

Canada  
Department of Forestry  
FOREST RESEARCH BRANCH

THIS FILE COPY MUST BE RETURNED

TO: INFORMATION SECTION,  
NORTHERN FOREST RESEARCH CENTRE,  
5320-122 STREET,  
EDMONTON, ALBERTA,  
T6H 3S5

A TEST OF HARVEST CUTTING METHODS  
IN ALBERTA'S SPRUCE-ASPEN FOREST

(Manuscript Draft based on Project A-12)

by  
J.C. Lees

---

If you wish to refer to all or any  
part of this report, you are  
requested to obtain prior consent  
in writing from the Director,  
Forest Research Branch.

---

Calgary, Alberta.

May, 1962.

## CONTENTS

	Page
INTRODUCTION . . . . .	1
Experimental Area . . . . .	2
METHODS . . . . .	4
Felling treatments . . . . .	4
Treatment Layout . . . . .	5
Seedbed Treatment . . . . .	5
Assessment . . . . .	7
Regeneration . . . . .	7
Stand growth and development . . . . .	7
RESULTS . . . . .	9
Regeneration . . . . .	9
Residual Stand Growth and Development . . . . .	11
Mortality . . . . .	14
DISCUSSION . . . . .	16
FUTURE WORK . . . . .	19
SUMMARY . . . . .	20
REFERENCES . . . . .	21
APPENDIX I . . . . .	22

- Progress Report 1961-1962 -

A TEST OF CUTTING METHODS IN ALBERTA'S MIXEDWOOD.

(Project A-12)

ABSTRACT

Eight harvest cutting methods, ranging from clear-cut to uncut control were applied in 1950 and 1951 to a 150-acre experimental block of white spruce-trembling aspen stands in the B-18a Mixedwood Section of Alberta. Hand scarification was carried out under each cutting method. This report deals with the regeneration and stand growth results to date, the 10-year remeasurement having been completed in 1961. The selection cutting method resulted in highest stand growth rates, low mortality and best regeneration status. This method and its application are further discussed.

INTRODUCTION

In 1950, a research project was initiated to devise a form of partial cutting, preferably based on individual tree marking, which would ensure future spruce timber supplies in the B-18a Mixedwood Section of Alberta. Previous diameter limit cutting to 14 inches diameter at breast height tended to leave patchy stands with groups of the unmerchantable hardwoods and sub-limit white spruce. Regeneration of spruce under these conditions was not satisfactory. Although practice in the region tended towards the introduction of partial cutting (in effect a two-cut shelter-wood system) it was decided to investigate eight treatments including clear-cutting and uncut control to cover as wide a range of conditions as possible. On this basis a project was established in co-operation with

