Forest Research Branch

PARTIAL CUTTING WITH SCARIFICATION IN ALBERTA SPRUCE-ASPEN STANDS

by

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Sommaire en français

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Partial Cutting with Scarification in Alberta Spruce-Aspen Stand[1]

by
J. C. LEES[2]

SUMMARY

In 1952 a study was begun in 110-year-old spruce-aspen stands in the B–18a section of Alberta's mixed-wood to investigate scarification for white spruce regeneration before and after partial cutting to four residual stand densities: *a*) control, *b*) heavy, *c*) medium, and *d*) light.

Scarification was carried out using a TD9 tractor with a 9-foot straight blade. Three seedbed types were compared: *a*) scarified, *b*) mounded, and *c*) undisturbed.

Germination and survival of spruce seedlings were tallied on sub-samples of 4,000 quarter milliacre quadrats between June 1956 and November 1957 and 400 scarified quadrats in 1959. Windfall and mortality, and residual stand growth were measured in 1959 on forty half-acre plots.

It was found that:—

a) Only the scarified seedbed permitted satisfactory establishment of spruce regeneration and remained receptive for five years.

b) Regeneration establishment was not affected significantly by residual stand density or time of scarification.

c) Mortality and windfall were slight, occurring mainly in stems damaged by either scarification or logging.

d) Growth rates for spruce were good considering the age of the stands, and a valuable recruitment to the merchantable size class (7 inches d.b.h.) was noted.
Growth of aspen was poor, many stems being overmature and decadent.

e) The success of partial cutting with scarification is sufficient to recommend its further use in the Mixed-wood Section.

INTRODUCTION

In 1950, partial cutting of white spruce (*Picea glauca*) with tree marking was introduced in the B–18a Section of Northern Alberta by the provincial Department of Lands and Forests. It replaced cutting to breast height diameter limits of 14 to 20 inches. The initial felling under the new system was to provide enough merchantable stems to allow economical logging and at the same time to leave a residual stand for seed supply and conditions suitable for germination and establishment of white spruce seedlings. Only the spruce was considered merchantable and aspen (*Populus tremuloides*) and balsam poplar (*P. balsamifera*)

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were left unmarked. In essence this was a two-cut uniform shelterwood. Private industry agreed to the method on a trial basis and it has subsequently been adopted.

In 1952, work[1] was begun by the Forest Research Branch to examine the system of partial cutting with individual tree marking, and to assess white spruce regeneration following scarification. Four residual stand densities were studied including three degrees of marking and an uncut control. Scarification was tested as a seedbed treatment both before and after logging. This report gives the results of examinations made in 1959.

EXPERIMENTAL AREA

The study area is about 25 miles east of Lesser Slave Lake in the B–18a Mixed-wood section of the Boreal Forest region (Rowe 1959) (Figure 1). The terrain is gently rolling with distinct ridges and long slopes. Grassy sloughs and seasonal streams occur in the lower areas. Soils are Grey Wooded with profiles in well-drained positions showing a characteristic leached A_e horizon and a dark brown-grey crumbly Bt horizon over a calcareous parent material. Textures range from sands and sandy loams on the ridges and slopes to heavy clays in the depressions. Humus accumulations vary from two to three inches on the ridges to more than one foot in the poorly drained bottomland.

A white spruce-aspen forest of fire origin occurs on the upland sites with balsam poplar, black spruce (*Picea mariana*), and larch (*Larix laricina*) on the lowland sites and muskegs. Mixtures tend to be by species groups rather than individual stems. Occasional white birch (*Betula papyrifera*) and jack pine (*Pinus banksiana*) are present.

The white spruce on the study areas was vigorous and sound and had an average age of 110 years. Diameter range at breast height was from 9 to 16 inches. The aspen was slightly older and decadent. Spruce volumes per acre were commonly 12,000 f.b.m. with 8,000 f.b.m. per acre of aspen and poplar. There was an understorey of about 600 aspen suckers per acre of one to two inches breast-height diameter and some suppressed spruce of three to five inches breast-height diameter that had originated after ground fires in 1904. Advance growth included 100 to 200 white spruce 1 to 4 feet high. Milliacre stocking to spruce reproduction in the area before any treatment amounted to 10 to 15 per cent. Tables of advance growth stocking are presented in Appendix I.

