1982 ANNUAL REPORT OF THE COOPERATIVE FORESTRY RESEARCH UNIT

Miscellaneous Report 284 April 1983

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COOPERATIVE FORESTRY RESEARCH UNIT
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CHAIRMAN'S REPORT

It requires a certain period of time after the initiation of a program for research to come of age so that conclusions can be drawn and specific recommendations developed. This was the seventh year of the Cooperative, and the record of publications is growing. A different type of tangible result of the Cooperative was the approval of a State of Maine label for the use of Garlon 3A® and Garlon 4® for conifer release. These are the second and third labels to be awarded primarily as the result of research by the CFRU.

This was also a year of new directions for the Cooperative. Research on hardwoods got underway with the hiring of Dr. William Ostrofsky, who arrived in August to begin work on the hardwood problem analysis. The test of the "Radio Horse 9" for small tree harvesting was initiated by Dr. Robert Seymour during the summer. Dr. Mark Houseweart began studies on the weevils attacking softwood regeneration and freshly planted seedlings as well as those insects feeding on cones and seeds of spruce and larch.

A most exciting equipment innovation for application of herbicides was tested during July by Dr. Maxwell McCormack. A cooperating aerial applicator, Evergreen Helicopters, developed a special spray nozzle to distribute herbicides in strips for precommercial thinning. The nozzle was tested in young, overstocked softwoods growing on lands of three members of the Cooperative. Since dealing with overstocked softwood regeneration is going to become more and more of a problem in the aftermath of the budworm epidemic, there is an intense need for cost-effective methods for pre-commercial thinning. Trials and refinement of this technology will continue.

As the Cooperative continues to mature, there will be an increased emphasis on interpretation of research results and the development of practical methods of application. And as the results of the budworm epidemic become more apparent, there will be an intense need to creatively apply the results of CFRU research to the forests of the State of Maine.

Charles D. Webb, Chairman
CFRU Advisory Committee

DEAN'S REPORT

The Cooperative Forestry Research Unit has achieved a record of accomplishment in 1982 that is impressive. The reports you will read in the pages to follow these comments require no elaboration by me. The scientists working in CFRU are highly productive and are doing an effective job for the cooperators.

I am pleased that the additional hardwood initiative became a reality in 1982. This effort took many hours of work resulting in additional memberships, despite the recession. The added funds received from the new members coupled with funds from all cooperators have been sufficient to get the program started. We were fortunate to obtain Dr. William Ostrofsky to lead the research under the direction of Dr. Maxwell "McCormack.

The CFRU became part of a new College in 1982 with the elevation in status of the School of Forest Resources to the College of Forest Resources. This has necessitated some reorganization internally, but the CFRU remains intact as a research unit. The faculty and staff of the College thank those of you who have helped us in reaching this goal.

Two long term members of the faculty retired in 1982. Both have been highly productive and are well recognized by the forestry community in the state. Dr. Harold Young retired on September 30, and Dr. Malcolm Coulter on December 31. We are currently searching for a tree physiologist to fill a named chair as a replacement for Dr. Young. Dr. Ray Owen has replaced Dr. Coulter as chairperson of the wildlife program. The remaining staff is unchanged though two administrative positions had not been filled permanently by the end of the year.

Fred B. Knight
Dean

March 1983

SILVICULTURE - Dr. Maxwell L. McCormack, Jr.

Intensive Forest Harvesting

The paired watershed study on Weymouth Point, T4R12 WELS, continued through 1982. This is a cooperative effort involving CFRU, Great Northern Paper Company and the U.S. Forest Service, Forest Sciences Laboratory, Durham, New Hampshire. The objective of the study is to evaluate the effects of intensive mechanical harvesting and residue management practices on short-term nutrient cycling and on long-term forest site fertility in the spruce-fir type. Soil solution samples were collected from the paired, porous, ceramic cup, tension lysimeters from June through October. These samples provide a basis for the monitoring of soil solution chemistry which has been continuous since before the full-tree harvesting operation in summer, 1981.

Laboratory analyses were completed on soil, biomass, organic pad and harvesting residue samples. These data will be reported, in detail, in the Ph.D. dissertation of C. Tattersall Smith, Jr. which is planned for completion in summer 1983. A progress report summarizing the work done through winter 1981-82 has been drafted for publication. Soil solution sampling and monitoring of the general conditions on the clearcut watershed will be continued.

Post-harvesting conditions and vegetation regrowth were monitored through the 1982 growing season. This monitoring is facilitated by reference to a grid system established before harvesting the watershed. The preharvest reference points were relocated and monumented.

Precommercial Thinning

Overstocking is a prevalent management problem in developing forest stands Of the northeastern spruce-fir forest _*Ab-ies balsamea* (L.) Mill., *Pioea rubens* Sarg., *P. mariana* (Mill.) B.S.P., *P. glauaa* (Moench) Vossj. There is an immediate need for feasible, operational-scale treatments to adjust density of stocking (ADS). Natural regeneration typically develops with 10,000 to 40,000 stems per acre on sites where 800 to 2,000 stems would be preferred. A silvicultural method allowing early entry to improve the overstocked stands would help to solve the problem. An acceptable ADS treatment should satisfy several requirements.

1. Safety to personnel. The terrain is irregular with logging slash and boulders distributed over the sites.

2. Minimum soil disturbance. Problem weeds such as raspberry _*Rubus idaeus* L. var. *strigosus* (Michx.) Maxim.] and pin cherry *(Prunus pensylvanioa* L.f.) often proliferate following disturbance.

3. Relatively low cost. These treatments must be applied in the early years of 30- to 70-year rotations needed for the production of timber crops.

