FOREST RESOURCES
RESEARCH ADVISORY COMHITTEE

1978 ANNUAL REPORT

The Forest Resources Research Advisory Committee reviews all research activities and priorities for the School of Forest Resources and offers advice and counsel on the entire research program of the School.

The year 1978 was the fifth year of the Forest Resources Research Advisory Committee which continued to show steady and improved progress toward the goals of coordinating and intensifying forest research efforts at the School.

In 1978, the Cooperative Forestry Research Unit, funded entirely by private landowners, presented a most stable research base. Membership and funding for the Unit remained consistent. All three research scientists continued to make considerable progress with the individual research proposals that had been approved in prior years. Excellent summer and fall weather conditions contributed to significant and rapid progress on the various field projects. Problems in temporary manning, transportation and housing were largely worked out within the year and stability in operation of the overall Unit became evident. Progress on individual projects is outlined later on in this report.

Several changes in the FRRAC Committee membership have taken place at the close of 1978. Keith Miller left Maine to accept an assignment as Superintendent for the North Cascades National Park in Washington. We will miss him. Other outgoing members were Richard Barringer, George Carlisle, Maynard Marsh and John Sinclair. We thank each of them for a job well done, especially during these early formative years of the Research Advisory Committee and the struggles to achieve adequate private funding for the Cooperative Unit. New incoming members of FRRAC appointed to three-year terms commencing in 1979 are Temple Bowen (Maine Forest Service), Duncan Hewlett (Small Woodlot Owners Association), William Peppard (Department of Inland Fisheries and Wildlife), David Semonite (J. M. Huber Corporation) and Al Leighton (Seven Islands Land Company).

The Committee is still seeking additional contributing members for the Cooperative Forest Research Unit in order that this most important work can be expanded to satisfy additional research requests. A field trip is now being planned for 1979 in order that all members can view first hand some of the various individual projects.

In looking back over the progress experienced during the last few years, I believe our Committee can be proud of the achievements. The private funding of the Cooperative Research Unit is indeed a milestone for the State and will have substantial impact on the future of its greatest natural resource. We feel that the Committee will continue to fill a most important function to all of the people of Maine.

As we look ahead, it would seem that our Committee should be taking a very broad view of their responsibilities in assisting University management people, the public and government leaders to know more about our forest research needs, limitations, costs and progress.

Morris R. Wing, *Chairman* **John G. Sinclair**, *Vice Chairman* **Barton M. Blum**, *Secretary*

COOPERATIVE FORESTRY RESEARCH UNIT

ANNUAL REPORT - 1978

Nineteen hundred and seventy-eight was a productive year for the Cooperative Forestry Research Unit as specific results from a number of the projects initiated in 1977 became available. In addition, continued progress was made in those cooperative research efforts which were funded by cooperators prior to the formation of the CFRU in 1975. The CFRU Scientists and School of Forest Resources Staff members have presented results to the CFRU Advisory Subcommittee at the regular meetings held in 1978 and in various publications which were published during the year. Individual progress reports on specific projects are included as part of this 1978 Annual Report.

During 1978 Forest Technologist James Rea terminated his employment with the CFRU to accept employment with the State of Maine. During the year one new Technologist, Mr. Paul Messier, was hired; thus the total number of Scientists and Technologists remained constant.

During the year a much needed combination garage, storage building, and workshop building was constructed by CFRU on the University Forest. A number of individuals and corporations contributed materials and services to this building project. Our sincere appreciation is extended to all of them.

Late in 1978 two of the original members of the CFRU Advisory Subcommittee asked to be replaced. Robert Bartlett who served as Chairman since September 1976 was replaced by Bart Harvey. Morris Wing, who has been extremely active on the Subcommittee since 1975, was replaced by Dr. Charles Webb. We express our appreciation to Bob and Morris for a job well done, and welcome Bart and Charlie to the Subcommittee,

Dr. Michael Newton, a herbicide specialist, spent 3 months in Maine as a visiting scientist at the CFRU. He made a valuable contribution to the Unit and provided invaluable assistance in understanding a number of complex technical issues.

The Unit remains in sound financial condition. Hopefully, additional cooperators will be obtained in the coming year and the Unit can achieve its original projection of four full-time scientists.

I look forward to continued progress of the unit and am confident that future results will justify continued and expanded support by cooperators.

H. M. Klaiber
Chairman

PROGRESS REPORTS ON COOPERATIVE FORESTRY

RESEARCH UNIT SPONSORED PROJECTS

Chairman Klaiber has cited the continued progress of CFRU sponsored research. Following is a summary of this progress. All projects, fully and partially funded by CFRU are reported on. As last year, the descriptions of CFRU scientist accomplishments are given separately from those not fully funded by the Unit.

REPORTS ON PROJECTS BY CFRU SCIENTISTS

SILVICULTURE - *DP. Maxwell L. MoCormack, Jr.*

HERBICIDAL SUPPRESSION OF RASPBERRY *(Pubus* spp.) TO BENEFIT SPRUCE-FIR *(Piaea rubens* Sarg., *Pioea glauoa* (Moench.) Voss, and *Abies balsamea* (L.) Mill.) REGENERATION

An evaluation was continued of the 196 plots established in strip cuttings, T5R12 WELS, during 1975, 1976 and 1977. Results indicate that up to three years of siIviculturally effective suppression can be accomplished. Vegetation cover is never completely eliminated and some changes in species composition occur. For example, with some treatments there has been an increase in red sorrel *(Rwnex acetosella* L.).

A moderate level of suppression has been achieved with 2,4,5-T. Two experimental herbicides, triclopyr (Garlon) and glyphosate (Roundup), exhibit outstanding potential.

Through the cooperation of Mr. Al Averill, Northeast Helicopter, seven promising treatments were aerially applied to 13 strips in August 1978. These operational applications included triclopyr and glyphosate. Dr. Terry May, Assistant Professor in Wildlife Resources, is assisting in an evaluation of these strip treatments.