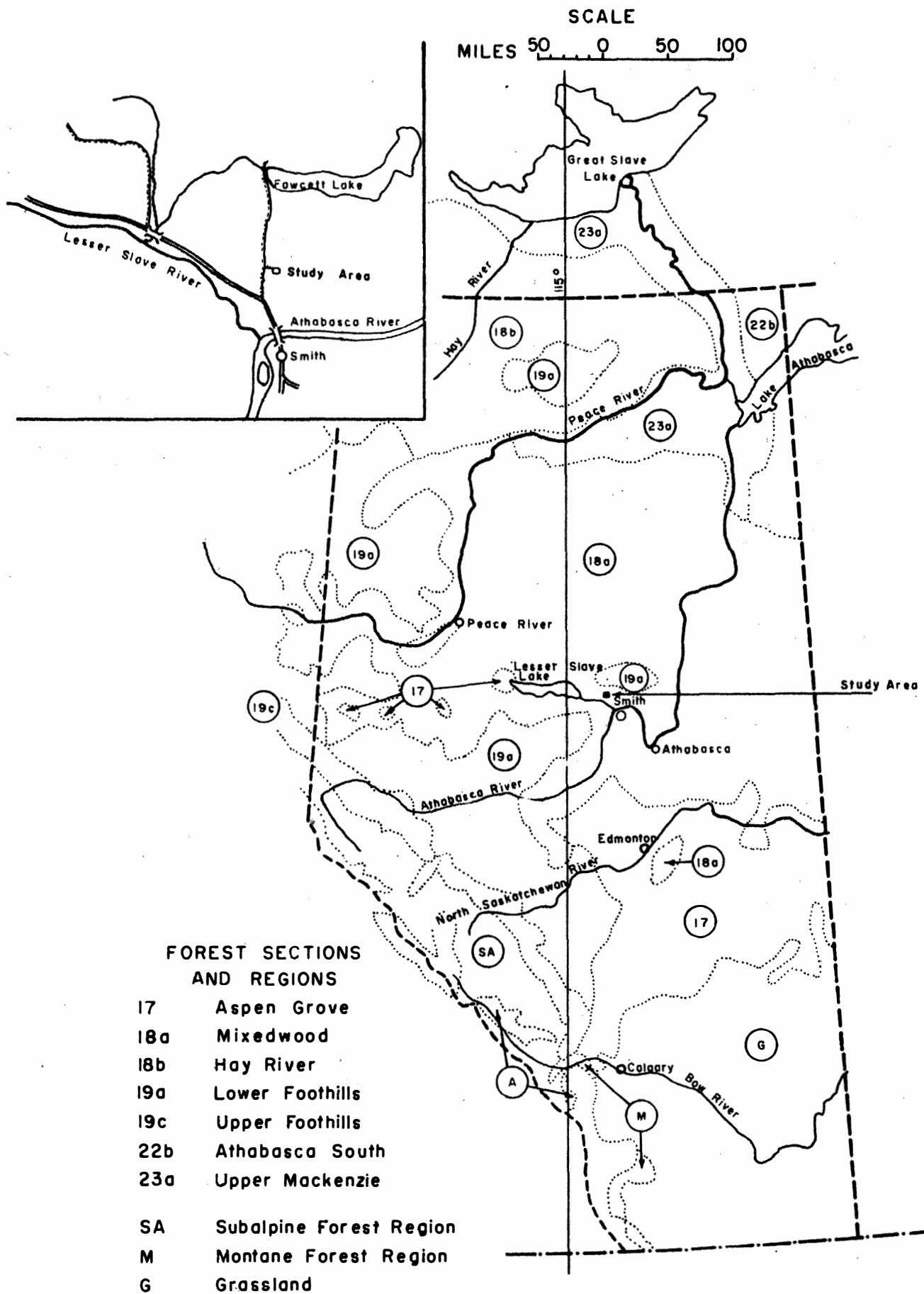
the Alberta Department of Lands and Forests and Swanson Lumber Company Edmonton. The Forest Research Branch was responsible for experimental design, supervision of the operation and assessment of results. A 150-acre Special Timber Permit area was approved and cutting was completed in the fall of 1951.

#### EXPERIMENTAL AREA.

The study area lies in the B-18a Mixedwood Section of the Boreal Forest Region (Rowe 1959) and is a few miles south of Fawcett Lake on the Smith-Fawcett Lake West End road (Figure 1). Altitude is 2,100 feet with drainage to the north and west. The terrain is gently rolling with a series of distinct ridges. Nowhere does the slope exceed 5 per cent. The soils are Grey Wooded with a characteristic leached  $A_e$  horizon and a dark brown grey crumbly  $B_t$  horizon over a calcareous parent material. Textures range from sands and silts to heavy clays in depressions. A layer of humus varying from 2 to 3 inches on ridges to more than one foot in wet bottomland overlies the soil profile. For much of the year the water table is above mineral soil in depressions.

The forest is white spruce (Picea glauca (Moench), Voss) and aspen (Populus tremuloides Michx.), of fire origin. On the wetter sites black poplar (Populus balsamifera L.) replaces the aspen. Occasional white birch (Betula papyrifera Marsh.), black spruce (Picea mariana (Mill.) B.S.P.), jack pine (Pinus banksiana Lamb.) and larch (Larix laricina (DuRoi) K. Koch) are found throughout the stands. Very moist to wet sites tend to support pure spruce stands. The spruce averages 105 years and is vigorous and sound. Diameter at breast height ranges from 6 to 20 inches.

FIGURE I. STUDY AREA LOCATION



The aspen is slightly older and is rather decadent. Before cutting, stand volumes were 25,000 f.b.m. per acre comprising approximately 18,000 f.b.m. of spruce and 7,000 f.b.m. of hardwood. An understory of aspen suckers of 1 to 2 inches diameter breast height developed after cutting.

Ground cover beneath the patches of residual spruce consists mainly of feather mosses and scattered herbs such as bunchberry, twinflower, and stinging nettle. Where aspen is the chief stand component, ground vegetation is abundant and includes tall shrubs such as rose, highbush cranberry, currant and sarsaparilla. Blue-joint grass dominates the moist sites.

