is listed in Table 14. Progeny of 21 out of 23 select trees are taller than the New Hampshire check seedlot, and all select progeny are taller than the Maine check seedlot. The 20 tallest families in this test represent an overall gain of 23 percent in height over the New Hampshire check seedlot. Nearly all of the select white spruce families also grew faster than the Norway spruce and red spruce seedlots.

Results of long-term studies in Wisconsin have shown that there is a very high correlation between the heights of white spruce at ages 7 and 22 (Nienstaedt, 1981). Based on this relationship, it appears that the superiority of these Spruce-Fir Committee's selections will be maintained in the near future. Scion material from the original selections is represented in several State and industry seed orchards in Maine, and should prove to be a valuable source of seed for reforestation programs.

Larches Results from Milo and T5R14 Plantations

Two trial plantations of exotic larches were measured at age seven. A total of 37 seedlots is represented in these plantations, including 11 provenances of European larch, 20 provenances of Japanese larch, five European - Japanese hybrids, and one Siberian larch seedlot. Plantations are located near Milo, Maine, and in T5R14 near Ragmuff Stream.

Statistically significant differences in growth and survival are evident at these two sites. At Milo, survival has been good for all species and growth is excellent, with heights averaging 17.4 ft. at the end of seven years (Fig. 10). As a group, the hybrid larches are tallest at this site and average 20.4 ft. in height, while European and Siberian larch average 19 and 18.5 ft. respectively, and Japanese larch are shortest, averaging 16.2 ft. (Fig. 11). There is also considerable variability between different seedlots of each species, with some individual seedlots of each species averaging as much as 1.5 to 2.0 ft. above or below the average for their species. This variability would translate into 10 to 15 percent gains in growth, simply through the selection of appropriate seedlots within a species.

Table 14. Total height of white spruce progeny from Spruce-Fir Committee select trees (AC #S) and comparison seedlots, 11 years after planting at Moscow, Maine. (Note the superior growth of select families compared to the New Hampshire check seedlot).

Seed Source	Height (ft)	Superiority Compared to H.H. Check (%)
AC 71	12.0	45
AC 55	11.5	39
AC 06	11.4	37
AC 47	11.2	35
AC 83	11.1	34
AC 85	11.0	33
AC 16	10.7	29
AC 73	10.5	27
AC 02	10.5	27
AC 66	10.2	23
AC 21	10.0	20
AC 67	9.9	19
AC 50	9.7	17
AC 68	9.6	16
AC 31	9.6	16
AC 72	9.6	16
AC 54	9.0	8
AC 39	9.0	8
AC 40	8.9	7
AC 78	8.8	6
Norway Spruce	8.7	—
AC 60	8.5	2
AC 37	8.3	0
N.H. check	8.3	—
AC 56	8.2	-1
Maine check	7.2	—
Red spruce	7.2	—

For European and hybrid larches at Milo, these differences in growth rate are related to the geographic origin of the seedlots. European larches that originated in seed orchards in Germany and Czechoslovakia grew much faster than trees from other locations. Among the hybrids, the best trees originated from a cross between male Japanese larch and female European larch

Figure 10. Seven-year-old exotic larches growing in a research plantation near Milo, Maine.