AERIAL APPLICATION OF HERBICIDES TO SUPPRESS UNDESIRABLE VEGETATION IN MAINE FORESTS

During the summer of 1978 the permanent sample plots on the four previously reported study sites were evaluated. In addition, Dr. Michael Newton, an Oregon State University forest ecologist specializing in the use of herbicides for vegetation management, participated in a thorough evaluation of all treatments at the Bald Mountain Township and Alligator Lake study areas. The following table shows a preliminary summary of some selected results.

PRELIMINARY SELECTED RESULTS HERBICIDE
SUPPRESSION OF BROADLEAVED COMPETITORS

Herbicide	BROADLEAVED COMPETITORS						
							BRAMBLES
2,4-D + 2,4-DP + MSMA	F!/	F	P	P	P	G	P
Tordon 101	G	G	F	P		E	P
2,4,5-T	G	E	G	F	F	E	G
Tri cl opyr–	E	E	G	E		E	G+
Glyphosate^/	E	G+	E	G	E	E	E

I/ Experimental herbicides
I/ P = poor; F = fair; G = good; E = excellent

The CFRU participated in the administration of the application of approximately 90 gallons of Roundup in Maine as part of an Experimental Use Permit issued for 1978-1979. This is an important step, within the procedures of the Environmental Protection Agency, in developing a forestry label for Roundup.

THINNING SPRUCE AND SPRUCE-FIR STANDS IN MAINE

The major silviculture research effort of the 1978 field season was expended on this study. An M.S. graduate student, Frank J. Conlon, Jr. (recipient of a Boise-Cascade Fellowship) pursued the short-term phase as his thesis project. Three additional study sites were thinned and prepared for the long-term phase. A fourth site in a young spruce stand was thinned, but unfortunately was rendered unusable by Christmas tree poachers during December.

Frank Conlon collected stem and crown analysis data from 100 residual trees on 11 different sites. These data are being used to characterize the trees at the time of their release and their growth patterns following release. The 1978 sample trees are summarized in the following table.

1978 SAMPLE TREES, SHORT-TERM PHASE THINNING STUDY

Species	D.B.H. (cm.)						Total
	10-14	15-19	20-24	25-29	30-34	35 -	
Red spruce	9	7	15	9	8	3	51
Balsam fir	5	9	7	5	1	-	27
Black spruce	1	6	6	3	2	-	18
White spruce	-	1	2	1	-	-	4
TOTAL	15	23	30	18	11	3	100

The three new long-term phase sites were carefully thinned with chain saws following the marking of all individual study trees. The area treated on a site ranged from about 2.5 acres up to 4 acres. The Rowel 1 Brook stand is primarily red spruce on Scott Paper Co. ownership north of 1st Roach Pond, T1R13 WELS. The Clayton Lake stand is black spruce on International Paper Co. ownership near the St. John River, T11R16 WELS. The Lakeville Plantation stand is predominantly red spruce on Dead River Co. ownership between the Syslodobsis Lakes. One or two possible additional study areas are being considered. A very general summary of stand characteristics is provided in the following table.

SUMMARY OF SAMPLE TREE AND PLOT DATA ,
AVERAGES ON THE THREE 1978 THINNING STUDY SITES-^

Study Site	Stump Age (years)			Height (feet)			D.b.h. (inches			Stems per Acre	
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Before Thinning	Residual
Rowel 1 Brook f/	160	42	69	55	26	41	10.2	3.2	5.4	1396	420
Clayton Lake	41	21	34	41	18	31	6.3	2.3	4.5	3419	723
Lakeville Plantation	79	55	67	57	42	49	8.9	4.1	6.3	1755	191

I/ Original data are in metric units; converted to English units for this table.

-* The range of data reflects a variation between study blocks which forms a continuous progression from one end of the area to the other.

Both phases of this thinning study involve individual study trees. This type of information should provide practical guidelines since tree marking or felling in a partial cutting direct attention to single trees. It is intended that these data will characterize possible crop trees and their respective responses to release.

STUDY PROPOSAL FOR EVALUATION OF EFFECTS OF MECHANIZED HARVESTING ON SITE QUALITY

A Ph.D. student, C. Tattersall Smith, Jr., began a problem analysis and literature review during the latter part of 1978. These are the basis for a study proposal now in preparation. Redistribution and removal of tree components such as branches and tops are among the factors being considered.

CFRU BUILDING CONSTRUCTION

Ellis B. Sprague has supervised and coordinated an effort utilizing materials provided by several unit cooperators. The exterior and some interior framing of the 22 x 56 feet building, located on the University Forest in Old Town, was completed. Much needed space will be provided for four of the scientists supported by the CFRU. The structure will contain space for the two unit vehicles, storage space for equipment, laboratory space for processing field samples, and a pesticide storage facility.

FOREST PROTECTION - *Dr. Mark W. Houseweart*

WHITE PINE WEEVIL
(Wayne N. Dixon)

Life Tables

Data collection for the 1978 field season was conducted as in 1977 in that white pine weevil-infested leaders (subsequently dissected) remained the primary sample units. Approximately 500 trees were sampled from late May to early August to determine natural mortality agents that operate on Maine's white pine weevil populations.

Average mortality per weevil-infested leader for the 1978 population was comparable to that of 1977 (90%). Mortality was attributable to pitch-drowning, intraspecific-competition, cannibalism, and natural enemies. The beneficial and associate insect complex under bark was composed of the following species:

TAXONOMY	ROLE
Hymenoptera	
Khopaliaus pulchripenni	Parasite of P strobi
Doli-ahomitus terebrans nubilipennis	Parasite of P strobi
Eurytoma p-issodis	Parasite of P strobi *
Braaon	Parasite of
Rhoptromerus spp .	Parasite of P strobi
Pediobius lonohaeae	L cortici
	L cortici s
Coleoptera	
Colopterus truneatus	Facultative predator of P_. strobi (?)
Enoclerus Undetermined spp.	Predator of P_. strobi * ¨
	Facultative predator of P_. strobi (?)
Diptera	
Lonchae	Facultative predator of P_. strobi
Lepidoptera	
Diopyctria abietella	Fa

cultative predator of IP. strobi *Not previously associated with weeviled leaders.