#### METHODS

##### Felling Treatments

Eight felling treatments were applied. All spruce to be cut was marked to the following specifications:-

- A. Control - no disturbance.
- B. Heavy residual - leaving 8,500 f.b.m. spruce per acre - 34 per cent removal by volume.
- C. Medium residual - leaving 5,500 f.b.m. spruce per acre - 43 per cent removal by volume.
- D. Light residual - leaving 4,500 f.b.m. spruce per acre - 53 per cent removal by volume.
- E. Selection - leaving only spruce which showed good growth potentialities - 55 per cent removal by volume.
- F. Diameter limit - removing all spruce 14 inches in diameter and over at a 12-inch stump height - 49 per cent removal by volume.

G. Seed Tree - removing all spruce over 6 inches in diameter at breast height. Six seed trees per acre were left - 88 per cent removal by volume.

H. Clearcut - removing all spruce over 6 inches diameter at breast height - 88 per cent removal by volume.

The aspen was unmerchantable and was left standing. Logging was carried out in the summer and fall of 1951 using crawler tractors hauling short log lengths. Road Location was carried out by the research officer in charge.

#### Treatment Layout

Within the 150-acre study area, twenty-four  $4/10$ -acre patches were selected and the eight felling treatments were randomly assigned giving three replications. A surround, approximately  $1\frac{1}{2}$  chains wide, was established for each  $4/10$ -acre patch. The stand in the surround was treated in the same manner as that in the patch. On those portions of the area outside the plots and surrounds, a diameter limit of 14 inches at 12-inch stump height was imposed. Each  $4/10$ -acre patch was sub-divided into four 1-chain-square sample plots for measurement. The layout of the cutting areas and sample plots is shown in Figure 2.

#### Seedbed Treatment

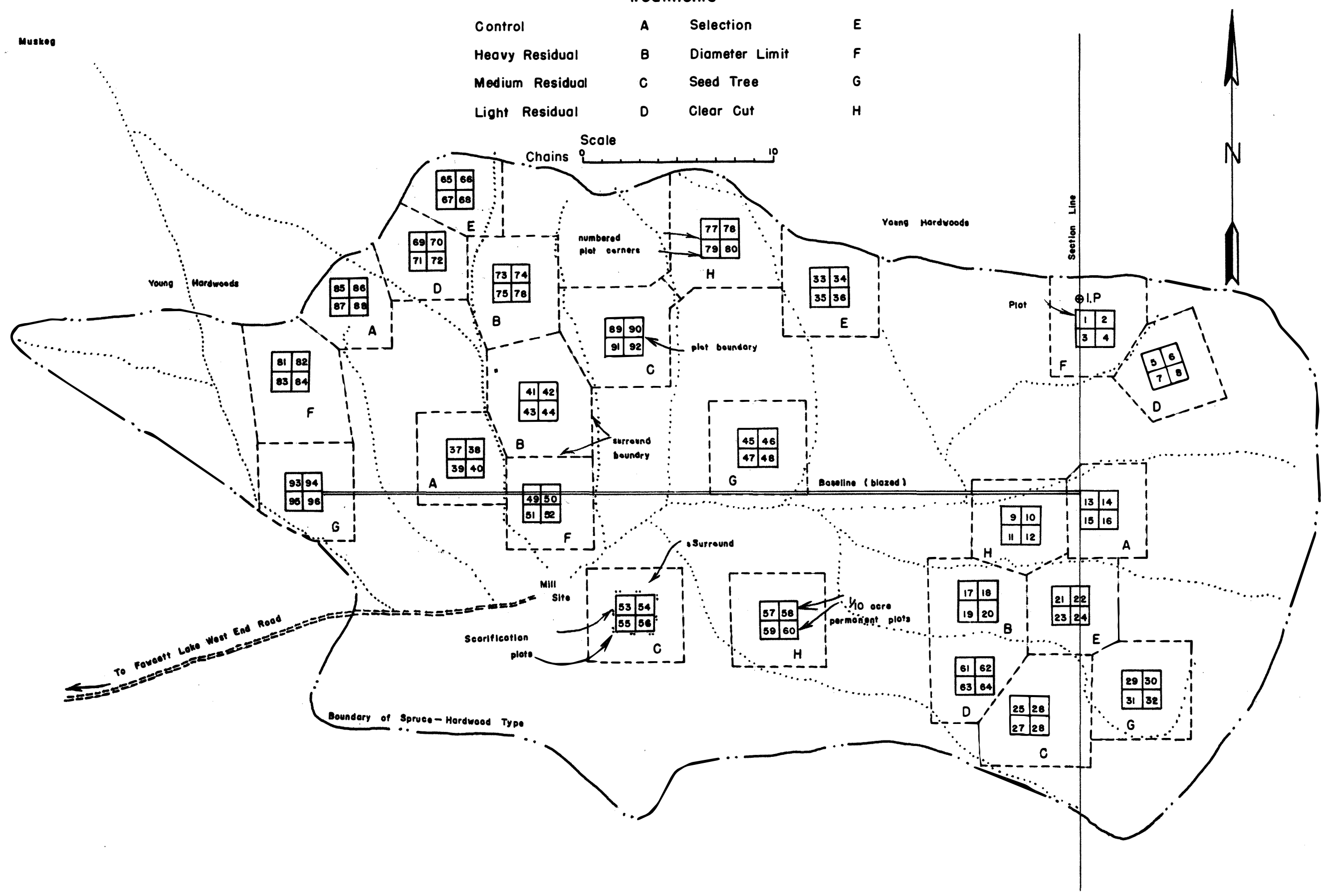
Since spruce advance growth was not adequate before logging, a limited test of hand scarification to expose a mineral soil seedbed for regeneration was included in the treatment. It was intended also to study differences in seedling survival on scarified seedbeds under the various