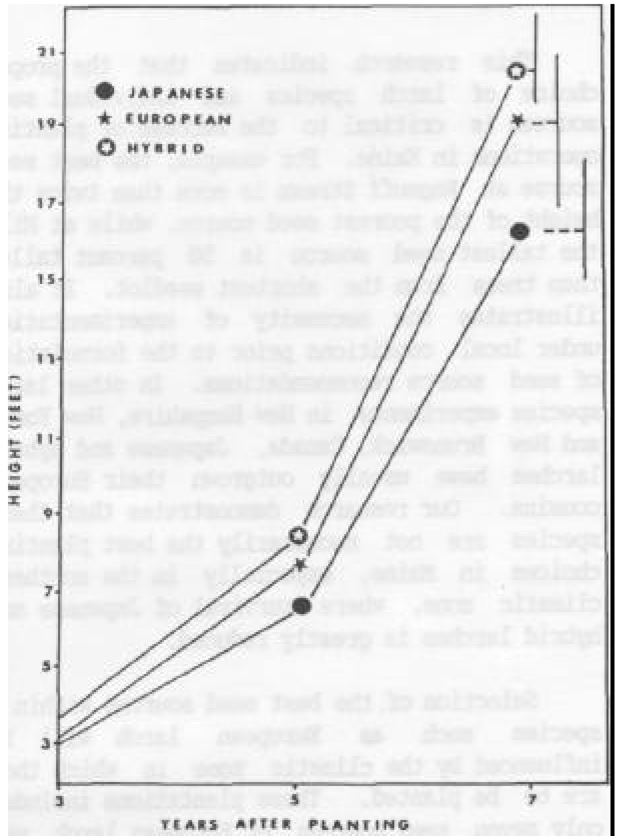


Figure 11. Growth curves for Japanese, European and hybrid larches at Milo, Maine. Vertical bars indicate the range of provenance means within each species.

from the Sudetan Mountains near the Polish - Czechoslovakian border. Trees from this cross were taller than any others, averaging 22.5 ft. in height.

Growth patterns in the northern Maine plantation (T5R14) were very different. The colder climate and shorter growing season at this site resulted in reduced growt h. Trees averaged only 9.1 ft. in height at age seven. In addition, almost half of the Japanese and hybrid larches at this site died, probably as a result of the harsh climate. Japanese and hybrid larches are known to be susceptible to injury and die back from late -spring and early - fall frosts. Siberian larch outgrew all other species at this site, averaging 12.5 ft in height. The European larch also survived and grew well, averaging 10.2 ft in height, but the best European seed sources at Ragmuff Stream are from different regions than are the superior European seed sources at Milo. The best European larch at Ragmuff Stream in T5R14 were from seed sources in Denmark, Poland and plantations in Quebec and Wisconsin. Among the hybrid larches, only one cross survived and grew well (average height 11.3 ft.) in northern Maine. This was the same Sudetan-Japanese cross which performed well at Milo. For the pure Japanese larch seedlots, average height at Ragmuff Stream was 8.3 ft. None of the individual seedlots equaled the performance of the European, Siberian and hybrid larches at that site.

This research indicates that the proper choice of larch species and individual seed sources is critical to the success of planting operations in Maine. For example, the best seed source at Ragmuff Stream is more than twice the height of the poorest seed source, while at Milo the tallest seed source is 50 percent taller than trees from the shortest seedlot. It also illustrates the necessity of experimentation under local conditions prior to the formulation of seed source recommendations. In other larch species experiments in New Hampshire, New York, and New Brunswick, Canada, Japanese and hybrid larches have usually outgrown their European cousins. Our research demonstrates that these species are not necessarily the best planting choices in Maine, especially in the northern climatic zone, where survival of Japanese and hybrid larches is greatly reduced.

Selection of the best seed sources within a species such as European larch will be influenced by the climatic zone in which they are to be planted. These plantations included only seven seed sources of European larch, yet the four tallest European seedlots performed differently at each of the two sites. It is likely that separate planting reccranendations should be developed for the different climatic areas of Maine.

New Test Plantations Established

In order to sample more of the genetic variability within and among larch species, we established two more test plantations in 1984. These plantations, located near Topsfield and Kokadjo, include 82 different seedlots of European, Japanese, Siberian, and hybrid larches, native tamarack and Dahurian larch, a previously untried species from central Asia. Data from these new plantations will allow us to refine the results derived from earlier studies and test the performance of these larches in the eastern and western regions of the State. The inclusion of many new seedlots which were not represented in the earlier plantations should lead to the identification of more individual seed sources that can be recommended for specific planting regions. Tamarack has been included in these tests because there is much genetic variability in this species. Several of these native larches have been found which have growth rates approaching those of exotic larches. In addition, tamarack is very frost-hardy and is capable of growing on poorly-drained sites where the exotic species do not grow well.