Ground cover beneath the spruce was mainly feather mosses and scattered herbs. Where aspen was the chief component of the stand, minor vegetation was abundant and included tall shrubs such as rose and high-bush cranberry. Moist sites were typically grassy under white spruce-aspen. This created severe competition for tree seedlings.

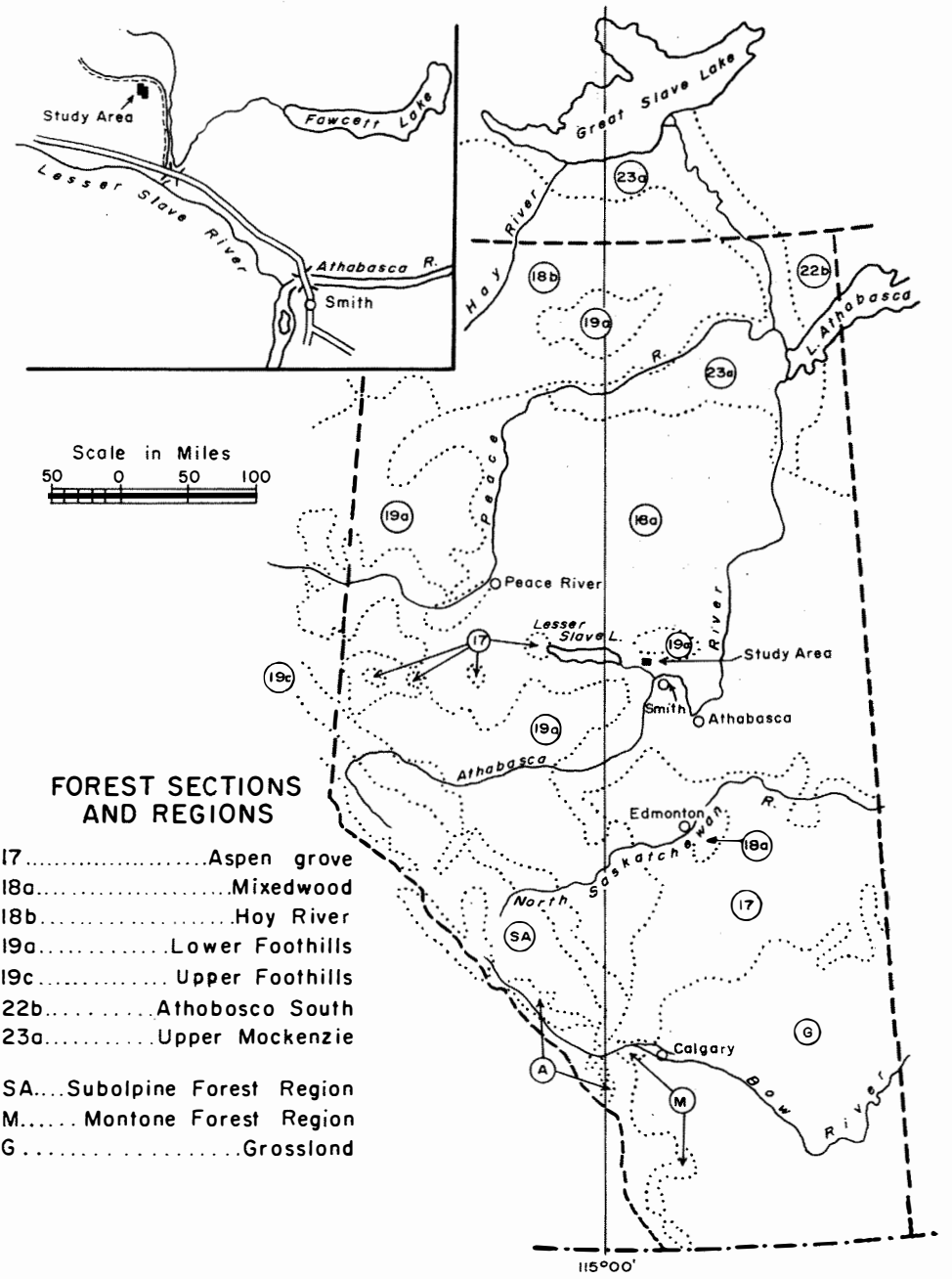
METHODS

The experimental design, covering 20 acres of forest, provided for four intensities of main stand treatment, three seedbed treatments, and two variations in the timing of the seedbed treatments.