Figure 2.

# Cutting Plan—Project — A12

## Treatments

Control	A	Selection	E
Heavy Residual	B	Diameter Limit	F
Medium Residual	C	Seed Tree	G
Light Residual	D	Clear Cut	H



residual stands.

Eight scarification plots approximately 5 by 5 feet were placed together with one control, just outside the boundary of each 4/10-acre patch. The distribution of the scarified spots about the plots 53 to 56 is shown in Figure 2. Scarification consisted of removing the humus with a shovel or hoe to expose mineral soil.

#### Assessment

##### Regeneration

Regeneration was tallied in 1952 and 1954 and the results published, (Quaite, 1956). In 1960 the regeneration on the hand scarified and control plots was remeasured and in 1961 a one-chain grid of 16 milacre quadrats was used to determine the regeneration status on the whole of each treatment area. Quality, vigour, and height of the tallest seedling of each species were assessed on each quadrat.

##### Stand growth and development

All stems on the 96 plots were tallied before and after logging. Approximately six dominant and co-dominant trees per plot were selected and tagged for height/diameter studies. Standing and down-dead trees were tallied. In 1952, 1953 and 1954 periodic mortality was measured and in 1961, ten years following logging, all trees were remeasured. Diameter increment at breast height for the ten years before and after logging was measured, and height and diameter were remeasured on the tagged trees. Mortality and windfall were tallied.

## RESULTS

### Regeneration

The stocking to white spruce regeneration in 1960 for the hand-scarified and control plots is given in Table 1. Analysis of variance shows that there was no significant difference between cutting treatments; only the effect of seedbed treatment was significant. Seedling establishment was consistently better on scarified spots than on controls. High values for per cent stocking in both 1954 and 1960 arise from the fact that scarified spots were completely exposed to mineral soil. The figures are, however, not representative of the stocking which might result from extensive scarification of a large area where the mineral soil exposure is intermittent and amounts to 20 or 30 per cent.

Scarified spots which were not stocked to spruce generally showed signs of flooding. To a great extent this is because the method of scarifying left distinct five-foot-square basins of various depths up to one foot. Some flooding might be attributed to a rise in the water table after heavy cutting but flooding occurs on wet sites under all treatments. Flooding affected 20 per cent of scarified spots.