Location of Fall Adults on Host Trees^

An intensive study was conducted in regard to location of white pine weevil adults on host trees this fall. Repeated observations on 100+ monitor trees provided the following spatial distributions:

1. Approximately 85% of the fall brood adults were found in the top one-third of the crown, where they remained almost exclusively throughout the day.

2. Of the total adult weevils, 99.7% were observed on the current growth and first whorls of lateral branches.

3. Although feeding sites were concentrated on current growth stems, the weevils actually occupied the buds the greatest amount of time throughout the day.

4. Distribution of weevils in the crown quadrants were: west - 19.4%, east - 23.8%, south - 22.3%, north .- 34.5%.

5. During the day, there was a general movement of adults into and then out of the southern crown quadrant, while the western quadrant was frequented least.

Location of Overwintering Sites

The movement of adult weevils from feeding sites to overwintering locations was investigated in 1978. Peak numbers of brood adults on host trees occurred in mid-September and by mid-October no weevils were apparent. At this time inspection of the soil/litter component beneath ca. 100 trees was initiated and conducted until first snowfall (11/23).

Two litter layers were readily apparent: (1) dry loose needles and (2) moist decaying needles, fungus mats, and other organic debris immediately below. These two layers on top of the mineral soil were examined weekly for weevils from 10/18 to 11/22. As the weeks progressed the weevils moved penetrating deeper into the litter. At first snowfall the adults were found to be positioned just into the second layer. The average distance of weevil locations from a tree bole was ca. 20 cm. Numbers of weevils were greatest in the western quadrant and lowest in the eastern. Average number of weevils found per tree was 2.2, although it ranged from 0 to 9.

Fall Insecticide Application

(Cooperation with Drs. J. Dimond and E. Osgood, Dept. of Entomology, UMO)

Past control efforts have been directed towards suppressing spring adult weevils. Disadvantages include limited target area, short application time span, and concurrent activity of beneficial insects. Fall insecticide application via helicopter was considered feasible because of expanded target area, extended application time span, and decreased activity of beneficial insects.

Preliminary tests conducted this fall utilized 3 insecticides: permethrin, methoxychlor, and carbaryl. A Bell helicopter fitted with 50' booms was used for insecticide spraying. Weevil counts on 20 trees within each plantation were made 6 and 1 day before and 1 and 7 days after application to monitor effects of spraying.

Post spray counts from all plantations revealed weevil reductions of 93% for permethrin, 92% for methoxychlor and 66% for carbaryl.

Actual declines in weevil populations will not be known until early summer of 1979 when reinfestation of sprayed plantations can be monitored. However, the apparent reduction of weevils due to insecticide mortality suggests that helicopter application of insecticides in the fall may be a useful method for suppressing white pine weevil populations in white pine plantations.

SPRUCE BUDWORM RESEARCH (Cooperation with Dr. D. T. Jennings, USFS, NEFES)

Increase of Egg Mass Parasitism using *TyLohogvarma minutum*

In 1977 and 1978, field tests were initiated to assess the feasibility of increasing parasitism of spruce budworm eggs by massive, inundative point source releases of *T. minutum.* In 1977, a California source of *T. minutum* was released at six densities (31,000 - 2 million) replicated 4 times near Telos Lake, Maine. Objectives were 1) to determine directional movement from a point source, and 2) to bracket the optimal release density. Results were quite variable. Only 3 densities showed positive parasitism increases over paired controls (31,250; 125,000; 2 million yielded + 8.4%,+ 5.0% and + 6.2% respectively). Remaining release densities were negative (62,500; 500,000; 1 million gave -4.6, -2.0, -0.6% parasitism respectively). Mean overall percent parasitism was +2.1%. Anticipating the importance of biotypes, native Maine *T. minutum* were collected and sent to several established rearing facilities. In 1978, both Maine and California strains were tested to determine the possible importance of parasite source in explaining the variability observed in 1977. Smaller scale tests were made using a constant release density of 125,000. Four point releases (31,250 parasites each), spaced 20m apart, were made in stands of small (2m) spruce-fir trees. Mid-crown branches were cut from surrounding tall trees and examined for egg masses in the laboratory. Results were:

	Mean Percent Parasitism			
	Calif(C)	M&C	Maine(M) Control	
Rep 1	45.4	4.3	6.8	3.2
Rep 2	2.8	26.1	15.9	5.0
Rep 3	1.6	0.6	2.3	10.0
MEAN	16.6%	10.3%	8.3%	6.1'

Spruce budworm parasitism by *T. minutwn* can be increased by inundative releases as shown above, while use of kairomones, multiple releases, and broadcast releases may further elevate parasitism levels. However, much additional information is needed on the possible effects of host-parasite interactions, and parasite-alternate host interactions.

Use of Kairomones in *Trichocrrarma minutum* Releases

A major problem in augmentation releases of *T. minutwn* has been the failure to retain the released individuals in the target area. Recently, chemical mediators, kairomones, have been utilized both in the lab and field to allow *T. minutwn* to key on these chemical stimuli associated with host eggs. Use of kairomones to stimulate *T. minutwn,* thus placing the parasitoids in a host seeking behavior, has not been tested in the field on spruce budworm. During 1978 moths and moth scales were sent to cooperator Richard Jones, University of Minnesota, for extraction of active chemical mediators for *T. minutwn* on spruce budworm. This kairomone was sent to Joe Lewis, ARS, Tifton, GA for lab bioassay using the Maine strain of *T. minutwn* on *Heliothis* eggs. Results of that assay showed an increase in parasitism from 34 to 61%. By utilizing both the specific kairomone and augmentation releases of *T. minutwn* a system may be developed as a feasible alternative to chemical spraying for spruce budworm. Such a technique could be utilized immediately for non-spray areas, e.g. along streams and near municipalities.