[1] Research Project A–22.

FIGURE I.

STUDY AREA LOCATION



FOREST SECTIONS AND REGIONS

17.....Aspen grove
18a.....Mixedwood
18b.....Hoy River
19a.....Lower Foothills
19c.....Upper Foothills
22b.....Athobosco South
23a.....Upper Mockenzie

SA....Subolpine Forest Region
M.....Montone Forest Region
G.....Grosslond

Partial Fellings

The stands were marked for cutting to provide three densities of residual spruce; an uncut control was also preserved. In no treatment was aspen or balsam poplar cut, nor was any spruce cut which was under 7 inches in diameter at breast height. The treatments were as follows:

1. Control—no logging
2. Heavy residual—leaving 8,000 f.b.m. spruce per acre. On the average 5,400 f.b.m. per acre was removed.
3. Medium residual—leaving 5,000 f.b.m. spruce per acre. On the average 3,900 f.b.m. per acre was removed.
4. Light residual—leaving 2,000 f.b.m. spruce per acre. On the average 5,600 f.b.m. per acre was removed.

The experimental layout is shown in Figure 2. The four felling treatments were randomly assigned to 40 half-acre plots combined into five uniform blocks. Within each block, two plots received the same treatment, thus providing a total of 10 replications of each treatment.

The original stand volumes of spruce were not uniform and practically the same volume was removed from the light residual treatment area as from the heavy residual (Appendix II). Since the aspen and balsam poplar were unmerchantable and left standing, the treatment affected only the spruce component of the stand volume. Residual stand density depended therefore, to some extent, on the distribution of the uncut hardwoods. In the summer of 1952, horses were employed to log the treated areas using short log lengths resulting in negligible damage to the residual trees.

Seedbed Treatment

On each half-acre plot two strips were scarified before logging (June and July 1952) and two after logging (September 1952) as shown in Figure 3. More complete scarification would have been possible particularly in the lighter residual stand densities, but treatment was limited to four strips to prevent excess damage to residual trees in the denser stands. Some small spruce were destroyed and roots of several large residual trees were exposed and scarred.

A TD9 tractor with a 9-foot straight blade was used. It proved to be easily manoeuvrable and capable of scarification after logging despite the slash. Alternate lowering and raising of the blade produced spots approximately 8 by 5 feet, scarified to mineral soil.

Following scarification, three distinct types of seedbed were available for comparison:

1. Scarified—mineral soil exposed.
2. Mounded—litter, humus and mineral soil dumped by the blade at the end of each patch.
3. Undisturbed.

ASSESSMENT

Regeneration

On each half-acre plot one hundred quarter-milliacre quadrats were established to sample regeneration on the scarified, mounded, and undisturbed