Two clonal test plantations of tamarack were established in 1985, in cooperation with Dr. E. K. Morgenstern of the University of New Brunswick. These plantations consist of rooted cuttings representing 490 clones propagated from 49 families collected from seven native tamarack stands in Maine and New Brunswick. These plantations will provide information on the variability within clones, among families and between stands. They also serve as a field test to assess the feasibility of planting rooted tamarack cuttings as an alternative to seedlings.

Black Spruce

One hundred black spruce half-sib seedlots were collected throughout the State in 1983 and 1984 to establish seedling seed orchards and for progeny tests. Seedlings from these seedlots were used to establish three seedling seed orchards in 1985. Additional seedlings from these seedlots will be used to establish accompanying progeny tests in 1986.

Economic Analysis of Regeneration Alternatives

Timothy Rensema completed his M.S. thesis study, an economic analysis of regeneration alternatives (Rensema, 1984). Three alternatives were considered: unmanaged spruce-fir regeneration, precommercially-thinned spruce-fir, and planting of genetically-improved seedlings of four species (white spruce, black spruce, Japanese larch and European larch). Discount rates and increases in mill-delivered price were varied so that net present values could be determined for a variety of possible economic situations. Tree improvement, planting, thinning and harvesting costs were included where appropriate. Expected yields are based on published values for the northeastern United States and Canada.

Table 15 gives the net present values obtained for each regime at 40 years, using a 5.8 percent real discount rate and a two percent annual increase in mill -delivered price. Under these assumptions, plantations of black spruce and larch are economically attractive.

Table 15. Productivity and net presen t value of regeneration regimes given a 40 -year rotation, 5.8 percent real discount rate, and two percent annual increase in mill - delivered prices.

Tree Improvement and Planting	Projected Volume Increase	Volume (cds/ac)	Net Present Value (S/ac)
White spruce	20	36.4	1.79
Black spruce	15	53.6	54.00
Japanese larch	20	74.3	113.61
European larch	20	50.6	25.67

Reference Cited

Nienstaedt, H. 1981. Super seedlings continue superior growth for 18 years. USDA For. Serv. Res. Note. NC-165. 4 pp.

SPRUCE BUDWORM GROWTH IMPACT STUDY

Dr. Thonas B. Brann

Introduction

Data from the Maine Spruce Budworm Growth Impact Study have been used to identify variables that significantly reduce the variability in explaining the probability of individual tree mortality for balsam fir and red spruce trees.

These data are for 45 of the original 400 plots established in 1975 as a cooperative effort among the USDA Forest Service Northeastern Area State and Private Forestry, Maine Department of Conse rvation/Bureau of Forestry, the CANUSA program and eleven private companies (Boise Cascade Corp., Diamond Occidental, Georgia -Pacific Corp., Great Northern Paper, J. M. Huber Co., International Paper Co., J. D. Irving Ltd., Prentiss & Carlisle Co., Scott P aper Co., Champion International and Seven Islands Land Co.) to document the effect of the spruce budworm on the growth and mortality of the Maine spruce -fir forest. Plots are remeasured annually by field crews of the above cooperators.

Statistical Analysis

Using stepwise variable selection, a logistic regression model (1) was fit to predict the probability of survival (P) for the eight year period 1975 to 1983.

P = exp 01)/U + exp (M)}, (1)

where: N is 6.1314 - 0.012563(FBA) - 0.024709 (%SBA) - 0.65728(00) - 0.34667(ND) + 1.3534(SPEC) + CRWN

P = probability of survival,

FBA = fir BA/ac;

%SBA = percent of stand BA/ac composed of spruce;

CO = mean of yearly old defoliation rating for the stand;

ND = -1 if defoliation of new foliage > 50 percent for at least one tree on the plot < 4 years;

= +1 if > 4 years; SPEC = -1

if balsam fir; = +1 if red

spruce;

CRWN = 0.69763 if dominant crown class; = 0.62942 if codominant crown class; = 0.36064 if intermediate crown class; = 0.96641 if suppressed crown class.

The variable OD is significant at P = 0.10 and all others are significant at P < 0.05.