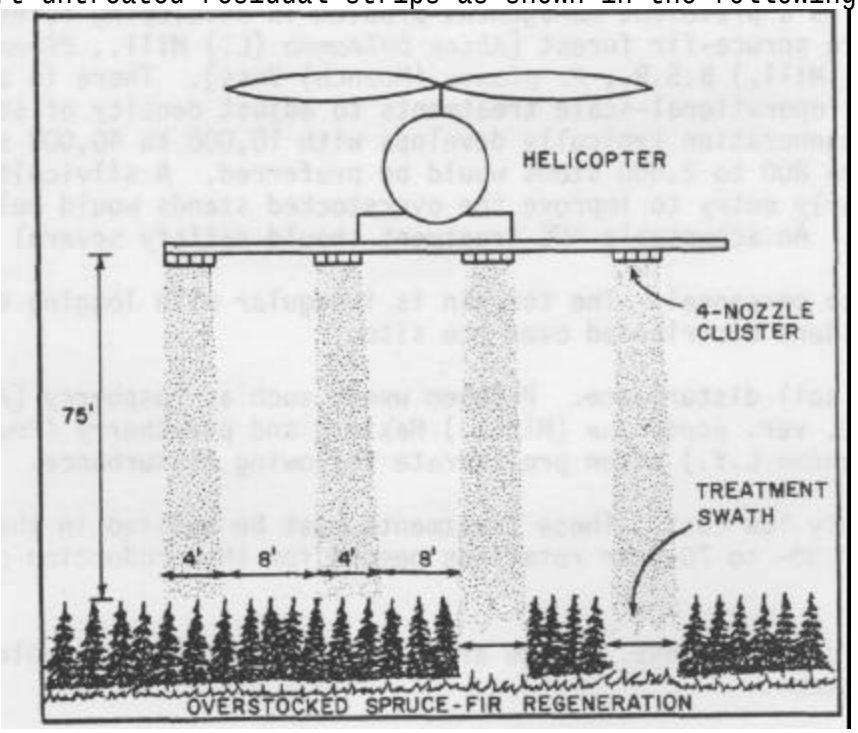
4. Minimum direct access. Large areas exist without well-developed road systems.

5. Treat large acreages within a limited calendar period. Weather conditions and other work requirements limit the time available to treat many of the areas.

6. Suppress, or remove, a broad spectrum of brush and tree species.

An ADS treatment system, utilizing helicopter application of herbicides, was developed as a possible means of satisfying this management need. Field tests have been initiated on three northern Maine cutover forest sites. Treatments were applied as helicopter swath pairs. Sixteen pairs were applied in the Town of Shirley, 13 in Spencer Bay Township (T1R14 WELS), and 25 in Township 14 Range 11 WELS. In addition to the spruces and fir, other conifers included eastern white pine *(Pinus strobus* L.), tamarack _*Larix laricina* (DuRoi) K. Koch], and northern white-cedar *(Thuja ocoidentalis* L.). Prominent hardwoods included red maple *(Acer rubrum* L.), paper birch *(Betula papyrifera* Marsh.) and quaking aspen *(Populus tremuloides* Michx.). These areas are typical regrowth following logging with scattered, individual residual trees with heights up to 65 feet. Young growth is heavy and ranges in height from 3 to 25 feet depending on site. Adjacent logging roads and landings served as helicopter ports.

In order to satisfy the anticipated operational conditions, helicopter spray patterns can be flown from altitudes of 75 to 100 ft. above the target surface. Total volumes delivered per surface acre of target were 20 gal. A desired pattern was achieved using a Microfoil Boom® fitted with 0.060 orifice nozzles. Treatment band widths and spacing could be modified by changing the numbers of nozzles on the boom. For the field tests the nozzles were in groups of four with 11 blank nozzle positions along the boom between each set of spraying nozzles. The resultant ground pattern was treatment bands 4 ft wide between 8 ft untreated residual strips as shown in the following diagram.



Conceptual diagram of spray delivery system for alternate strip treatments,

Chemical treatments offering potential for the required broad spectrum control were prepared and mixed separately. Each was applied as a pair of helicopter spray swaths. Most of the treatments were replicated across at least 'two of the study sites. The treatments which were applied on July 10 and 14, 1982 are summarized in the following Table.

SUMMARY OF STRIP TREATMENTS APPLIED TO ADJUST DENSITY OF STOCKING IN DEVELOPING SPRUCE-FIR STANDS

Herbicide	Rate, lb/a-[1]	Swath Pairs Applied
dicamba (3,6-dichloro-o-anisic acid)	6	6
dicamba + 2,4-D [(2,4-dichlorophenoxy)acetic acid]	2+3.8	7
dicamba + 2,4-D	3+5.7	5
dicamba + picloram (4-amino-3,5,6-trichloropicolinic acid)	3+1	6
dicamba + 2,4-D + picloram	4+4+1	5
picloram + 2,4-D	1+4	5
picloram + 2,4-D	1.5+6	5
bromacil (S-bromo-S-sec-butyl -6-methyl uraci 1)	4	5
bromaci 1	8	5
glyphosate [N-(phosphonomethyl) glycine]	6	2
glyphosate + (d-limonene + emulsifiers)	6+(2 qt)	1
dicamba + 2,4-D + (d-limonene + emulsifiers)	2+3.8+(2 qt)	2

– All rates are active ingredient except the adjuvant added to the last two treatments listed.

The delivery system performed well under operational conditions. The configuration of the swaths resulted in one acre of ground being sprayed across three acres of treated forest land. Considering this ratio, the production rate and projected costs were satisfactory.

The visible patterns observed two months after application are promising. Treatments including picloram and dicamba were most apparent in the preliminary evaluations. An earlier date of treatment might have provided more thorough initial defoliation of the conifers.

Early evaluation of the delivery patterns on the ground indicates the desired treatment spacing was achieved. The sprayed strips of four bands per helicopter swath are well-defined. Though interactions of root uptake and transfer are questions requiring study, the rigid control of herbicide band delivery which is possible could provide some compensation in the event complications are identified. This type of treatment shows promise as a means of making an initial silvicultural entry into overstocked forest regeneration.

Thinning Spruce and Spruce-Fir Stands

The long-term phase of the original thinning study, initiated in 1977, continued through 1982. Individual study tree records were maintained for the four study sites which have been described in previous annual reports. They are:

(1) Scott Brook, T5R15 WELS ,

(2) Rowel 1 Brook, T1R13 WELS,

(3) Clayton Lake, T11R16 WELS, AND

(4) Lakeville Plantation

Conditions of the individual study trees will be remeasured during 1983. This will provide information following a period of five growing seasons after thinning. An additional study site in an old field white spruce plantation near Ashland was thinned in 1980. It will be reevaluated during 1983.