FIGURE 2

DESIGN OF EXPERIMENT

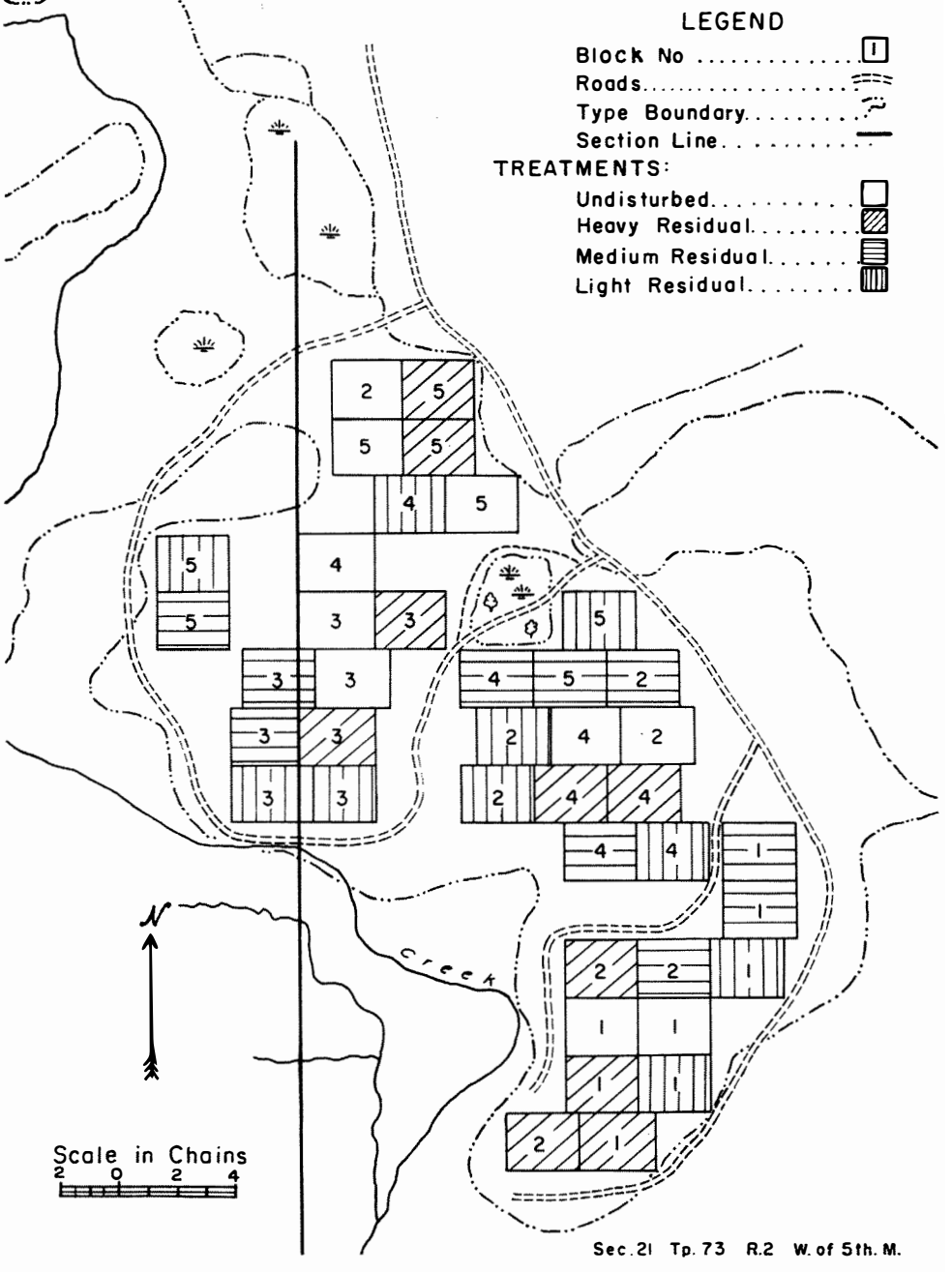
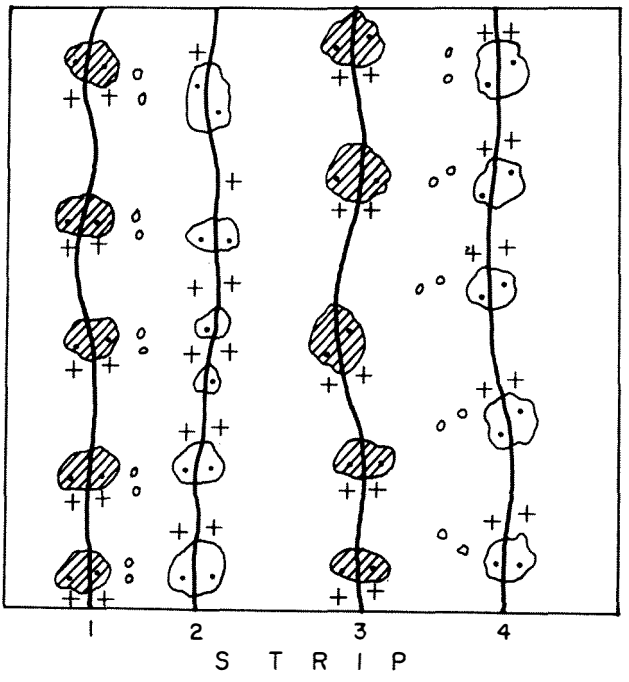