The coefficients of the logistic equation indicate that:

1. As fir BA/ac increases, the probability of survival decreases;
2. As percentage of spruce BA/ac increases, the probability of survival decreases;
3. As the mean value of defoliation of old foliage for the plot increases, the probability of survival decreases;
4. Trees on plots with > 4 years of defoliation > 50 percent for at least one tree have decreased survival probabilities;
5. Red spruce has a greater probability of survival than balsam fir; and
6. As crown position improves, so does probability of survival.

Discussion

Interpretation and use of the logistic regression model is best illustrated by some examples. Survival probabilities for the eight-year period 1975 to 1983 are used to demonstrate the effect of individual tree and stand variables on the predicted probabilities of survival (Table 16).

Table 16. Predicted probabilities of survival (P) for some selected trees.

Tree No.	Species	Crown Class[3] '	Fir BA	Spruce BA	Mean Old Defoliation	No. Years New Defoliation > 50 Percent	P
			(sq ft/ac)	(% total)			
1	Balsam Fir	4	120.74	34.63	3.9	6	.1870
2	Red Spruce	4	120.74	34.63	3.9	6	.7750
3	Balsam Fir	2	120.74	34.63	3.9	6	.5314
4	Balsam Fir	4	120.74	34.63	3.9	6	.4465
5	Balsam Fir	4	120.74	0.00	3.9	6	.3508

*/ Crown class 4 = suppressed tree
Crown class 2 = codominant tree.

The comparison made in Table 16 can be thought of as a sensitivity analysis, where all but one variable is held constant. For example, Tree 1 and Tree 2 differ only in that Tree 1 is a balsam fir (P = 0.1870) and Tree 2 is a red spruce (P = 0.7750). Tree 3 is a codominant balsam fir (P = 0.5314) and Tree 1 is a suppressed balsam fir (P = 0.1870). Tree 4 (P = 0.4465) and Tree 1 (P = 0.1870) illustrate the influence of fir basal area per acre, and Tree 5 (P = 0.3508) and Tree 1 (P = 0.1870) indicate the effect of percent spruce basal area per acre,

SUHLETHAL EFFECTS OF INSECTICIDES ON SPRUCE BUDWDRM Dr.

A. Randall Alford

This project was initiated in response to questions concerning the permanence of the present spruce budworm outbreak in Maine. In the past, research efforts to explain this persistence have focused on the resistance of the spruce budworm population to the insecticides and the reduction of natural enemies. This study examined the direct consequences of low dosages of insecticide stress on the development and fitness of spruce budworm larvae in the laboratory. In the field, the potential for insecticide drift and irregular spray deposits lead to the application of low dosages at some target sites. Consequently it would be of great importance in formulating and modifying future budworm management practices if we could predict some of the sublethal effects. The insecticides chosen were representative of those used in Maine and the region in spruce budworm management programs. These include carbaryl, fenitrothion, aminocarb and B.t.. The LD -50 values were determined for each treatment ma terial as follows: (1) carbaryl = 20 ppm; (2) fenitrothion = 1.3 ppm; (3) aminocarb = 2.3 ppm; and (4) B.t. = 130 ppm.

Dosages at or below the LD -50 range were incorporated into an artificial diet, and 4th - instar spruce budworm were allowed to feed on the treated diet for seven days before being transferred to an untreated diet. Control groups (i.e., no insecticide exposure) were handled similarly. In addition, the interaction of suboptimal rearing conditions (i.e., crowding) on the direct effects of the insecticide were measured.

The sublethal effects on developmental time for larvae, and pupal weights were determined and compared to controls for female survivors of the chemical treatments (Table 17). Significant reductions in pupal weight occurred with dosages of 10 ppm of carbaryl (two and five larvae/cup). However, with each material, increases in dosages resulted in increases in pupal weights to values comparable to controls. With carbaryl, developmental times were significantly longer than controls for 10 and 20 ppm (two and five larvae/cup). Also 0.3 (two larvae/cup and 1.7 ppm (five larvae/cup) aminocarb and 50 and 100 ppm B.t. exposure significantly extended the larval period. Similar effects were found for male spruce budworm, not reported here.