Table 2 gives the per cent stocking of tree species for each treatment as assessed in the 1961 survey. The survey did not include any of the small scarified spots. Although regeneration stocking is everywhere below a satisfactory level, it is interesting to note the levels with undisturbed ground conditions. Stocking to spruce under the selection cutting treatment is highest at 29.5 per cent by milacre quadrats. Figures for the other treatments range from 10 to 23 per cent. It was observed

TABLE 1. STOCKING TO WHITE SPRUCE REGENERATION BY FELLING AND SEEDBED TREATMENT 1960.  
( $\frac{1}{4}$  milacre quadrats)

Felling Treatments	Scarified 192 quadrats				Unscarified 192 quadrats			
	1960		1954	1960	1960		1954	1960
	Stocked	Unstocked			Stocked	Unstocked		
	number of quadrats		per cent		number of quadrats		per cent	
A Control	14	9	88	61	1	18	0	5
B Heavy Res.	12	12	67	50	2	13	17	13
C Med. Res.	12	11	66	52	3	10	25	23
D Light Res.	16	7	75	70	1	16	13	6
E Selection	13	11	75	54	6	14	17	30
F Diameter	18	4	83	82	2	14	17	12
G Seed Tree	15	6	79	71	1	13	17	7
H Clearcut	13	9	75	59	0	6	0	0

TABLE 2. REGENERATION STATUS BY FELLING TREATMENT 1961 SURVEY.  
(Based on 1,536 milacre quadrats)

Treatment	White spruce		Trembling aspen		Balsam poplar		White birch	
	Stocking No.	per cent per acre	Stocking No.	per cent per acre	Stocking No.	per cent per acre	Stocking No.	per cent per acre
A Control	12.0	300	22.0	550	12.0	300	-	-
B Heavy Residual	10.2	225	34.7	990	16.3	408	6.1	347
C Medium Residual	16.7	417	37.5	1187	18.8	594	8.3	406
D Light Residual	20.8	719	35.4	885	6.2	156	6.2	156
E Selection	29.5	927	37.5	1187	25.0	750	20.8	845
F Diameter Limit	18.7	1042	62.5	1562	20.8	646	14.8	812
G Seed Tree	22.9	573	39.6	989	12.5	989	22.9	698
H Clearcut	14.6	490	45.8	1646	20.8	1646	29.2	1104

that seedlings occurred mainly on rotten wood, old logging trails and areas disturbed by logging, as is the case throughout this region.

A summary of the vigor and quality of the tallest seedlings on each quadrat is given in Table 3. The spruce seedlings are well established and fall mainly within classes I and II in both vigour and quality. There is little variation between treatments. Aspen and black poplar reach their best development under diameter limit cutting while white birch is most vigorous on the seed-tree and clear-cut areas and is almost absent on control areas.

#### Residual Stand Growth and Development

Table 4 shows the volume growth, mortality, and recruitment to the merchantable 7-inch diameter class in the residual stands for each treatment. Growth is best under the selection cutting treatment. Gross increment is slightly higher in the heavy residual stands, 575 cubic feet per acre, than under selection treatment, 558 cubic feet per acre, but stand volume in 1951 after cutting was 3,200 cubic feet per acre in heavy residual stands and only 1,484 cubic feet per acre under selection treatment. Thus volume production under the selection treatment is considerably higher. The light residual stands have lowest gross increment with 276 cubic feet per acre although number of stems and stand volume in 1951 are almost identical to that of the selection stands. This is a result of the marking under each treatment, since the strict diameter limit cutting removes those large residual stems which are characteristic of the selection treatment stands.

Net volume increment per acre per year and stand volume increment

TABLE 3. SUMMARY OF VIGOUR AND QUALITY OF TALLEST SEEDLINGS BY TREATMENT.  
(Total Number of Seedlings)

TREATMENT	white spruce			trembling aspen			balsam poplar			white birch		
	Vigour			Quality			Vigour			Quality		
	1	11	111	1	11	111	1	11	111	1	11	111
Control	1	4	1	3	3		2	5	4	2	3	6
Heavy Residual	3	2		4	1		4	11	2	1	11	5
Medium Residual	3	5		6	2		9	9		3	5	1
Light Residual	4	6		7	3		8	4	5	3	11	3
Selection	7	6	1	8	4	2	9	7	2	4	9	5
Diameter Limit	3	6		7	2		8	15	7	5	17	8
Seed Tree	6	5		9	2		10	6	3	10	6	3
Clearcut	4	3		5	1	1	11	9	2	5	13	4

Vigour: I Dense foliage, good colour - dominant crown

II Foliage not very dense - crown slightly overtopped

III Scanty foliage, poor colour - crown completely overtopped

Quality: I Good form, well formed crown - straight stem

II Fair form, poorly formed crown - crooked stem

III Poor form, no definite main stem, coarse branching.