Spruce budworm _*Choristoneura fwnifevana* (Clemens)] has caused some defoliation on the four original sites and losses of balsam fir study trees continue to occur. Heavy defoliation of red spruce study trees has also taken place. Lower-crown defoliation from the yellowheaded spruce sawfly _*Pikonema ulaskensis* (Rohwer)] occurred after thinning in the white spruce plantation. Some spruce budworm damage was noted at the tops of these trees in 1982, but no mortality has been observed to date.

Management of Undesirable Vegetation with Herbicides

In April, the Maine Board of Pesticide Control approved local need 24(c) registrations for triclopyr amine (Garlon 3A®) and triclopyr ester (Garlon 4®) to be used for conifer release in Maine. Past work, some of which was summarized in the 1981 Annual Report, served as a basis for these labels. The availability of these products for release treatments adds to the options for specific silvicultural prescriptions which can be developed by forest managers.

Evaluations of previously established field treatments were carried out during 1982. Of particular interest was an evaluation of residual control of dense stands of raspberry. Comparisons of first and second year effectiveness of selected treatments are summarized in the following table.

FIRST AND SECOND YEAR
SILVICULTURAL EFFECTIVENESS[3] OF BACKPACK MISTBLOWER-
APPLIED HERBICIDES IN CONTROLLING BRAMBLES

	RATE[1] lb/a	Date of Application 31 JULY	27 AUG	15 SEPT
hexazinone				
	1		8.5 9.5	
	2		9 8	
	4		8.5 7.5	
	6			
fosamine				
	4			6 7.5
	6			7 7.5
	8			7 6.5
glyphosate	2			6.5

Zero to 4 represents inadequate siIvicultural advantage; five is the threshold of benefit; 6 to 10 indicates increasing silvicultural effectiveness up to complete control. Ratings are based on four independent appraisals.

All rates are active ingredient.

All July treatments of hexazinone, fosamine and glyphosate retained good effectiveness. Higher rates of hexazinone were needed in August and September to retain good effectiveness. August applications of fosamine faded below effective levels of suppression, but the September treatments were satisfactory. Glyphosate maintained acceptable levels of suppression, but September treatments decreased notably. This appears to reflect the influence of autumn frost prior to treatment.

FOREST PROTECTION - Dr. Mark W. Houseweart

Regeneration Weevil Study

In 1982, Celeste Welty, M.S. graduate student, and I initiated a cooperative project with Sue Goldman and Jim Knight of International Paper Company, Corporate Research - Science and Technology Division of Tuxedo Park, New York. Debarking damage caused by the regeneration weevil, *Eylobius congener* Dana-Torre, had been detected in 1981 on several species of pine, spruce, and larch seedlings on International Paper Co. plantations across the state, with the most severe damage occurring on white pine in Glenwood, Maine. In 1982, all field work was conducted in black spruce plantations near Glenwood.

First-year (preliminary) results on the influence of site factors indicate: 1) there is little difference in the extent of seedling damage between softwood and mixedwood plantation sites; 2) seedlings planted in older cuts seem less vulnerable to weevil damage than those planted in more recent cuts; 3) neither slash removal nor increased slash caused any difference in seedling damage; 4) seedlings near both softwood and hardwood stumps had more damage than seedlings in open areas on the most recently cut sites; 5) slightly more debarked seedlings were found in plots near the edge than in the interior of the plantations; 6) removal of the duff from around the bases of seedlings reduced weevil damage from 7 to 26 percent on the most recently cut sites.

Of the various trapping techniques used for monitoring weevil populations, the most effective was the split-bolt trap, which is a common technique used for sampling *Pales* weevil in the South. Screen-cone traps were used to time weevil emergence from the duff in the spring. Barrier and malaise traps were used to assess aerial dispersal of weevils, while pitfall traps were used to monitor ground movement of the weevils. Rainfall and temperature, which may affect weevil activity, were also monitored.

Seedling species susceptibility tests indicate that debarking occurs on all of the following species: white pine, *Pinus strobus* L.; red pine, *Pinus resinosa* Ait.; jack pine, *Pinus bariksiana* Lamb.; black spruce, *Picea mariana* (Mill.) B.S.P.; Norway spruce, *Picea abies* (L.) Karst.; white spruce, *Picea glauca* (Moench) Voss; red spruce, *Pioea rubens* Sarg.; Japanese larch, *Larix leptolepis* (Sieb. and Zucc.) Gord.; European larch, *Larix decidua* Mill.; and tamarack, *larix laricina* (Du Roi) K. Koch. Live weevils collected during the summer were used to initiate a laboratory colony. These colony weevils were used in tests on host susceptibility and weevil feeding preference which are being conducted in the greenhouse. A parasitic wasp has been found to cause considerable mortality of weevils in the larval stage.

During the spring and summer of 1983, studies will involve obtaining additional information on weevil seasonal activity patterns, a continuation of the duff and slash experiments, and further studies in both the field and the laboratory on susceptibility of various tree species.

Seed and Cone Insects

Assistant Scientist, Robert Lawrence, has started preliminary investigation of larch and spruce cone insects. During 1982, we collected over 6 major insect species damaging larch cones. Specimens have been sent to taxonomic specialists in Washington, D.C. for positive identifications. Initial studies have involved distributions of the cone-insect complex within the tree crown, survey of

geographic distribution, and comparisons of seed damage between tamarack (60+%) and exotic larches (3-10%). A Ph.D. graduate student is being recruited to augment our efforts on seed and cone insects of larch. Lawrence will be looking into spruce cone damage by insects. Coordination of our projects will be maintained with Dr. R. Brown, University of New Brunswick, who is conducting similar studies, and is starting insecticide application trials. Formal research proposals will be submitted to the Advisory Committee in the spring of 1983.