The concept of homolygosis predicts that sublethal quantities of an insecticide will be stimulatory to an insect. This work did not indicate such an effect for the spruce budworm, in contrast to previous reports. However, one would expect sublethal dosages to reduce the fitness of survivors, but this was not observed either. In fact, the LD -50 dosage of carbaryl produced female pupae weighing more than survivors of 3, 7 and 10 ppm (two larvae/cup), indicating a possible recovery or enhancement of vigor at this exposure rate.

Table 17. Female spruce budworm pupal weights and larval development time after exposure to sublethal levels of insecticides.

Chemical Dosage (ppn)	Tw Larvae/Cup Mean Pupal Weight (ing)	Tw Larvae/Cup Mean Development Time (days)	Five Larvae/Cup Mean Pupal Weight (ing)	Five Larvae/Cup Mean Development Time (days)
Carbaryl				
0	121. 8aW	20.9ab	110. Sab	20. 6a
1	122. 7ab	17. 9a	88.0 be	21.2ab
3	117.1 be	21.4ab	91.9abc	20.0a
7	114.8 be	19. Sab	95.8abc	21. lab
10	101.8 c	23.4 b	73.6 c	24.1 be
20	132. 3a	27.7 c	114. 5a	25.4 c
Fenitrothion				
0	108.6	21.1	101.9	23.2
0.3	109.0	22.0	84.6	23.0
0.7	115.3	23.3	86.9	24.9
1.0	104.6	23.2	102.3	22.6
Aminocarb				
0	120.4a	19.5	93.0	20.4a
0.3	98.7 b	20.3	108.9	21. 9a
0.7	104. 3ab	22.1	97.2	21.0a
1.0	116.2*	20.4	98.6	22.6a
1.7	115. lab	23.0	76.0	29.4 b

B.t.	One Larva/Cup	
0	127.6	18.2a
12.5	130.1	18.5a
25	141.2	20.3ab
50	127.3	22.1 b
100	124.8	26.4 c

Column values followed by different letters, within chemicals, are significantly different (P = 0.05).

SONGBIRDS AND SMALL MAMMALS ON GLYPHOSATE-TREATED CLEARCUTS IN MAINE

David J. Santillo

Introduction

Herbicides are commonly applied to regenerating forest stands in Maine, to release softwood seedlings fran undesirable competition with deciduous trees and shrubs. When properly applied, herbicides are not tox ic to wildlife; however, they do have a potential effect on wildlife through habitat modification.

There have been few studies investigating effects of herbicide application for forest management on the habitat quality of wildlife species, and none have be en conducted in the intensively-managed spruce -fir forests of the northeastern United States. This study is designed to determine the effects of habitat changes resulting from treatment of clearcuts with glyphosate (Roundup^ on songbirds and small mammals.

The primary objectives of this study are to: (1) determine the effects of herbicide - induced vegetation changes on species composition, densities and distribution of breeding birds; (2) determine effects of herbicide-induced vegetation changes on the relative abundance and species composition of the small mammal community; (3) examine abundance of birds and small mammals in relation to vegetation structure and composition; and (4) observe patterns in the response of small mammals and breeding birds to herbicide treatment over a range of three years following treatment.

Project Status

Treatments

Six study sites were selected in north - central Maine to represent typical sites treated with herbicides in the region; namely, clearcuts with a suppressed softwood component. Five of the sites were harvested in 1980, and one in 1979. All sites have few residual trees. The six sites represent th ree categories: (1) untreated controls (2) treated in 1983; and (3) treated in 1985.

Glyphosate was applied to the treated sites as Roundup® at the rate of 2 Ibs. a.i./ac. The six sites are being sampled in a sequence that allows observation of three year s of post - treated effects (Table 18).

Table 18. Proposed use of study areas to observe effects of herbicide use on breeding birds and small mammals, 0 to 3 years post-treatment.

Treatment	Plots (n)	Field Season 1985	Field Season 1986
Control	(2)	control	control
Treated 1983	(2)	2nd year effects	3rd year effects
Treated 1985	(2)	control	1st year effects

Breeding Birds

Breeding birds were censused on 10 -ha plots located in each of the six study sites. The spot-map method was used to derive the number of territories of breeding birds encompassed within the borders of each plot. The 10 -ha plots were gridded in 60 -m intervals to facilitate mapping of territories.