TABLE 4. ESTIMATE OF STAND VOLUME INCREMENT AND MORTALITY PER ACRE BY FELLING TREATMENT.  
(TOTAL VOLUME IN CUBIC FEET)

TREATMENT	Species	Volume Removed By Cutting	Volume After Cutting '51	Volume '61	Number of stems '61	Net Volume Increment '51 - '61	Volume of Mortality '51 - '61	Gross Volume Increment '51 - '61	Net Volume Increment ac/year	Recruitment to 7" d.b.h.		Per Cent Volume Increment
										No. of Stems	Cubic Feet	
Control	WS	---	4883	5650	455	767	144	911	77	28	202	1.7
	Hwd.		1424	1432	68	8	26	34				
	Total		6307	7082	523	775	170	945				
Heavy Residual	WS	1619	3201	3513	327	312	262	574	31	20	146	1.6
	Hwd.		1020	1184	99	164	15	179				
	Total		4221	4697	426	476	277	753				
Medium Residual	WS	2432	1849	1908	176	59	247	306	6	13	81	1.5
	Hwd.		1142	1107	63	-35	121	86				
	Total		2991	3015	239	24	368	392				
Light Residual	WS	1759	1543	1764	247	221	55	276	22	13	82	1.6
	Hwd.		1700	1508	110	-192	311	119				
	Total		3243	3272	357	29	366	395				
Selection	WS	1843	1484	1963	207	479	79	558	48	27	168	3.1
	Hwd.		1661	1636	130	-25	428	403				
	Total		3145	3599	337	454	507	961				
Diameter Limit	WS	1565	1658	1841	328	183	304	487	18	18	113	2.6
	Hwd.		1618	1776	586	158	246	404				
	Total		3276	3617	914	341	550	891				
Seed Tree	WS	3373	453	439	93	-14	130	116	--	15	89	2.3
	Hwd.		1018	885	796	-133	371	238				
	Total		1471	1324	889	-147	501	354				
Clear Cut	WS	2751	368	283	67	-85	108	23	--	8	49	0.6
	Hwd.		967	997	210	30	105	135				
	Total		1335	1280	277	-55	213	158				

per cent are highest under selection treatment. The selection treatment too, shows the greatest recruitment to the merchantable size classes.

TABLE 5. WHITE SPRUCE DIAMETER INCREMENT 1941 to 1951 and 1951 to 1961  
(Pressler's formula)

Treatment	Average Diameter 1961 inches	Diameter Increment Per Cent	
		1941-51	1951-61
		per cent	
Control	9.9	0.62	0.62
Heavy Residual	9.2	0.82	0.93
Medium Residual	10.1	0.92	1.12
Light Residual	9.0	0.99	1.21
Selection	9.4	1.06	1.13
Diameter Limit	8.3	1.24	1.34
Seed Tree	7.0	1.04	1.77
Clear-cut	5.9	1.24	2.78

Diameter increment values in Table 5 show that there has been only a slight increase in growth rate during the past ten years compared to the ten-year period before cutting. Individual stem increment is highest on the clear-cut and seed-tree areas and lowest on control and heavy residual areas.

#### Mortality

Mortality and windfall was noticeably light throughout the study area. Mortality figures are presented in Table 6 for the periods 1951 to 1956 and 1956 to 1961. Higher mortality of spruce in the earlier period may be attributed to logging damage and the shock of release. Many small stems succumbed in the first five years. Control area figures show a trend of increasing mortality.

TABLE 6. PERIODIC MORTALITY BY TREATMENT

TREATMENT	SPECIES	MORTALITY PER ACRE			
		1951 - 1956		1956 - 1961	
		Number of Stems	Total Volume Cubic Feet	Number of Stems	Total Volume Cubic Feet
CONTROL	wS	13	56	21	89
	Hwd.	4	14	1	11
	Total	17	70	22	100
HEAVY RESIDUAL	wS	35	158	13	104
	Hwd.	1	15	---	---
	Total	36	173	13	104
MEDIUM RESIDUAL	wS	21	140	14	107
	Hwd.	7	38	6	72
	Total	28	178	20	179
LIGHT RESIDUAL	wS	16	33	4	23
	Hwd.	13	130	12	182
	Total	29	163	16	205
SELECTION	wS	13	67	3	12
	Hwd.	7	101	11	326
	Total	20	168	14	338
DIAMETER LIMIT	wS	41	245	8	60
	Hwd.	14	116	15	130
	Total	55	361	23	190
SEED TREE	wS	24	87	4	42
	Hwd.	19	233	15	149
	Total	43	320	19	191
CLEARCUT	wS	23	83	6	25
	Hwd.	3	6	10	99
	Total	26	89	16	124