Spruce Budworm - *Trichogramma* Projects

Active field studies have been curtailed, but publication of previous research results have intensified. A major effort has been made this year to complete analyses and writing of the 5-year field studies using the egg para-si toid, *Trichogramma minutum* Riley, as a suppression strategy for spruce budworm egg mass populations. This manuscript is now being reviewed by other scientists in Canada and California. An abstract of the report of the field release studies follows:

> Field release trials of *T. minutum* for suppression of spruce bud-worm, *Choristoneura fumiferana* (Clemens), egg populations were conducted in Maine from 1977 to 1981. In 1977 and 1978, point-source releases using both commercial California and native Maine parasitoids indicated that the native Maine strain performed better. In 1979, tests of 3 release strategies (4-point, broadcast and multiple) provided information that broadcast and multiple releases were applicable in a spruce-fir forest environment. In 1981, three closely-timed, aerial, broadcast releases from a helicopter were conducted. Important variables and suggestions for future aerial releases are discussed.

Several research manuscripts have been published and appear in the journal, Canadian Entomologist. Two additional manuscripts on the basic biology of the parasitoid, *T. minutum,* have been submitted: one on *T. minutum* progeny production, and another concerning longevity and development of *T. minutum* in the laboratory. Abstracts of these follow:

> Mean daily progeny production per *T. minutum* ("Maine strain") female was 15.2 in *C. fumiferana* and 10.9 in *Sitotroga cerealella* (Olivier) eggs. Total progeny production was higher in *S. cerealella,* but not significantly different than progeny produced in *C. fumiferana* eggs. Significantly more eggs were deposited by *T. minutum* the first day than in subsequent days regardless of host. We found no significant reduction in progeny produced by females in relation to day of male death. Ratio of females:males decreased significantly as daily egg production proceeded. About 68% of the adult life of the females was spent ovipositing in *S. cerealella* eggs; whereas, significantly less time (60%) was spent ovipositing in *C. fumiferana* eggs.
>
> Our laboratory results on progeny production, longevity, and sex ratios suggest a significant advantage for using spruce budworm eggs as hosts for rearing the "Maine strain" of *T. minutum* in terms of a higher female proportion of the progeny produced. Conversely, parasitoids utilizing 5. *cerealella* eggs lived longer. The combination of these results enables one to select for those criteria deemed most desirable. For inundative releases, increased longevity is probably not as advantageous as the early progeny production and the female-favored sex ratios.

The effects of differences in the sex ratio are quite dramatic, when one considers numbers of parasitoids needed for releases. It would require over twice the number of females, if *S. oerealella* eggs were utilized during the last laboratory-reared generation prior to field release, compared to using spruce budworm host eggs. Regardless of these advantages, one must still consider rearing costs of the easily-produced *S. aerealella* versus larger hosts.

Our laboratory results also point out another important factor to consider for augmentative releases. Regardless of host utilized, progeny production drops off quickly following the first two days of oviposition, suggesting the merit of multiple, closely-timed releases versus single or widely-spaced releases.

The following is an abstract of the longevity and development manuscript for which CFRU Assistant Scientist, Robert Lawrence, is senior author:

Developmental rates of the parasitoid, *T. minutwn,* in *C. fumiferana* and *S. cerealella* host eggs were studied at constant temperatures of 14°C, **2T°C, and** 27°C. Adult parasitoid longevity was also investigated at these temperatures for *T. minutim* reared in *C. fumiferana* eggs, but whose parents were reared in *C. fwniferana* or *S. cerealella.*

Development of *T. minutwn* required the fewest degree days at 27°C. Within each temperature treatment, *T. minutwn* developed more rapidly in *S. aerealella* eggs than in *C. fumiferana* eggs, and male *T. minutwn* adults emerged prior to female adults from eggs of both host species.

Although parental host had some effect on adult longevity of *T. minutwn,* longevity was more strongly affected by rearing temperature and sex of the parasitoid. *T. minutwn* from both parental host groups had the greatest longevity at 21°C. Among *T. minutwn* of the *S. cerealella* parental-host group, mean adult longevity of females was significantly greater than mean adult longevity of males.

With specific information on developmental rates and longevity, more precise timing of field releases and prediction of adult survival may be made.

White Pine Weevil Studies

Two of three research manuscripts have appeared in national entomology journals -- "Life tables of the white pine weevil" and "Fall activity and overwintering sites"; the third, "Spring activity patterns", should appear shortly. All CFRU members will receive reprints when they become available. A new graduate student is being recruited to initiate further follow-up studies on fall insecticide applications for suppression of the white pine weevil. Dr. James Dill, UMO Pest Management Extension Specialist and Dr. Eben Osgood, Dept. of Entomology, will be cooperating on this study.

TIMBER MANAGEMENT AND HARVESTING - Dr. Robert S. Seymour

Problem Analysis Completed

Early 1982 was spent completing a problem analysis to guide CFRU research in timber management and harvesting for the next 5 years. Work was proposed in three areas:

1. Development and analysis of silvicultural systems - to provide direction and propose options for investment in intensive management practices;

2. Development and testing of harvesting systems for small wood, emphasizing partial-cutting techniques - to expand foresters' stand-treatment capabilities and extend wood supplies; and

3. Long-term timber supply forecasting - to identify options for future productivity of Maine forests and to encourage a long-term perspective in timber management planning.

The problem analysis was reviewed by the CFRU Advisory Committee at the April 21 meeting. The Committee voted to assign top priority to the development of small wood harvesting systems, and approved a proposal^ to evaluate four thinning systems for small diameter spruce-fir. The rest of the year was spent completing field work and beginning data analysis for this study.

New Research Associate Hired

In March, Charles J. Gadzik, a 1979 graduate of the Forest Management program at the University of Maine, School of Forest Resources, began work as Research Associate, replacing Ellis Sprague who had resigned earlier. Gadzik brings to the Unit a unique set of talents from his experience on a variety of harvesting and silvicultural operations, most notably a year spent working for the Swedish Forest Service (Domanverket) gaining knowledge of Scandinavian systems. Gadzik helped lay out and administer the thinning study, and has been a valuable addition to the CFRU staff.