Trap Nesting Wasps Associated with Spruce Budworm

Anaistocerus antilope., A. aatskill and a *Euodynerus* sp. (Hymenoptera: Eumenidae) were found to be present in spruce-fir stands of central Maine. Adult female wasps provision their young, which are reared in natural cavities, with stung and paralyzed spruce budworm larvae. Pine blocks with predrilled holes were used as nesting traps in both dense stands and strip cuttings. Collection results showed that wasps used only the strip cut areas for nesting sites. This study points out the importance that some silvicultural methods may have on natural enemy populations. Final results of this study will appear in a CFRU or journal publication.

Ground Invertebrate Inventory in Open and Dense Forest Areas

Pitfall traps were utilized to sample ground beetles and other potential spruce budworm predators in strip cut and dense stands. Five transect pairs, one member of each pair in a strip clearcut and one in dense forest, were established. Four traps were placed along each transect and examined weekly for insects.

In 1978, the age of the strip cut was added as a variable for determining differences in trap catch. Preliminary results show greater diversity in species and greater numbers of predators of spruce budworm in strip cuts as compared to dense stands. Although this was the second year of this study and originally planned to be the last, an opportunity to assess spray effects on ground dwelling predators may prompt its continuation for at least one more year.

Pheromones of the Spruce Budworm

Of the original 3 studies concerning spruce budworm pheromones, only the Trap Density Project was continued in 1978. Data collection for the Blend and Trap Saturation experiments has been completed. In 1977, although inter-

ference was indicated with the use of the 5, 10, and 20m-from-center trap design, the optimum distance was not definitive. Thus in 1978, a center, 20 and 40m trap design was installed and tested with collections being made nightly. Minimal trap interference occurred at the 40m spacing. After final analysis of the trap density experiment, all 3 studies will be included in a publication.

Mite Parasites of Adult Spruce Budworm Moths

Red mite parasites, *Leptus* spp., were found infesting both sexes of spruce budworm adults in 1977 and 1978. As many as 4 mites were observed on a single adult female spruce budworm. The biological significance of mite parasitism (mean 29% infested) may be in the effect on budworm population quality, female fecundity, and possible use as population trend indicators. A manuscript is in preparation describing the findings in detail.

Dispersal of Small Spruce Budworm Larvae

Spruce budworm larval dispersal losses are currently being studied. Two dispersal phases of the budworm provide opportunities for larval mortality. The first is after hatching from the egg prior to location of overwintering sites, and the second is upon emerging from overwintering sites in the spring prior to feeding establishment in the needles and buds. Boards coated with stickem were utilized during the sampling periods. Trapped larvae are currently being counted and analysis will commence soon.

Spruce Budworm Antifeedants

In cooperation with International Paper Company's Corporate Research and Development Division in Tuxedo Park, NY work was initiated on collection, extraction, and analysis of ca. 45 plant species with potential spruce budworm antifeedant properties. Development of bioassay procedures and subsequent tests will be conducted in the future.

SPRUCE BUDWORM GROWTH IMPACT STUDY
(Jim Rea and Robert Lawrence)

Robert K. Lawrence was hired in January 1979 to replace James Rea who accepted a position with the Maine Forest Service's Planning Division. This report and the 1978 Progress Report are a cooperative effort, providing a degree of continuity to the study.

Changes in the 1978 study involved providing 4 local "on-plot training sessions" at Woodland, Millinocket, Ashland and Greenville. Responses indicated this procedure was well received and it will be continued in 1979, the final year of the present study.

Analysis of 1978 results thus far indicates a higher degree of spruce budworm mortality as indicated below.

PERCENTAGES OF THE TOTAL VOLUME OF SPRUCE OR FIR MORTALITY REPRESENTED BY INDIVIDUAL CAUSAL AGENTS

	SPRUCE		FIR	
	1976	1978	1976	1978
Spruce Budworm	9.0%	10.1%	15.3%	40.9%
Slowdown	64.1	45.3	33.0	28.5
Logging Damage	1.2	13.3	1.1	1.1
Other	14.4	28.6	32.7	23.2
Unknown	11.3	2.7	17.9	6.3
	100.0	100.0	100.0	100.0

The total spruce-fir mortality rate from all causes ranged in 1978 from 0.0 cu.ft./A in Franklin County (n=5 plots) to 62.2 cu.ft./A in Washington County (n=67 plots).

As shown in the following table net annual growth from 1975 to 1978 ranged from +55.6 in Franklin County to -120.1 cu.ft./A in Baxter State Park. This is an indication of the spruce budworm activity and demonstrates the diversity of conditions found in the spruce-fir protection district. Washington, Somerset and Piscataquis counties had a negative net annual growth for balsam fir of -14.0, -1.7, and -12.4 cu.ft./A respectively.

After 4 years of data collections, trends are becoming more definitive. Increased spruce budworm-caused mortality as well as considerably lower growing stock volumes are evident, especially for the fir component. These trends reflect the severity of the spruce budworm problem in Maine.