Plots were censused nine to ten times each during June and July. During each census, the position and activities of birds detected around each grid point were plotted on a map. Results of daily censuses were transferred to composite maps for individual species, and territories were delineated.

The population densities for each bird species and whole community densities will be expressed as the number of stationary males or breeding pairs per 10 -ha. Community diversity and evenness will be determined.

Small

Snail mammals were sampled by removal trapping. One 8 X 8 station grid with 15 -m spacing between grid points (1.44 ha) was established within each 10 -ha study plot. Two snap traps were set at every station and a pit - fall trap at every third station.

Small mammals were trapped for five consecutive nights in July, and three nights in October. The following information was recorded: species, sex, weight, body and head - to-tail length, and hind foot length.

Small mammal captures will be analyzed for diversity and evenness. The relative abundance of each species will be obtained by calculating catch/unit effort (number/100 trap nights) for each small mammal plot. Total biomass of small mammals trapped on each plot will be compared.

Characterizing the Habitat Modification

The vegetation of study sites was characterized to associate any differences and annual changes in the faunal community of observed differences or changes in the habitat. Vegetation composition and cover are being estimated on circular 200 m^2 plots randomly located throughout each 10-ha study plot.

On each 200 m^2 plot, visual estimates of species, cover-by-area, and community structure within height strata are being made. The height strata chosen for cover estimates are: (1) bare ground; (2) 0 to 0.3 m; (3) 0.3 to 1.0 m; (4) 1.0 to 2.0 m; and (5) 2.0 to 3.0 m. Cover estimates for slash, grass, forbs, and shrubs were obtained within each height stratum.

Foliage volume is being estimated with a density board. The density board (0.5 m by 3 m) is divided into 10 cm^2 blocks: five blocks across by 30 blocks high. The number of blocks in each row which is at least 50 percent obscured by vegetation is being recorded. In addition, an ocular tube is being used to estimate the percent of exposed ground and slash.

Preliminary Results

In the first field season, 57 bird censuses were completed on four control and two 2 -year post-treatment sites. Results indicate some difference in bird densities (Table 19). The difference seemed related to how much area of

Table 19. Bird density estimates (birds/10 ha) on two untreated control areas, and two glyphosate treated areas, two years post-treatment.

Bird Species	Untreated		Treated	
	Control 1	Control 2	2 Years Post	2 Years Post
Cannon yellowthroat	20	13	10	7
White-throated sparrow	16	17	10	7
Lincoln's sparrow	7	12	3	3
Song sparrow	6	4	2	1
Alder flycatcher	7	2	0	0
Northern junco	0	2	2	2
Wilson warbler	2	0	0	0
Chestnut-sided warbler	1	0	0	0
Eastern bluebird	0	1	1	0
Total	59	41	**28**	

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the treated sites was "skipped" or missed during treatment.

A total of 429 small mammals was trapped between July 15 and 20, 1985, and 31 between October 11 and 14, 1985. Captures were higher on untreated sites than on 2 -year post-treatment sites (Table 20). The masked shrew was the most abundant small mammal captu red and the one most affected by treatment. The masked shrew requires moist sites with "good cover. Treated sites have less vegetative cover and were exposed to drying by the sun.

Future Plans

Preliminary analysis of 1985 data has been completed. Songbirds , small mammals, and vegetation will be censused and sampled again in 1986, on the same study plots. Two sites will still be controls, two will now be 3 -years post-treatment and two will be 1 -year post - treatment.

Table 20. Comparison of small manroal captures on two untreated control clearcuts, and two 2-year post herbicide treatment clearcuts.