Thinning Systems for Smal1-Diameter Spruce-Fir Stands

In May, work began on a major study to compare four thinning systems in terms of production and their effects on the residual stand quality.

Seymour, Robert S., Charles J. Gadzik, and Maxwell L. McCormack, Jr. 1982. Development of harvesting systems for partial cutting in small diameter stands, I. Commercial thinning in spruce-fir stands - a test of a radio-controlled portable winch for prebunching tree-length wood to a skidder or cable yarder. II. Evaluation of the Smith Timbermaster, a small skyline yarder.

In cooperation with Seven Islands foresters, an area was selected on T12R6 (Nashville Plantation) where active harvesting operations were planned for 1982. Four treatments were laid out: 1) prebunching with the radio-controlled winch, and yarded by the cable skidder; 2) prebunched with the winch, and yarded by the cable yarder (Smith Timbermaster); 3) conventional 2-man skidder crew (not prebunched; and 4) cable yarder only (not prebunched). The major goals of the study were to test the hypothesis that winch prebunching would reduce yarding costs and residual stand damage, and to compare the production and operating costs of cable yarding with conventional skidding, with and without prebunching.

To conduct the prebunching treatments, CFRU acquired a Radio Horse 9 radio-controlled prebunching winch. In May, a 2-man summer crew was hired and trained by Chuck Gadzik, who supervised the felling and winching during the June-September operating period. About 220 cords (3,300 trees) were prebunched in the process of thinning a 14-acre stand. Winch prebunching was done by both butts-ahead and tops-ahead systems at various distances. Eighty cords of this wood were yarded by the Smith Timbermaster in July, and the remaining wood was yarded in September by a Franklin 120B cable skidder.

Thinning treatments using the skidder or Timbermaster alone (without first prebunching the wood with the winch) were carried out by regular production logging crews working for Seven Islands' contractor, Paul Nadeau. A 4-man crew was normally employed on the Timbermaster operation: a machine operator, a choker setter, a full-time chopper, and a swing man who alternated between hooking and chopping. Only two men were used to yard the prebunched wood. Unbunched skidder treatments were logged by a conventional two-man crew working "hot." Skidder yarding of the prebunched wood was done by the same operator working alone. All operations were tree-length, felled and limbed manually in the woods.

Before thinning, permanent plots were installed to evaluate removal rates, residual stand damage, and to provide a basis for measuring long-term stand response to thinning. All operations were monitored in detail by time-and-motion studies, and by maintaining a daily log of each crew.

In total, about 28 acres, in two separate but similar stands, were thinned. The stands are about 75 years old, heavily stocked, with spruce comprising 76 percent of the pre-harvest basal area (Table 1). The prescription was to leave good growing stock trees on a uniform 10-15 ft spacing. Well-formed codominant or dominant spruce were favored, but firs were left where necessary to fill what would otherwise have been "holes" in the residual stand. Removals of spruce were concentrated heavily on the small-diameter lower crown classes. Thinning removed 85 percent of the fir and 29 percent of the spruce, changing the stand composition from 70 to 86 percent spruce, leaving a residual basal area of 106 square feet per acre. Overall, 50 percent of the stems, 38 percent of the basal area, and 37 percent of the volume were cut. About 18 cords per acre were removed (including wood taken in skid trails or skyline corridors), in wood averaging about 7 in dbh or 14 trees per cord.

Average production rates determined from time studies (Table 2) were used to derive thinning costs per cord (Table 3). These data are presented mainly to allow comparisons among the systems; their applicability to a particular operation would depend on how closely actual field conditions resemble the assumptions made in the calculations.

Table 1. COMPOSITION OF STANDS THINNED IN 1982 CFRU STUDY, T12R6 (AVERAGED OVER ALL TREATMENTS). ALL TREES 4.6 INCHES DBH AND LARGER (BASIS: 47 0.1 ACRE PLOTS).

	Number of Trees	Basal Area (sq ft)	Volume (Cords)	Avg	Trees per Cord
ORIGINAL STAND:					
Spruces	307	per acre	37.7	8.5	8.1
Fir	158	120	41 10.7	6.9	14.8
All Species	484	172	area in skid 48. 4[1]	8.1	9.6[1]
RESIDUAL STAND:					
Spruces	202	91	5.7 29.3	9.1	6.9
Fir	25		1.4	6.5	17.9
All Species	243	106	30. 7[1]	8.9	7.4[1]
REMOVED IN THINNING:					
Spruces	105	29	8.4	7.1	12.5
Fir	133	35	9.3	6.9	14.3
All Species	241	66	17.7[1]	7.1	13. 5[1]

Total volumes include spruces and fir only

Table 2. PRODUCTION OF FOUR THINNING SYSTEMS IN TREE-LENGTH SPRUCE-FIR 1982 CFRU OPERATION, T12R6. REMOVALS = 18 CORDS/ACRE. (38% OF ORIGINAL STAND), 15 TREES/CORD.

	YARDING			
	PREBUNCHED WOOD		WOOD NOT PREBUNCHED	
	Cable skidder[1] (one man)	Skyline yarder[2] (2-man crew)	Cable skidder[1] (2-man crew)	Skyline yarder[2] (4-man crew)
Trees yarded per productive hr.	96	45[3]	27	30[3]
Avg. cycle time (minutes)	18.78	6.7E[4]	22.73	6. 51 5
Cords per scheduled hr. (70% utilization, all systems)	4.5	2.1	1.3	1. 4
Avg. yarding distance (ft)	660	500	660	50 0
PREBUNCHING (Radio Horse 9 Portable Winch)				
Trees winched per productive hr.	(tops ahead) 30	(butts ahead) 22		
Avg. cycle time (minutes)	5.98	3.80		
Cords per scheduled hr. (70% utilization)	1.4	1.0		
FELLING AND DELIMBING (Chainsaw)				
Trees felled and del imbed per productive man-hour	15	22	28	20

1 Franklin 120B ? "Smith Timbermaster

Setup of skyline system included in productive time.