CHANGES IN GROWING STOCK VOLUME (1975-78)

COUNTY	SPECIES	1975 Volume (cu.ft./A)	1978 Volume (cu.ft./A)	Net Annual[1] Growth (cu.ft/A)
roostook (n=131)	Spruce	650.7	622.5	- 1.9
	Fir	720.9	704.7	0.4
ranklin (n=5)	Spruce	1343.2 *	1454.3	55.6
	Fir	76.8 *	87.9	5.6
enobscot (n=47)	Spruce	491.5	490.8	5.2
	Fir	379.6	394.9	9.0
iscataquis (n=75)	Spruce	899.1	940,2	17.3 -
	Fir	854.6	758.5	12.4
omerset (n=76)	Spruce	818.4	839.6	20.9 -
	Fir	751.0	709.0	1.7
/ashington (n-67)	Spruce	728.3	685.8	4,7 -
	Fir	446.3	367.4	14.0
Baxter State Park (n=6)	Spruce	1510.5 **	1532.2	21.7 -
	Fir	1030.7 **	910.6	120.1

Net Annual nrowth: (1978 volume - 1975 volume) + (1976 ,77,78 harvest volume)

3 Years

- 1976 Growing stock volume
** - 1977 Growing stock volume

MARKETING, UTILIZATION, ECONOMICS - *Dr. David B. Field*

My report last year listed seven project proposals which I presented to the CFRU Advisory Committee in October, 1977:

Project 1: Potentials for a Maine Hardwood Charcoal Industry
Project 2: Maine's Potentials for Wood Furniture Manufacture
Project 3: Simulation of Regional Timber Markets
Project 4: Models for Forestry Investment Analysis
Project 5: Economics of Spruce-Fir Management
Project 6: Problem Analysis of Economic Losses from Degradation of Spruce Budworm-Damaged Timber Project 7: Public Benefits from Private Forest Land Ownership and Management in Maine

Projects 1 and 6 were approved October 31, 1977; Projects 3, 4, and 7 were approved on March 14, 1978. Project 2 was intended to: 1) test the hypothesis that Maine's furniture industry could successfully increase to a degree which would significantly aid the State's economy, and 2) provide information that would encourage investments in new Maine furniture manufacturing facilities. The Maine Legislature's Joint Select Committee on Forest Resources has recommended an investigation of opportunities for increasing secondary wood processing in the State. The CFRU Advisory Committee suggested that Project 2 be deferred until I can explore possibilities for coordinating CFRU research efforts with whatever the State might do.

Project 5 proposed developing a methodology and data base for evaluating the economic implications of alternative methods of spruce/fir timber stand regeneration and intermediate cultural treatment. As for Project 2, the proposal requires further development of specifics.

Following is a summary of progress on each of the approved studies:

Project 1

I described the purpose of this project in last year's annual report. David J. Brooks completed his M.S. thesis "The Potential for Producing Charcoal from Low-grade Maine Hardwood for Domestic Space Heating Fuel" in December, 1978. I have prepared a Research Bulletin ("Potentials of Charcoal Production for Forest Stand Improvement and Domestic Space Heating in Maine") based, in part, on this thesis. The Bulletin is about to go to press and should be available before April.

The purpose of this research has been to explore charcoal production as a possible means of creating a new market for low-grade hardwood in those areas of Maine where no profitable markets now exist for such material. This first bulletin develops an estimate of the available raw material resource, describes the charcoal production process and currently-available production equipment, and presents an economic analysis of the chances for charcoal to compete in the domestic space-heating fuel market. Later studies will explore the markets for metallurgical and filtration charcoal.

About five billion cubic feet (59 million cords, 87.5 million oven-dry tons) of low-grade hardwood and hardwood thinnings are physically available for charcoal production in Maine. This estimate presumes the use. of conventional bolewood only from "rough and rotten" standing timber, low grade sawtimber, and thinnings. It should be reduced to account for inaccessible stands and the volumes within economic reach of existing low-grade fiber users such as pulp mills and pallet manufacturers. But, if only 16 percent of Maine's total domestic space heating market could be captured by charcoal, half of the standing volume could be used up over an interval of 20 years, allowing significant opportunities for stand improvement.

The report makes an excellent case for the use of solid wood for fuel, but charcoal might be expensive. Charcoal produced in a multiple-hearth furnace would have to sell (delivered to the user) at from $80-$200 per ton. Charcoal delivered at $120 per ton would be the equivalent (in $/BTU) of wood (burned in a stove) at $106 per cord, wood (burned in a furnace) at $138 per cord, fuel oil at $0.74 per gallon, and electricity at $0.0286 per Kwh. Charcoal could compete with non-wood fuels now, but whether its added convenience would be enough to offset its high cost compared with wood remains to be seen.

Project 3

Project 3 is designed to: 1) adapt an existing forest products market computer simulation model to the University of Maine Computer System and prepare a user's manual for the model, and 2) validate the model by using it to simulate an existing Maine market region. In 1978, I prepared a paper entitled "SORTIM: a model for the simulation of regional timber markets" and presented it at a meeting of Working Party 53.04.01 of the International Union of Forest Research Organizations at Wageningen, the Netherlands. I have experienced serious difficulties in implementing this large model on the University's computer system, but hope to complete the User's Manual during 1979.

Project 4

Project 4 calls for: 1) a critical review of publicly-available computer programs for forestry investment analysis and 2) a handbook on models for investment analysis in forestry. The project was approved as a "filler", and has been treated accordingly, but I have been doing some work on financial returns to forest land ownership and management. Part of this work has involved a study of impacts of inflation on timber products. The following results offer some idea of these impacts:

1. The average annual rate of compound inflation (in wholesale prices of all commodities) for several intervals of interest are:

1869-1969	0.33%
1970-1976	8.78%
1972-1973	13.10%

2. The following table summarizes information on real (over-and-above inflation) price increases for several timber and round-wood products:

Commodity	Interval of Comparison	Avg. Ann. Rate of Real Price Increase (%)
White birch boltwood, mi 11 -delivered	1911-1976	5.28
White birch boltwood, stumpage	1959-1976	3.31
Rough hardwood pulpwood, mi 11- delivered	1962-1976	1.69
White birch boltwood, mi 11- delivered	1962-1976	1.55
White pine sawlogs, stumpage	1959-1976	1.29
White pine sawlogs, mill -delivered	1962-1976	1.08
Spruce-fir pulpwood, mi 11 -delivered	1951-1976	0.26
Rough hardwood pulpwood, stumpage	1959-1976	-0.08
Spruce-fir pulpwood, stumpage	1959-1976	-0,22

3. If the average rate of inflation recorded from 1970 - 1976 continues to the year 2000, and if mi 11-delivered roundwood prices keep up with that rate, then prices in the year 2000 will include:

White birch boltwood, mi 11-delivered	$550.17/cord
Rough hardwood pulpwood,	220.82/cord
White pine sawlogs,	761.20/cord
Spruce-fir pulpwood, "	278.86/cord

 Project 6

This state-sponsored project, described in last year's Annual Report, will this year include a report on the utilization of budworm-damaged timber. Because Maine mills are just beginning to use such timber, the study will deal mostly with experiences in other regions of North America where insect and disease damage has caused significant milling problems.