FIGURE 3

THE LAYOUT OF SCARIFICATION STRIPS AND THE ONE HUNDRED 1/4 MILLIACRE REGENERATION QUADRATS ON THE 1/2 ACRE PLOTS



LEGEND

Scarified 1/4 milliacre reg. quadrat.....•

Mounded 1/4 milliacre reg. quadrat.....+

Undisturbed 1/4 milliacre reg. quadrat.....o

Area scarified before logging.....

Area scarified after logging.....

(control) ground (Figure 3). This resulted in a total of 4,000 quadrats of which 1600 were on scarified, 1600 on mounded and 800 on undisturbed ground.

There was no appreciable spruce seed crop in the area until 1955 and regeneration was assessed first in 1956 and 1957 when a stratified sample of 500 quadrats was used to record bi-weekly seedling germination and mortality throughout the growing seasons. Results were analysed and a report was published (Smithers 1959). In 1959, four years after the first seedlings appeared, 400 scarified quadrats were measured to determine whether the earlier stocking to spruce had been maintained and if the regeneration was firmly established.

Residual Stand

All trees, 0.5 inches in diameter at breast height and over, were tallied on each of the 40 half-acre plots before and after cutting. Six trees per plot were tagged and measured for height/diameter studies. Dead trees standing and down were tallied in 1953, 1954, and 1956 and the cause of mortality was noted when this could be determined.

In 1959, a complete tally was made of all living trees and of all dead trees since 1956. Radial growth was measured from increment cores on ten dominant and co-dominant spruce per plot and the original tagged trees were remeasured.

RESULTS

Regeneration

Smithers (1959) found that up to 1956 there was no significant difference in either number of spruce germinants or per cent stocking to spruce between blocks, times of scarification or between cutting treatments. As only the effect of the scarification treatment was significant, the data for all blocks and times of scarification are combined in Table 1. Scarified spots with mineral soil exposed provided a consistently better seedbed than either the mounded or undisturbed conditions. The level of stocking on scarified ground is acceptable.

In 1959 the average milliacre stocking to spruce regeneration on scarified areas remained high at 75 per cent and did not vary between stand densities. Quadrats were stocked mainly with 4- to 5-year-old seedlings up to 6 inches in height, which were survivors from the earliest seedling catch in 1956. Apparently, overwinter and second season mortality had been low; survival had been aided by favourable rainfall in the spring and summer of 1957. A few younger seedlings, 2- to 3-years old, had subsequently seeded in.

By 1959, encroachment of vegetation on the scarified ground was severe and the seedbed could no longer be classed as receptive. Spruce seedlings were most vigorous where the canopy was open and they were suppressed under dense spruce. Other regeneration on the scarified spots, particularly in the more open stands, included white birch and aspen.

Residual Stand Development

Stand volumes and growth for the period 1952 to 1959 are given in Table 2. Between 1952 and 1959 the spruce component on the treated areas had a net volume increment per acre which ranged from 151 to 371 cubic feet, while on the uncut control, the amount was 245 cubic feet. Although the period between measurements is short, some release of individual trees is evident in the merchantable sizes of residual spruce; recruitment to the 7-inch diameter class is a substantial contribution to the merchantable volume increment. Examination of increment cores showed that the growth rate of the residual stems throughout the treatment areas was sustained while growth on control areas decreased.

The aspen showed little increment and on the control area there was a decrement. However, the volume of the hardwood component was relatively stable between 1952 and 1959. Losses owing to mortality in the old decadent trees were offset by increment in younger vigorous stems.