Treatments	Total Captures	Catch/ 100 Trap Nights	Total Number Species	Masked Shrew
Untreated sites	140	9.3	8	90
2-Year post-treatment sites	54	3.6		20

REGENERATION ASSESSMENTS USING AERIAL PHOTOGRAPHS

Dr. Marshall D. Ashley

The work reported as initiated in the 1983 Annual Report has been completed. Stocking estimates made on large scale, color infrared photography (CIR), adjusted through a linear regression using ground sub -survey data, were found to be within five percent of what would have been obtaine d by the more time consuming intensive ground survey methods now commonly used.

CIR 1:3600 or 1:12000 photos were used to stratify stands into broad stocking classes. Ten percent stocking estimates were obtained from tree counts on a set of sample quadrats within each stratum on 1:1200 photos. These percentages then underwent regression adjustment and provided the final stocking estimate within each stratum in each stand.

A CFRU Technical Note (Ashley and Cohen, 1985) describing how the photo interpreter and field forester can make regeneration assessments has been published. The steps involved are discussed in detail and an example is given of how each step is performed.

1984-1985 PUBLICATIONS RESULTING FROM RESEARCH SUPPORTED BY CFRU

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ADDITIONAL TECHNOLOGY TRANSFER ACTIVITIES
BY CFRU PERSONNEL

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____. Panel member, Biorationals discussion group. Canada/United States Spruce Budworm Program Symp., Bangor, ME, September, 1984.

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Shepard, R.K. Evapotranspiration from forest wastewater spray areas. Report for the Sugarloaf Corp., January, 1984.

____ . Reforestation to reduce drought effects in Zimbabwe. Report for an attorney, Springfield, MA, January, 1984.

____ . Application of fish processing wastes. Discussion with Biotherm International, South Portland, ME, February, 1984.

____ . (1) Intensive fore st management practices in Maine; and (2) Potential impact of intensive forest management on water resources. Presentations to Crop Management class, Dept. of Plant and Soil Sciences, Univ. Maine, Orono, April, 1984.

____ . Forest application of pulpmill sludge. Presentation to Great Northern Paper Company, Millinocket, ME, April, 1984.

____ . An update on the white pine fertilization project. Presentation to P.H. Chadbourne and Co., Bethel, ME, June, 1984.

____ . Land applica tion of pulpmill and municipal sludges and nutrient questions in general. Discussion with research foresters of Scott Paper Company, Fairfield, ME, November, 1984.

____ . Application of municipal sludge to forest lands. Participated in the formulation of the Northeast Research Regional Proposal NE - 54.

____ . (1) Intensive forest management practices in Maine; and (2) Potential impact of intensive forest management on water resources. Presentations to Crop Management class, Dept. of Plant and Soil Sciences, Univ. Maine, Orono, April, 1985.

_____ . Participation in research presentation at Pulp and Paper Foundation, Univ. Maine, Orono, April, 1985.

_____ . Does it pay to fertilize white pine? Seminar to Coll. For. Resour., Univ. Maine, Orono, April, 1985.

_____ . Fertilization of white pine in Maine. Poster (with T. Brann) at the White Pine Symp., Univ. New Hampshire, Durham, June, 1985.

_____ . White pine fertilization project. Presentation to Western Maine Forest Forum, Lewiston, ME, December, 1985.

MADE AGRICULTURAL EXPERIMENT STATION MISCELLANEOUS REPORT 321

COOPERATIVE FORESTRY RESEARCH UNIT ADVISORY COMMITTEE

1984 & 1985 Membership

The CFRU Advisory Committee sets priorities and reviews proposals for the Cooperative Forestry Research Unit. Members active during all, or part, of 1985 were:

Robert V. Withrow, Jr., General Manager, Wood Department, Boise-Cascade Corporation (Chairman)
Clifford L. Swenson, President, Seven Islands Land Company (Vice Chairman)
E. Bart Harvey, Jr., Director, Forest Management, Great Northern Paper (Financial Officer)
Robert Gardiner, Director, Maine Bureau of Public Lands (Member at Large)
Gregory N. Brown, Dean, College of Forest Resources (CFRU Director)
Barton M. Blum, Project Leader, USDA Forest Service
Robert P. Chadbourne, Land Division Manager, P. H. Chadbourne & Company
Edward Chase, Chase Tree Farm
Robert D. Cope, Regional Timberlands Manager, Champion International Corporation
William Hepburn, Lumber Exchange of North America
Harold M. KLaiber, Forestry Manager, Scott Paper Company
Ronald Lovaglio, Manager, Forest Management, International Paper Company
Dwight Newman, President, Christmas Tree Acres
Michael Partridge, Calley and Currier Company, Inc.
L. Oscar Selin, Director of Forestry, Georgia-Pacific Corporation