Project 7

Most of my part of the Unit's research is currently devoted to this project. Project 7 is designed to increase and improve publicly-available information on the economic benefits of Maine's privately-owned forests and forest-based industries. The research will produce a statement of facts about the connections and values of private forest land ownership and management to Maine's general economy. The purpose of presenting this information is to provide a means of assessing impacts on that economy of private actions, public laws, administrative decisions, and general attitudes which either help or hinder the activities of private land management and forest products manufacture and sale. The project is organized to produce: 1) a basic, factual collection of historical data, 2) a set of mathematical models for estimating future values of variables in the historic data base, and 3) a model which links Maine's general economy with its forest-based economy.

Much of the work on this project during 1978 was devoted to gathering data and placing quantitative information into computer files. A manuscript ("On defining and measuring public benefits from private forest land ownership and management") has been submitted (but not yet accepted) for publication, A CFRU progress report, an information report on trends in Maine's forest products economy, and a research report on estimation of future demands for Maine's timber resources will be available over the next few months.

PROGRESS ON PROJECTS PARTIALLY SUPPORTED BY FUNDS FROM THE COOPERATIVE UNIT

TREE IMPROVEMENT - *Dr. David Canavera*

Tree planting activities in 1978 were the largest that have ever been accomplished by members of the cooperative with ca. four million seedlings being planted. This represents a significant increase over last year's efforts as has been the case each year since the tree improvement program was started in 1974. Also, as was reported last year, the availability of proven reliable seed sources and good-quality bare-root seedlings continue to be acute problems for almost all tree species. The availability of local spruce and balsam fir seed may become more serious in the future if spruce budworm population levels remain high throughout the State.

Provenance Collections and Species' Trials

A total of six new plantations was established in 1978. A brief description of each plantation follows. More detailed information on seed source data, plantation lay-out, and exact geographic location of the plantations is available in mimeographed form and will be provided to any interested cooperators upon request.

Pit. 1 - 78. Green ash *(Fraxinus pennsylvanica* Marsh.) This is a provenance study of 34 sources that was established with 1-1 stock on May 12-17 on land in Augusta administered by the Bureau of Public Lands, Department of Conservation. The seedlings were raised by Dr. Kim Steiner, Pennsylvania State University and averaged about 16 inches at the time of outplanting. The experimental design consists of four-tree row plots with four randomized complete blocks.

Pit. 2 - 78. Monarch birch *(Betula maximowicziana* Reg} This is a provenance study of this highly valued Japanese species. Six sources were planted on May 25th in four-tree row plots in ten randomized complete blocks in Augusta next to the green ash described in Pit. 1-78. These seedlings were raised in the School of Forest Resources' greenhouse in Spencer-Lemaire Rootrainers. Average height of the seedlings at planting time was about 12 inches.

Pit. 3 - 78. Scotch pine *(Pinus sylvestris* L.). This is a provenance and some individual tree collections that will be evaluated for both Christmas trees and timber potential. Fifty-nine sources are represented. Four-tree row plots and five replications were established on June 14-15 on land owned by Georgia Pacific Corporation in Crawford. The seedlings were raised in the

School of Forest Resources' greenhouse in size 608 Japanese Paperpots. The largest seedlings averaged ten inches at the time of planting.

Pit. 4 - 78. Scotch pine *(Pinus sylvestris* L.). This is another planting of the same material described in Pit. 3-78. This planting was established on June 19-20 on Scott Paper Company land in West Forks.

Pit. 5 - 78. Monarch birch *(Betula maximowicziana* Reg.). This is another planting of the same material described in Pit. 2-78. Five replications were planted on July 12-13 on land owned by Georgia Pacific Corporation in Talmadge.

Pit. 6 - 78. Scotch pine *(Pinus sylvestris* L.). This is another planting of the same material described in Pit. 3-78. Five replications were planted on July 17-20 on the Potter Farm in Palermo.

The Norway spruce *(Piaea abies* (L.) Karst.) provenance study (58 sources) has had another year to grow at the State Forest Nursery and will be ready for outplanting in the spring of 1979. The provenance collections (112 sources) of Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco) were grown in the greenhouse during the winter and summer of 1978 and will also be ready for outplanting in the spring of 1979. Additional seedlots received in 1978 were sources of Scotch pine all originating in the USSR and several sources of European alder *(Alnus glutinosa* (L.) Gaertn) located throughout Europe, but primary emphasis was placed on receiving seedlots from northern sources.

Eastern spruce gall aphid *(Adelges abietis* L.) is a serious pest on plantation grown white spruce *(.Pioea glauaa* (Moench) Voss). The degree of infestation of this insect was investigated on 24 range-wide white spruce seed sources growing in the Penobscot Experimental Forest at the beginning of their sixteenth growing season in the field (Table 1). Significant differences were found between seed sources for both number of gall aphids present and percent of trees attacked. Results indicate that the seed sources most severely attacked were those from the eastern part of the botanical range of white spruce. This means that Christmas tree growers and other persons with an interest in the aesthetic value of white spruce could lessen the extent to which trees are attacked by using seed from either the Lake States or western Canada. No sacrifice in height growth would be made by using seed from those sources since several of them are among the fastest growing in the plantation. The local source (1655) from Maine was one of the most severely attacked sources in the plantation.