Treatment produced difference in per cent diameter increment. Table 3 shows that values for ~~diameter~~ basal area increment in per cent, obtained by Schneider's

TABLE 1. PER CENT STOCKING TO SPRUCE SEEDLINGS ON SCARIFIED, MOUNDED AND UNDISTURBED SEEDBEDS

Date	June, 1956 (500 Quadrats)						Sept. 1956 (4,000 Quadrats)						June 1957 (500 Quadrats)					
	Scarified		Mounded		Undisturbed		Scarified		Mounded		Undisturbed		Scarified		Mounded		Undisturbed	
Treatment	¼*	1**	¼	1	¼	1	¼	1	¼	1	¼	1	¼	1	¼	1	¼	1
Uncut	36	83	4	14	0	0	27	71	2	7	0	0	24	68	2	7	0	0
Heavy	26	71	0	0	0	0	18	55	0	0	0	0	16	50	0	0	0	0
Medium	22	63	6	21	4	14	18	55	2	7	2	7	16	50	2	7	2	7
Light	32	79	4	14	0	0	26	71	4	14	0	0	26	71	0	0	0	0

Date	Nov. 1957 (500 Quadrats)						July 1959 (400 Quadrats)					
	Scarified		Mounded		Undisturbed		Scarified		Mounded		Undisturbed	
Treatment	¼	1	¼	1	¼	1	¼	1	¼	1	¼	1
Uncut	22	63	2	7	0	0	21	61	—	—	—	—
Heavy	16	50	0	0	0	0	30	78	—	—	—	—
Medium	16	50	2	7	0	0	33	80	—	—	—	—
Light	20	59	0	0	0	0	35	82	—	—	—	—

* ¼ — ¼ milliacre stocking (as measured)
** 1 — milliacre stocking (after Grant 1951).

formula[1] for dominant and co-dominant stems, were highest in the light residual stands. Spruce height growth amounted to half a foot per year with no variation between treatments.

TABLE 2.—VOLUME AND GROWTH PER ACRE

(Total Volume in Cubic Feet)

Treatment	Species	Number of stems 1959	Volume 1952		Volume 1959	Net increment 1952–59	Mortality 1952–59	Gross increment 1952–59	Net volume increment /ac /year	Recruitment to 7" dbh class 1952–59
			before cut	after cut						
Control....	wS	207	—	3187	3432	245	92	337	35	96
	Hwd	122	—	2077	2033	−44	142	98	—	—
	Total	329	—	5264	5465	201	234	435	—	—
Heavy....	wS	164	3377	2066	2437	371	76	447	53	68
Residual...	Hwd	110	2026	1907	1922	15	144	159	—	—
	Total	274	5403	3973	4359	386	220	606	—	—
Medium...	wS	160	2410	1420	1666	246	49	295	35	72
Residual...	Hwd	151	2301	2181	2219	39	184	223	—	—
	Total	311	4711	3601	3885	285	233	518	—	—
Light.....	wS	116	2069	740	891	151	30	181	22	65
Residual...	Hwd	175	2363	2321	2374	54	268	322	—	—
	Total	291	4432	3061	3265	205	298	503	—	—

basal area

TABLE 3.—~~DIAMETER~~ AND HEIGHT INCREMENT 1952–1959 DOMINANT AND CO-DOMINANT WHITE SPRUCE

Residual Stand	Average d.b.h. 1959	~~Diameter~~ basal area increment 1952–1959	Average dominant height 1959	Average annual height growth 1952–1959
	(inches)	(per cent)	(feet)	(feet)
Control	13.9	1.96	83.0	0.6
Heavy	13.6	1.87	85.7	0.6
Medium	12.8	2.25	79.1	0.6
Light	11.3	2.83	69.5	0.5

Mortality figures are presented in Table 4 for the periods 1952 to 1956 and 1956 to 1959. Spruce mortality was noticeably light. It occurred mainly in stems damaged by either scarification or logging; windfall was negligible. The 1 to 6 inch diameter class was most affected. Average annual figures show that mortality volume was slightly higher in the initial period because of damage to some large stems and possibly due to insolation and shock of release. Aspen, on the other hand, showed an increasing mortality trend as the larger stems disappeared from the overwood. This left residuals relatively free from insect attack and disease.