4. includes 1.43 min for setup time (3 hr/setup ^ 118 turns/setup)

5, includes 1.98 min for setup time (3 hr/setup ^ 92 turns/setup)

Table 3. COSTS OF FOUR THINNING SYSTEMS IN TREE-LENGTH SPRUCE-FIR, 1982 CFRU OPERATION, T12R6. (REMOVALS = 18 CORDS/ACRE, 15 TREES/CORD; 70% UTILIZATION FOR ALL SYSTEMS)

	PREBUNCHED WOOD		WOOD NOT PREBUNCHED	
Component	Cable Skidder	Skyline Yarder	Cable Skidder	Skyline Yarder
Felling cost	17.21	11.74	9.22	12.91
Winching cost	9.51	12.97	none	none
Yarding cost	5.49	17.36	19.01	29.54
Total, roadside:	32.21	42.07	28.23	42.45

Machine rates ($ per scheduled hour): Cable skidder = $15.04; skyline yarder = $16.85; radio-controlled portable winch = $3.25; chainsaw = $2.25.

All labor figured at $7.00 per hour + 40% overhead.

Detailed analyses of each system will be reported in publications now in preparation. The following summary highlights the major findings:

1) Winching tree-length stems,tops ahead,was more productive than butts-ahead operations; however, felling trees for tops-ahead winching is more demanding in time and skill, which appears to negate the advantages of this system.

2) Prebunching reduces the costs of both skidding and cable yarding, but the total system cost (i.e., at the roadside, including felling and winching) of the prebunching treatments was no less than the comparable unbunched operations. In the skidder treatments, pre bunching and skidding tops ahead were actually less expensive than yarding butts ahead right from the stump, but the added felling costs with prebunching more than offset these savings. Reduced cable yarding costs with prebunching were only enough to offset its added cost.

3) Cable yarding thinning operations, with or without prebunching, were significantly more costly than comparable treatments done with a conventional cable skidder. Added time required to set up cable systems, larger crew size, and more frequent and expensive operating delays appear to be the major causes.

4) No treatments caused unacceptable damage to residual stands, and all are capable of carrying out thinnings from below. In stands of the kind examined in this study, skidders apparently can perform commercial thinnings efficiently without prebunching if operations are carefully laid out and proper work techniques are employed.

5) Extra logging costs, if any, incurred in commercial thinning with systems utilizing skidders apparently were due primarily to the smaller size of the wood removed, not to the fact that partial cutting was done. However, further research is needed to predict how thinning costs and residual-stand damage vary with stand conditions and tree size.

Evaluation of the Holder A60 in Thinning

In March, we took advantage of an opportunity to evaluate the production of the Holder A60, a 48-HP four-wheel drive,articulated German farm tractor which resembles a small skidder. Contractor Brian Souers of Lincoln, Maine, had acquired two of these machines equipped with Igland double-drum bunching winches and 7/16" cable, and was operating in commercial thinnings on International Paper Co. land in T3R1 NBPP. Snow depth was about 30 in, and the machine operated on main trails that were prepared beforehand by an International lag skidder. Both one- and two-man crews were monitored by time study over a four-day period. The stand was nearly pure spruce, with the wood removed in thinning averaging about 15 trees per cord. Limbing was done manually in the woods, and stems were bucked into four-foot bolts in the yard.

Results from this limited study (Table 4) cannot be considered conclusive, but allow some interesting comparisons to be made with the other systems discussed above. On these Holder operations, the average time required to skid 9 trees 660 feet ranged from 37 to 49 minutes; 61 percent to 116 percent longer than the two-man skidder crew in the T12R6 study (Tables 2 & 4). Much of this can be attributed to differences in operational delays, which consumed nearly 30 percent of the total productive time of the two-man Holder crew compared to only 11 percent in the skidder operation. Working several machines off the same skid trail (required by the snow depth) frequently led to one crew blocking the other on the trip in or out. On the two-man operation, interference between felling and skidding (mostly the skidder operator waiting for or helping the faller) and time spent by the machine operator running a saw, amounted to over seven minutes per hitch. Choking and unhooking were slightly longer with the Holder, probably because chain chokers were used instead of cable slings. Decking also took somewhat longer; the Holder apparently did not have the power or traction to push up as many trees at once.

In this particular evaluation, a one-man crew proved to be slightly more economical than two men. The man working alone spent less time cutting a hitch, resulting in felling costs which were $6 less per cord than the two-man operation. This savings was more than enough to offset the less efficient use of the tractor for skidding. If the chopper on the two-man crew had produced at the same rate (eliminating interference delays and allowing the machine operator to perform only skidding functions), production of the two-man crew would have risen to 0.86 cords per scheduled hour (up from 0.69, Table 4), reducing the cost below that of the one-man operation to only $35.62 per cord.

Table 4. ESTIMATED PRODUCTION AND COST OF THINNING TREE-LENGTH SPRUCE-FIR WITH THE HOLDER A60 (SMALL 48 HP SKIDDER WITH DOUBLE-DRUM WINCH), USING EITHER A ONE-OR TWO-MAN CREW. (BASIS: FOUR DAYS OF TIME-STUDY EVALUATION OF SOUERS[1] OPERATION, T3R1 NBPP, MARCH 1982).

	One-Man Crew	Two-Man Crew
Trees yarded per productive hour:	11.0	14.8
Avg. time per hitch:	49.19	36.59
Cords per scheduled hour (15 trees/cord; 70% utilization)	0.51	0.69
COSTS:	--------- per scheduled hour - - - -	
Holder AGO	8.88	8.88
Chainsaws	2.25	2.25
Labor ($7.00/hr + 40%)	9.80	19.60
Total operating cost per scheduled hour:	$20.93	$30.73
	- - -$ per cord, roadside - - -	
Felling	12.29	18.59
Skidding	28.75	25.94
Total	$41.04	$44.54

FOREST FERTILIZATION - Dr. Robert K. Shepard

Approximately 300 new plots were established during the 1982 field season, bringing the total number of plots in the Cooperative Forest Fertilization Project to slightly more than 1,000. The majority of plots established in 1982 are in pine or mixed pine-spruce stands, most of which had been thinned. Fifty plots were established in hardwood stands. Where an entire stand was not thinned, plots were also established in the unthinned portion. Most of the plots established in 1982 are in eastern and southwestern Maine. Considerable work was also accomplished in plots established prior to 1982. Details of this work are presented below in two parts, one part describing work with spruce, the other describing work with pine.