Height/diameter relationships were affected by top break and whipping damage. Height decrement was common under all treatments. Many spruce stems in those patches to the west of the area also appeared to have been affected by insect attack about seven years ago. This confirms the suspected spread of infestation by spruce bark beetles (Ips perturbatus) from sawmill waste to living stems in 1952, reported by the investigator. The sawmill waste was subsequently burned and no further damage was noted. As a result, height/diameter curves for 1961 were often lower than for previous measurement and comparison is not valid and the data were not analysed further.

#### DISCUSSION

The most valuable stand treatment is that which produces the largest volume of merchantable timber at the earliest age. Thus a stand producing 7,000 f.b.m. per acre at age 70 may be as valuable as one producing 10,000 f.b.m. per acre at age 110. This is particularly true where there are stand establishment costs which must be compounded to the end of the rotation.

Provided that stem spacing is not limiting, nothing can be done to alter appreciably the total volume production of the stand in given rotation. Nevertheless, treatments such as partial cutting methods as used in this experiment, especially when applied at an earlier age while the stand is growing vigorously should improve the quality of the timber and make a large part of the volume production available at an earlier date. Merchantable volume production may thus be increased.

If the advantages of increased yield of high quality stems can be coupled with adequate regeneration of the commercially important species,

then a treatment is worthy of application.

The treatments in this study have met with some measure of success. Lack of uniformity in the stands between treatments precluded clear comparisons, but certain effects should be noted. Strict diameter limit cutting, for example, produced average regeneration stocking compared to other treatments and despite its inherent weakness of poor residual stem distribution, there was good recruitment of small stems to the 7 inch diameter breast height merchantable size class. Little difference in growth and regeneration was recorded between the heavy, medium, and light residual stand densities. The few stems remaining on the seed tree and clear-cut areas, together with marginal stands, supplied sufficient seed to stock the scarified spots. Thus relatively few stems are necessary to seed the area provided there is a receptive seedbed. Survival on seed tree and clear-cut areas is, however, problematical. Vegetation, especially grasses, is rank, and there is a dense young stand of aspen and poplar suckers of 1- to 2- inches in diameter and 6 to 15 feet in height. The various partial cutting treatments have only occasional groups of aspen suckers and vegetation is less dense.

The selection treatment is more outstanding and is worthy of further examination. Despite somewhat restrictive marking, the cut produced about 12,000 f.b.m. per acre, as much as the volume removed from any other treatment, and total volume production is among the highest when current stand volume is added to this figure. The high volume increment, 3.16 per cent, shows that the residual stand is growing most vigorously of all treatments. This is in part because the marking left a preponderance of vigorous stems (Quaite 1953)<sup>1/</sup> and is not the result of release alone.

<sup>1/</sup> Quaite, J. 1953-Experimental cutting of white spruce in a mixedwood stand in Northern Alberta. Canada Dept. of Northern Affairs and National Resources, Forestry Branch, Forest Research Division. Unpub. progress report.

Recruitment to the 7-inch diameter breast height is the highest of all cut stands and spruce regeneration stocking is also highest. Mortality is next to lowest of all stands. In contrast, the un-cut stands are decreasing in growth and would be better removed and replaced with artificial regeneration to make best use of the sites.

The selection system as applied in this study is not the true selection system of classical silvicultural working. It is in fact a 2-cut uniform shelterwood system, with the introduction of more intensive marking than had previously been envisaged in the region. The first cut involves removal of at least 55 per cent spruce by volume and marking ensures that only those stems are left which show good growth potentialities. Scarification to provide a receptive seedbed should follow the first cut. Timing of the removal cutting will depend on residual stand growth and regeneration status. The method embodies the following advantages:

- (1) Site protection.
- (2) Seed supply from selected vigorous parent trees.
- (3) Shelter for establishing seedlings.
- (4) It inhibits colonization by intolerant species.
- (5) It permits valuable recruitment to merchantable size within the residual stand.
- (6) There is accelerated growth on crop trees.
- (7) It increases the value of the stand.
- (8) Seeding may be induced by increased insolation following the first cut.