[1] $P = \frac{400}{nD}$ Schneider's formula

basal area

value P = ~~diameter~~ increment in per cent
D = present diameter breast height over bark in inches.
n = number of rings in the last inch of radius.

TABLE 4.—MORTALITY

Treatment — Species		Average Annual Mortality Per Acre					
		1952–56		1956–59		Total	
		Number of Stems	Total Volume Cu. Ft.	Number of Stems	Total Volume Cu. Ft.	Number of Stems	Total Volume Cu. Ft.
Control	wS	1	9	1	14	2	23
	Hwd.	1	10	2	25	3	35
	Total	2	19	3	39	5	58
Heavy Res.	wS	1	11	1	8	2	19
	Hwd.	1	14	1	22	2	36
	Total	2	25	2	30	4	55
Medium Res.	wS	1	8	1	4	2	12
	Hwd.	1	10	1	36	2	46
	Total	2	18	2	40	4	58
Light Res.	wS	1	4	1	4	2	8
	Hwd.	1	31	2	36	3	67
	Total	2	35	3	40	5	75

DISCUSSION AND APPLICATION

Treatment of the stands proved successful in providing an overhead spruce seed source and shelter for the seedlings during the establishment period. The mineral soil seedbed produced by scarification remained receptive to seed at least up to 1957. This resulted in good stocking to spruce on scarified spots compared with failure on the mounded and undisturbed seedbeds. Because the superficial layer of moss and litter dries out too quickly to provide a suitable medium for germination and survival, regeneration on undisturbed areas failed. Likewise, the moisture levels of the loose, structureless mineral soil on the mounded seedbeds were apparently too low to support regeneration.

Although good spruce seed crops are infrequent, occurring about once every seven years, the increase in stocking of spruce seedlings between 1957 and 1959 suggests that there may be a light seedfall at more frequent intervals. However, as the period during which scarified ground remains receptive to seed (about 5 years) may be shorter than the intervals between adequate seed crops, scarification in partial cut stands should be synchronized with good seed years; otherwise some artificial seeding or planting may be necessary to obtain adequate regeneration. The advantages of scarification shown to date in trials in the area are considered sufficient to warrant inclusion of scarification as a standard procedure in regeneration silviculture in spruce-aspen stands.

The residual spruce remained vigorous and healthy. Height and diameter growth of dominant and co-dominant stems has been satisfactory considering the advanced age of the stands. There has been recruitment to the merchantable seven-inch diameter size class. Mortality has been light and windfall negligible.

Several points are noteworthy with respect to application of the results. Since current marking practice provides for removal of less than 50 per cent spruce by volume, the resulting residual stands most closely resemble medium

to heavy residual stands on the experimental area. Results of this study suggest, however, that up to 70 per cent spruce by volume can safely be removed in partial cutting provided the residual stems are vigorous and healthy.

Rotation age and the end product of stand treatment depend on the level of silviculture which it is economical to practice. Within the framework of the present sawlog economy, regeneration and growth data from this experiment indicate that present cutting and regeneration practices are producing good results for the amount of effort expended. If age class distribution was satisfactory, the first cutting could be made when stands are about 75 years of age. Improved growth would result in the residual stems during the ensuing regeneration period. If defective and poorly formed trees could be removed, well-spaced desirable parent trees would be left. Scarification could then follow, and timing of removal felling would depend on regeneration status and residual stand growth.

Damage to residual stems during felling and scarification operations can be minimized through education, supervision of operators and the layout of well-planned extraction routes. The selection of appropriate logging equipment and methods is important and would vary with the density of the stand. It is preferable to scarify after rather than before logging; tractors are more easily manoeuvred and slash is seldom a hindrance. For removal fellings, winter logging is preferable as snow lends some protection to seedlings and thus minimizes damage.

Under more intensive management, greater advantage could be taken of the production potential of sites and stands. For example, under a pulpwood economy, which would allow the use of hardwoods, two 60-year rotations of hardwood and one 120-year rotation of spruce could be realized. Only selected spruce crop trees would be allowed to grow to full rotation age for sawtimber. The remainder would be removed as pulpwood in a series of thinnings and regeneration fellings. Higher yields might also justify the cost of artificial regeneration to achieve more rapid restocking.