Table 1. Mean height and the degree of susceptibility to attack by the eastern spruce gall aphid of white spruce from 24 seed sources planted in central Maine in 1961 and examined in June 19773.

Seed Source Number	State or Province	Number Trees Evaluated	Height (Meters)	Number Galls per Source^	Percent Trees Attacked
1647	Minnesota	35	3.34	0.65	10.0
1669	Minnesota	33	3.47	0.45	17.5
1630	Montana	27	1.80	0.62	26.6
1687	Ontario	32	3.33	2.86	28.2
1645	Wisconsin	38	3.56	0.93	29.1
1676	Michigan	28	3.99	0.70	35.8
1665	Saskatchewan	21	2.02	1.03	38.4
1653	Alaska	25	1.62	1.32	39.2
1631	Manitoba	29	3.32	0.97	39.1
1654	Alaska	21	1.58	0.60	43.3
1662	Ontario	29	3.24	1.61	44.1
1677	B. Columbia	30	2.64	1.95	43.2
1686	Ontario	35	3.06	1.73	46.3
1657	Labrador	29	2.00	1.25	54.2
1664	Manitoba	28	2.73	2.52	52.5
1644	New York	28	3.46	6.79	64.1
1655	Maine	33	3.46	3.56	65.0
1660	Quebec	37	3.62	5.09	65.0
1661	Quebec	25	3.04	5.28	67.5
1663	Ontario	31	3.86	2.68	68.3
1649	N. Hampshire	31	3.74	3.78	70.8
1628	S. Dakota	29	2.53	2.38	74.2
1658	Labrador	28	2.60	2.41	75.0
1659	N. Brunswick	30	3.63	6.81	87.6
Average			3.05	2.46	49.4

[a] Sources are arranged in order of increasing percent of trees attacked, b Average number of galls on the eight branches examined per tree.

Individual-Tree Selections

Black spruce *(P-iaea mariana* (Mill.) B.S.P.) selections of phenotypically superior and average trees from 17 stands located throughout the State were completed in the summer of 1978. Cones were collected and processed in the fall, and seeds were sown in the School's greenhouse in January 1979. These seedlings will be outplanted in the summer of 1979 at the State Forest Nursery and will be evaluated for two additional years. A graduate student, Kevin Ken!an, has done this work.

Another graduate student, Ron Tebbetts, has completed first-year growth measurements on white spruce seedlings originating in southeastern Ontario. These seedlings will probably be field planted as seedling seed orchards in 1980. Previous research data have shown that 15 to 20 percent height-growth gains can be expected by using seed from these sources.

A study comparing different methods of plus-tree selection was initiated with white birch *(Betula papyr-ifera* Marsh.) by Brian Stanton in the summer of 1978. Trees were selected by three different selection methods (comparison tree, base-line, absolute standards) in two even-aged stands. Seeds were collected in the fall and sown in the School's greenhouse in January. Progeny will be evaluated in the greenhouse and field planted for further observation.

Containerized Growing

White birch seedlings grown in five different containers were field planted in 1976 to study the effects of the different containers on root formation. The five containers used were: 608 Japanese Paperpots; Styroblock 8; Tinus Rootrainers; Hi 11 son Rootrainers; and Zeiset Plant Bands. Two seedlings for each type of container from each of eight replications (total of 16 seedlings for each type of container) were excavated in the fall of 1978 and taken to the School's nursery. These seedlings will be analyzed in the winter of 1979 to see if any differences exist in root formation.

Plantation Growth and Yield

Jim DiGennaro has completed his field measurements of older red pine *(Pinus resinosa* Ait.) and white spruce plantations that should enable him to develop yield tables. This work should be completed in 1979.

FOREST FERTILIZATION - *Dr. Robert K. Shepard, Jr.*

The second phase of the Cooperative Forest Fertilization Project is well in progress. A total of 215 plots have been established at various locations around the state and it is intended that the number of plots will ultimately reach 350 to 400. In addition, considerable effort is being expended to determine what effect fertilization may have on those properties that are important to the suitability of wood for pulp and paper. Analyses of data collected during the first phase of the study, which emphasized red spruce, have been completed with several exceptions. Highlights of the work with an emphasis on 1978 are presented below.

Volume Growth

Stem analyses and determinations of volume growth were completed for the Rangeley stand. These indicated that as in the Princeton stand, nitrogen was the only element that improved growth rate significantly.

Data from the three stands of Phase I (Princeton, Telos Lake, Range!ey) are presently being subjected to a detailed analysis of covariance. In addition, analyses will be conducted in an attempt to establish whether there was any relationship between response and such easily measurable variables as dbh, total height, crown height and age.

Specific Gravity

Specific gravity determinations were completed for the Rangeley stand. As with the Princeton and Telos Lake stands, specific gravity was not adversely affected by fertilization.

Yields and Physical Characteristics of Pulp

Total yield of pulp per unit weight of wood was 2 percent greater for post treatment wood from fertilized trees from the Princeton stand than for unfertilized trees. The percentage of rejects of pulp made from post treatment wood from fertilized trees also increased by about 2 percent, almost exactly offsetting the increase in total yield. Kappa number of pulp from fertilized trees increased dramatically. Fertilization did not adversely affect Canadian Standard Freeness, bulk, burst factor, tensile strength or tear factor.

Other Hood Properties

Lignin content of post treatment wood from fertilized trees was 3 percent greater than lignin content of post treatment wood from unfertilized trees. Resin content of the former was 2 percent greater than resin content of the latter (3.5 percent vs 1.5 percent). Fertilization also appeared to have increased ash content, but not substantially.