Liaison to Forest Resources Research Advisory Committee

Richard B. Anderson, Commissioner, Maine Department of Conservation

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(December 31, 1985)

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Mark W. Houseweart, Associate Research Professor of Forest Resources
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Katherine K. Carter, Assistant Professor of Forest Resources
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Peter Caron, Research Technician (Tree Improvement)
Ronald C. Lemin, Jr., Research Associate (Timber Management and Harvesting)
Frank E. Spizuoco, Research Associate (Silviculture)

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Maine Christmas Tree Association
Maine Wood Turning Company
Ray T. McDonald, Jr.
Monsanto Agricultural Products Company
Moosehead Manufacturing Company
Northeastern Lumber Mfg. Association
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Sprowl Brothers
General Clayton Totman
USG Industries, Inc.
Valle Vu Farms
Velsicol Chemical Corporation
Western Maine Nursery
R. Leon Williams Lumber Company
H. G. Winter & Sons

OTHER ORGANIZATIONS PROVIDING SUPPORT FOR CFRU PROJECTS

Evergreen Helicopters
Frontier Helicopters, Inc.
Helicopter Systems
Maine Agricultural Experiment Station
Maine Forest Service
Mclntire-Stennis
Osmose Wood Preserving Company
USDA Northeastern Forest Experiment Station
USDA State & Private Forestry

APPENDIX - TERMS

COMMON NAME

TREES
Bigtooth aspen
Beech
White Birch
Yellow Birch
Balsam fir
Hemlock
Dahurian larch
Eastern larch
European larch
Japanese larch
Siberian larch
Sugar maple Red
oak Jack pine
Red pine White
pine Black
spruce Norway
spruce Red
spruce White
spruce

BIRDS
Cannon yellowthroat
White-throated sparrow
Lincolns sparrow Song
sparrow Alder flycatcher
Northern junco Wilson
warbler Chestnut-sided
warbler Eastern bluebird

MAMMALS Masked
shrew

INSECTS
Spruce budworm Seedling
debarking weevil Larch
cone maggot White pine
weevil Larch Seed Midge

BACTERIUM
B.t.

SCIENTIFIC NAME

Populus grandidentata Kichx.
Fagus grandifolia Ehrh. Betula
papyrifera Marsh. Betula
alleghaniensis Britt. Abies
balsamea (L.) Mill. Tsuga
canadensis (L.) Carr. Larix
gmelini (Rupri) litvin Larix
laricina (DuRoi) K. Koch. Larix
decidua Mill.
Larix leptolepsis (Sieb. and Zucc.) Gord.
Larix siberica Ledeb.
Acer saccharum Marsh.

Pinus banksiana Lamb.
Pinus resinosa Ait.
Pinus strobus L.
Picea mariana (Mill.) B.S.P.
Picea abies (L.) Karst.
Picea rubens Sarg.
Picea glauca (Moench) Voss

Geothlypis trichas (Subsp.)
Zonotrichia albicollis Melosphiza
lincolnii lincolnii Melosphiza
melodia (Subsp.) Empidomax
traillii traillii Junco hyemalis
(Subsp.) Wilsonia pusilla pusilla
Dendroica pensylvanica Sialia
sialis (Subsp.)

Sorex cinerceus

Choristoneura fumiferana Clemens
Hylobius congener Dalla-Torre, Schenkling and Marsh
Lasioma sp.
Pissodes strobi (Peck)
Resselliella sp.

Bacillus thuringiensis Berliner

PRODUCTS AND EQUIPMENT

Roundup	Glyphosate
Garlon 31®	Triclopyr
Shigonetei®	
Radio Horsed	
MorbeUP	