Spruce

Plots in two, thinned Norway spruce *(Pioea db-Les* (L.) Karst.) plantations near Orono were fertilized. Treatments consisted of three rates of nitrogen: 50, 100, and 200 pounds per acre. Plots in northcentral Maine were also fertilized. These plots are part of that portion of the study to determine whether response to fertilization on soils originating from the same parent material is affected by drainage differences.

Increment cores were taken from fertilized and control plots in red spruce *(Piaea rubens* Sarg.) stands on soils of different drainage. Growth measurements made from these cores indicate that response to fertilization has been significant on the moderately well- and well-drained soils and on the poorly drained soil,but not on the somewhat poorly drained soil. When data from all soils were pooled, response was significant.

Analyses of the alcohol/benzene soluble extractives content and lignin content of trees growing on the above soils of different drainage were completed and showed that there were no differences among soils. Extractives content averaged about 2 percent and lignin content about 27 percent. There was more variation in both extractives among locations on each soil than among soils.

Increment cores were taken from trees in fertilized and control plots in five stands. Growth determinations made from these cores and cores taken previously from plots in all other spruce stands have been completed and the results are being analyzed.

Pine

Plots in six white pine *(Pinus strobus* L.) stands were fertilized. A variety of treatments, including three rates of nitrogen, were used in four of the stands, with the remaining two stands receiving only nitrogen at three different rates.

Diameter measurements were made in plots in 11 white pine stands that had completed either two, three, or four years since fertilizer treatments were applied. Although analyses of the data have not been completed, it appears that most stands have responded to at least one fertilizer treatment, with 100 pounds of nitrogen per acre generally being the best treatment.

TREE IMPROVEMENT - Dr. Katherine K. Carter

Black Spruce Provenance Test

Yuriy Bihun finished his M.S. thesis, an evaluation of two, six-year-old rangewide black spruce provenance tests. There were significant differences in height among provenances at both plantations, with provenance mean heights ranging from 46.0 in (117.9 cm) to 11.9 in (30.4 cm) at Telos Lake and from 40.0 in (102.6 cm) to 9.9 in (25.5 cm) at Dover-Foxcroft. The shortest trees were generally from northwestern Canada, while provenances from the Great Lakes region of the United States and from southern Ontario and Quebec generally had the greatest growth and survival. Provenances from these regions tended to be taller than provenances of local origin. Height in 1981 was highly correlated ($p > .91$) with height in 1979, indicating that early selection of fast-growing provenances may be possible. In addition to height, evaluations were made of stem diameter, time of bud break, and frequency of insect damage to the leader.

Black Spruce Progeny Test Plans

Earlier studies at UMO and elsewhere have indicated that plus-tree selection of black spruce in natural stands is not as effective as selection based on family performance in progeny tests. Several CFRU members have expressed interest in establishing cooperative black spruce progeny tests which would identify fast-growing families to serve as a basis for future seed orchards. Selection of parent trees and collection of seeds will begin in 1983.

Tamarack

After examining many stands throughout the state, twenty selections were made of straight, fast-growing tamarack trees. The measurements which were made on these trees, plus those taken from non-selected trees, will provide a standard for the evaluation of future tamarack selections.

Studies of rooting methods for tamarack were also undertaken in 1982. Cuttings taken in March failed to root, whereas those taken in July from nine parent trees were successful (Table 1). Rooting success was not related to age of the parent tree, but was affected by the composition of the rooting medium. Pure peat or a peat/vermiculite mixture was superior to pure perlite as a rooting medium. These results indicate that rooted cuttings can be produced from mature tamarack trees, and the method may be a useful alternative to grafting as a means of propagating superior trees.

Paper Birch

Fifth-year height and survival were evaluated for a rangewide paper birch provenance test planted near Canterbury, New Brunswick. Survival ranged from 100 percent for trees from two Michigan provenances to 4 percent for trees from the Yukon Territory, Canada. Height also varied greatly among provenances, from a high of 5.4 ft (1.6 m) for trees from Topinabee, Michigan, to a low of

Table 1. PERCENT SUCCESSFUL ROOTING OF CUTTINGS FROM NINE PARENT TAMARACK TREES IN THREE MEDIA.

Parent Tree	Age	Percent Rooted in			
		Peat	Peat & Vermiculite	Perlite	All Media
1	31	94	83	100	93
2	38	44	16	8	23
3	41	97	86	83	89
4	37	69	47	47	55
5	24	55	66	36	53
6	19	91	86	66	81
7	23	86	91	86	88
8	33	69	80	41	66
9	32	53	91	92	78
All trees		73	72	62	

1.0 feet (0.3 m) for trees from the Yukon. Several individual provenances from Michigan, Vermont, and Massachusetts were more than 25 percent taller than the plantation-wide average of 3.5 feet (1.07 m). Trees from Maine and New Brunswick were near the plantation mean in height.

Plantations Established

Four new experimental plantations were established during 1982. These include one white spruce progeny test of 117 families from Maine and from the Ottawa River Valley of Canada; one provenance test of 113 Maine sources of balsam fir; a test of 78 provenances of Douglas-fir; and a combined range-wide provenance/progeny test of paper birch.