Proposed Work for 1979

1. Fertilize plots established near Rangeley, Orono, and Searsport.
2. Establish new plots in unthinned spruce-fir stands near Rangeley; thin some of the plots to obtain a more favorable stocking level.
3. Establish additional plots in white pine stands in southern and western Maine.
4. Establish new plots in spruce-fir stands and white pine stands in central and eastern Maine.
5. Conduct a pulp yield and pulp physical properties study on trees from the stand at Rangeley that was fertilized in 1971.
6. Perform analyses of lignin and resin contents on wood of fertilized and unfertilized trees from the Phase I Rangeley and Telos Lake stands and hopefully also from company-fertilized stands.
7. Sample foliage and soil where necessary.

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FRRAC **SUBCOMMITTEE** ON THE COOPERATIVE FORESTRY RESEARCH UNIT

MEMBERSHIP AS OF DECEMBER 31, 1973

The members of the subcommittee appointed to set priorities and review proposals for the Cooperative Forestry Research Unit are as follows:

Mr. E. Bart Harvey, Jr., Woodlands, Great Northern Paper Co.
Dr. Barton Blum, Project Leader, U.S. Forest Service
Mr. Harold M. Klaiber, Chief Forester, Scott Paper Co. ----------Chairman
Dr. Fred B. Knight, Director, School of Forest Resources
Mr. James L. Robbins, Robbins Lumber Co. ----------Secretary
Mr. John G. Sinclair, President, Seven Islands Land Co.
Dr. Charles D. Webb, Manager Northern Research Center, Int'l. Paper Co.
Mr. George W. Weiland, Vice President, Dead River Co.

COOPERATORS OF THE FORESTRY RESEARCH UNIT ON DECEMBER 31, 1978

Baskahegan Co.
J. H. Beardsley
Earl Bessey
Charles Blood
Boise-Cascade
P. H. Chadbourne
Ralph Clifford
Dead River Co.
Dunn Timberlands
Georgia-Pacific Co.
Great Northern Paper Co.
Hall, Inc.
Hanington Brothers
Louis Hilton
Huber Corp.
International Paper Co.
I.T.T. Rayonier
Irving Pulp & Paper Co.
Kennebec Equipment Co.
Abbott Ladd
Perry Lamb
Ray McDonald
Monsanto Chemical Co.
Dwight E. Newman
Henry Plummer
Prentiss & Carlisle Co.
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Scott Paper Co.
Seven Islands Land Co.
James W. Sewall Co.
Douglas and Dennis Smith
Smith Timberlands
Sprowl Brothers, Inc.
Clayton Totman
J. J. Tree Farm
Ted Tryon
Western Maine Forest Nursery
Leon Williams

OTHER ORGANIZATIONS PROVIDING SUPPORT FOR CFRU PROJECTS REPORTED

Maine Forest Service
USFS, Northeastern For. Expt. Sta.
USFS, State & Private Forestry
Diamond International
St. Anne-Nackawic
Dow Chemical Co.
Weyerhaeuser
Pejepscot
Sherman Lumber Co.
Mclntire Stennis Formula Funds

SCHOOL OF FOREST RESOURCES
STUDENT PROFILE

Year	Four-Year Undergraduates			Two -Year Forestry	Graduate	Others	Totals
	Freshmen	Soph. Forestry	Jr. Sr. Wildlife				
1964	71	108	42	0	9	5	235
1969	104	95	92	63	25	2	381
1974	134	225	151	95	44	68	717
1976	140	289	186	87	52	121	875
1978	138	243	97	82	51	138	749

FACULTY AND STAFF OF THE SCHOOL
(DECEMBER 31, 1978)

Fred B. Knight, Director and Dwight B. Demeritt Professor of Forest Resources; Associate Director of Maine Life Sciences & Agriculture Experiment Station
Malcolm W. Coulter, Associate Director for Wildlife and Professor of Wildlife Resources Marshall D. Ashley, Associate Director for Administration, Director of Summer Camp Programs and Professor of Forest Resources Thomas J. Corcoran, Professor of Forest Resources Ralph H. Griffin, Professor of Forest Resources Maxwell L. McCormack Jr., Research Professor of Forest Resources

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James E. Shottafer, Professor of Wood Technology and Head, Forest Products Laboratory Harold E. Young, Professor of Forest Resources and Head, Complete Tree Institute
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Timothy G. O'Keefe, Extension Forestry Specialist and Assistant Extension Educator
Roger F. Taylor, Superintendent of University Forest Denise A. Brown, Assistant Wildlife Technologist Ellis Sprague, Assistant Forest Technologist Paul R. Messier, Assistant Forest Technologist J. Louis Morin, Assistant Forest Technologist and Instructor in General Engineering (College of Engineering and Sciences)

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John B. Dimond, Professor of Forest Entomology (Department of Entomology)
Harold C. Gibbs, Professor of Wildlife Resources (Department of Animal and Veterinary Sciences) Roland A. Struchtemeyer, Professor of Forest Soils (Dept. of Plant & Soil Sciences)

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Robert M. Frank, Research Forester, U.S. Forest Service
Lloyd C. Irland, Forest Insect Manager, Maine Forest Service
Jerry R. Longcore, Biologist, U.S. Fish & Wildlife Service
Gordon D. Mott, Research Forester, U.S. Forest Service
Ralph S. Palmer, Retired from New York State Museum & Science Service; Current Lecturer in Zoology Dept., UMO Howard E. Spencer, Jr., Leader, Migratory Bird Project, Maine Department of Inland Fisheries and Wildlife
Thomas B. Saviello, Northern Forest Research Center of International Paper Company
Charles D. Webb, Manager, Northern Forest Research Center of International Paper Company

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Gregory Baker, Professor Emeritus of Forestry
Frank K. Beyer, Associate Professor Emeritus of Forestry
Lewis P. Bissell, Extension Forestry Specialist Emeritus
Edwin L. Giddings, Associate Professor Emeritus of Forestry
Howard L. Mendall, Professor Emeritus of Wildlife Resources
Albert D. Nutting, Director Emeritus
Henry A. Plummer, Associate Professor Emeritus of Forestry
Arthur G. Randall, Associate Professor Emeritus of Forest Technology