Although the other partial fellings provided these advantages to varying degrees, the more intensive marking system provided benefits which justify the extra care necessary. The results corroborate those of another study in the same area where four residual stand densities were examined following partial cutting of marked stems and seedbed scarification (Lees, 1962). The system is being adopted in the region by the Provincial Department of Lands and Forests and the first fellings using tree marking were made in conjunction with this study. Further investigation is now required of removal cutting.

#### FUTURE WORK

Remeasurement is scheduled for 1971 at which time the residual stems will be removed. Results will be available at that time of total volume production for each treatment.

Because the initial scarification of the various treatment areas was limited to particular spots, regeneration stocking to white spruce nowhere exceeds 30 per cent. Since it is planned to remove the overstorey within the next ten years, treatment to restock the areas to spruce is now due. It is planned to scarify the whole experimental area with a medium size tractor and a toothed blade. The work will co-incide with a good seed year. Following scarification, a tally will be made of all trees uprooted or damaged by the equipment.

One hundred per cent enumeration will precede cutting. Following final clear cutting in 1971, regeneration will be assessed for each treatment area.

#### SUMMARY

A research project was initiated in 1951 in 95 year old spruce-aspen stands, in the Mixedwood Section of Alberta's Boreal forest, to investigate eight harvest cutting methods and to assess spruce seedling establishment on scarified spots under each of these treatments. It was planned to develop a tree marking system for partial cutting in the region but treatment also included clear-cut and seed tree areas. There was an uncut control.

Seedlings were tallied in 1952, 1954 and 1960 on specific scarified spots. In 1961 the regeneration status on the whole 150-acre study area was assessed. Growth was measured in the residual stands in 1961 and windfall and mortality was assessed in 1952, 1953, 1954 and 1961.

It was found that:-

- a.) The scarified bare mineral soil seedbed provided a receptive medium for spruce seedling establishment under all harvest cuttings.
- b.) Seedling survival did not vary between treatments.
- c.) Overall regeneration establishment including unscarified conditions was unsatisfactory and an extensive scarification of the area is planned before final felling in 1971.
- d.) Mortality and windfall in the residual stands was slight, occurring mainly in stems damaged by logging.
- e.) Growth rates improved following cutting with the best in the lightest residual stands.
- f.) "Selection" cutting provided highest stand growth rates, low mortality and the best regeneration.

- g.) The spruce responded to release under all partial cutting treatments and provided a valuable recruitment to the seven-inch diameter breast height merchantable size class.
- h.) The more intensive marking carried out under the "selection" treatment resulted in improved quality growing stock which will provide high yield at the final felling.

A two-cut uniform shelterwood system with the first cut removing 55 per cent spruce by volume is recommended for the region. The marking ensures that only those stems are left which have good growth potentialities. Scarification is to follow the first cut.

Further research is planned in assessment of regeneration status and total volume production under each treatment. Final removal fellings will be made in 1971 at which time total volume production and regeneration will be assessed for each treatment.

#### REFERENCES

- LEES, J.C., 1962 - Partial cutting with scarification in Alberta Mixedwood stands. Canada, Dept. of Forestry, Forest Research Branch, Technical Note in press.
- QUAITE, J. 1956 - Survival of white spruce seedlings resulting from scarification in a partially cut Mixedwood stand. Canada, Dept. of Northern Affairs and National Resources, Forestry Branch, Forest Research Division, Technical Note 44.
- ROWE, J.S. 1959 - Forest Regions of Canada. Canada, Dept. of Northern Affairs and National Resources, Forestry Branch, Forest Research Division. Bulletin No. 123.

APPENDIX I

TABLE 7. ANALYSIS OF VARIANCE FOR PERCENTAGE OF QUADRATS STOCKED WITH  
WHITE SPRUCE SEEDLINGS, 1960.  
(Percentages were transformed into angles).

<u>Source of Variation</u>	<u>Degrees of Freedom</u>	<u>Sum of Squares</u>	<u>Mean Square</u>	<u>F</u>
<u>Main Plots</u>				
Blocks	2	1,883.4	941.7	7.23 **
Cutting Method	7	1,570.5	224.3	1.72 N.S.
Error	14	1,824.0	130.3	
<u>Subplots</u>				
Seedbed (T)	1	18,443.6	18,443.6	127.7 **
T X Cutting Method	7	2,165.8	309.4	2.14 N.S.
Subplot Error	16	2,309.6	144.4	
Total	47	28,196.9		