HARDWOOD RESEARCH - Dr. William D. Ostrofsky

The hardwood research program was initiated on August 1, 1982. This program is largely the result of planning by the Hardwood Research Committee of the CFRU, and by the support of many new cooperators from the hardwood manufacturing industry. Development of the program during its first five months has included the following activities:

Research Problem Analysis

The problem analysis for the Hardwood Research Program has been prepared and submitted to the CFRU Advisory Committee for review. The analysis outlines a research program focusing on the use of silviculture! techniques for the improvement of hardwood quality. Problem areas of priority are:

a) Branches: Branches are the primary cause of value reduction in hardwood stems. Some branching characteristics can be directly manipulated by silvicultural treatments, but relationships are, at this time, poorly understood.

b) Internal Defects: Discolorations and decays are no longer beyond the control of silviculturists. New methods of defect detection now allow for the evaluation of total stand defect as influenced by silvicultural treatments.

c) External Defects: Many external defects are the result of improper choice or use of harvesting equipment. New harvesting systems need to be evaluated in terms of damage to the residual stand.

d) Defects Caused by Pests: Defects in this category include those caused by sugar maple borers, beech bark disease, and other widespread or chronic forest pest situations. Silvicultural treatments can directly influence pest populations and favor the propagation of resistant trees.

e) Influence of Site Quality on Timber Quality: Stands on optimum sites will grow faster, provide maximum return from silvicultural treatments, and be of higher quality than those on poor sites. New techniques are now available which allow for more accurate measurement of stand vigor and site quality.

f) Influence of Timber Quality on Product Quality: Characteristics which impart product suitability to a tree species, or to a wood condition within a species, need to be more fully understood and defined. Silvicultural treatments designed to manipulate such characteristics can then be tested.

Newsletter

All CFRU personnel are committed to keeping the cooperators and others will informed with regard to current research results. To this end, a newsletter series entitled "Hardwood Headlines" has been developed. The newsletter provides short descriptions of new and ongoing research of Federal, State, and university organizations, information relating to the CFRU projects, and lists upcoming meetings, new publications, and other announcements pertaining to hardwood management and utilization. The newsletter is published on a bimonthly basis.

Paper Birch Plot Resurvey

In 1958, a study was initiated on the Penobscot Experimental Forest by the USDA Forest Service. The study was designed to test various site preparation techniques for paper birch regeneration. These plots were evaluated after five and ten years, and results were published as USDA Forest Service Research Paper NE-79 (Seedbed preparation methods for paper birch) and Research Paper NE-238 (Stand changes in the first 10 years after seedbed preparation for paper birch).

Since an excellent stand history had been established by these two reports, and since the original plots were still clearly marked and undisturbed, a remeasurement of the plots was undertaken, with the approval and cooperation of Dr. Larry Safford, USDA Forest Service, Durham, NH.

This resurvey will provide a benchmark of stand development, on differently-prepared sites, at age 24. Earlier reports and the current resurvey can provide the basis for comparing stand quality attributes in the future. The resurvey has been completed, and results are being summarized. A CFRU report of the results will be prepared in 1983.

Hardwood Sumposia

Two symposia of particular interest to the Hardwood Program were conducted during the fall of 1982. The first was a one-day symposium sponsored by the CFRU and the UMO College of Forest Resources, and was entitled "Hardwood Forest Management and Utilization". The ten papers given covered many topics, from stand biology to harvesting and product quality. The Symposium proceedings are being published as a CFRU Information Report, which will be available by mid-1983.

The second Symposium was a "study-tour" of the beech bark disease, and was sponsored by the International Union of Forest Research Organization working party on beech bark disease. The working party and the study-tour were coordinated by Dr. David Houston, USDA Forest Service, Hamden, Connecticut. The tour started at UMO and tracked the disease from eastern Maine, where it first occurred in the United States, to western New York, the farthest known westward extent of the disease. Over thirty presentations were made during the 10-day tour, and numerous forest sites were visited.

GROWTH IMPACT STUDY - Dr. Thomas B. Brann

The 1981 annual report of the Spruce Budworm Growth Impact Study is out for review. The last of the 1982 field data were received from the cooperators on January 23, 1983. Adhering to the three-month schedule for the completion of our annual report after receipt of the field data, the 1982 report will be circulated for review on the first of April 1983.

The Northeastern Area State and Private Forestry cooperators have commissioned a cumulative analysis of Growth Impact Study Data for the period 1975-1980. The analysis is a cooperative effort between the regular Growth Impact Study staff and Dr. Thomas J. Corcoran, Harvey M. Schiltz and William S. Warner. The table below is extracted from that, yet unreleased, report.

FIVE-YEAR GROWTH IN BOLE VOLUME BY FOREST TYPE AND SPECIES.
(cu ft/a)

	ACCRETION	+ INGROWTH	+ GROSS GROWTH	- MORTALITY	- CUTTING	- NET GROWTH
BALSAM FIR	139.02	15.50	154.52	276.60	71.10	-193.18
SPRUCE	159.23	11.45	170.68	69.60	85.90	15.18
HEMLOCK	23.20	1.37	24.57	0.34	3.84	20.39
OTHER SOFTWOOD	54.73	2.77	57.50	34.23	21.13	2.14
HARDWOODS	66.88	4.58	71.46	27.67	8.65	35.14
TOTAL SOFTWOOD	443.06	35.67	478.73	408.44	190.62	-120.33

Gross growth is the summation of ingrowth and accretion. Ingrowth reflects the increase in volume due to trees that have reached measurable size since the previous plot measurement. Accretion is the annual growth increment of stems that were at least 4.5" dbh at the last measurement.

In the softwood type, growth on spruce and fir accounted for 68 percent of the total volume growth and 61.5 percent of the basal area growth. Net growth (gross growth minus mortality and cutting) was negative. Negative net growth resulted from very high balsam fir mortality and substantial harvesting of both spruce and fir. Close examination of the spruce and fir removal in harvest, indicates that a large proportion of harvest volume represents more of a salvage operation than a traditional harvest.

The greater hardwood representation in the mixedwood type contributed to increased hardwood growth, which accounted for 45 percent of the gross volume growth. In the mixedwood type, hemlock-hardwood harvest volume (50% of cut total) and balsam fir mortality caused the most significant negative impact on net growth.

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Take

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1982 MEMBERSHIP

The members of the CFRU Advisory Committee during part, or all, of 1982 were appointed to set priorities and review proposals for the Cooperative Forestry Research Unit are as follows:

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Richard Anderson, Commissioner, Department of Conservation
Duncan Hewlett, Small Woodland Owners Association of Maine

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(December 31, 1982)

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Maxwell L. McCormack, Jr., Research Professor of Forest Resources
Mark W. Houseweart, Associate Research Professor of Forest Resources
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