SOMMAIRE

Une étude a été entreprise en 1952 dans des peuplements d'épinettes et de peupliers faux-trembles âgés de 110 ans dans la section B–18a des bois mixtes d'Alberta aux fins d'étudier l'effet de la scarification sur la régénération de l'épinette blanche, avant et après une coupe partielle visant à obtenir quatre densités différentes de peuplement résiduel, soit: *a*) densité témoin, *b*) forte densité, *c*) densité moyenne, *d*) faible densité.

La scarification a été effectuée au moyen d'un tracteur TD9 muni d'une lame droite de 9 pieds. On a fait la comparaison de trois types de planches à semis: *a*) planches scarifiées, *b*) planches en comble, *c*) planches non remuées.

On a enregistré la germination et la survivance des semis d'épinette dans des sous-échantillons de 4000 quadrats d'un quart de milliacre chacun entre juin 1956 et novembre 1957, et dans 400 quadrats scarifiés en 1959. On a aussi mesuré, en 1959, le chablis, la mortalité et la croissance du peuplement résiduel dans 40 places d'une demi-acre.

On a découvert que:

a) Seule la planche à semis scarifiée permettait l'établissement satisfaisant de la régénération d'épinette et demeurait en état de réceptivité pendant cinq années.

b) L'établissement de la régénération n'était pas modifié de façon importante par la densité du peuplement résiduel ou par l'époque à laquelle la scarification fut effectuée.

c) La mortalité et le chablis étaient faibles et se produisaient surtout dans le cas des tiges endommagées par la scarification ou par l'exploitation.

d) Les taux de croissance de l'épinette étaient bons, compte tenu de l'âge des peuplements, et un apport précieux à la classe de grosseur marchande (7 pouces de diamètre à hauteur de poitrine) a été enregistré. La croissance du peuplier faux-tremble a été médiocre, plusieurs tiges ayant passé l'âge d'exploitabilité et étant en état de décadence.

e) Le succès de la coupe partielle avec scarification est suffisant pour en recommander la continuation dans la section des bois mixtes.

APPENDICES

Appendix I

ADVANCE GROWTH—1952

No. of Stems Per Acre

Before Cutting

Ht. Ft.	Control				Heavy Residual				Medium Residual				Light Residual			
	wS	tA	bPo	wB	wS	tA	bPo	wB	wS	tA	bPo	wB	wS	tA	bPo	wB
1	36	130	35	8	31	135	44	12	50	84	19	10	102	74	26	25
2	30	204	44	38	30	299	56	36	50	278	56	26	58	215	49	61
3	19	194	64	21	26	231	49	25	56	237	41	27	29	288	48	119
4	8	143	53	4	15	161	36	11	34	155	47	21	14	239	36	90
5	2	36	27	—	5	34	24	—	19	32	33	1	4	93	17	13
6	—	31	18	1	6	30	14	—	14	20	14	3	3	58	17	13
7	1	33	34	2	1	22	14	4	1	23	15	3	1	42	18	7
8	—	19	26	—	1	17	4	—	1	27	15	—	—	57	18	2
9	—	11	14	—	—	10	6	—	—	8	8	—	—	24	12	2
10	—	3	2	—	—	2	1	—	—	2	4	—	—	10	2	—
Total	96	804	317	74	115	941	248	88	225	866	252	91	211	1,100	243	332

After Cutting

1	19	102	19	1	15	81	27	4	24	76	8	2	38	53	17	10
2	27	173	27	11	12	143	220	11	19	118	25	15	34	110	17	12
3	6	121	37	14	4	119	29	11	22	108	19	12	11	137	18	28
4	6	67	28	5	3	58	13	8	16	54	14	6	7	91	20	27
5	4	27	13	1	3	21	9	4	9	35	12	—	4	38	6	7
6	—	26	13	4	—	15	5	2	5	10	13	1	1	11	7	1
7	—	19	22	—	7	17	5	1	1	14	3	1	4	13	3	1
8	2	20	13	—	2	34	4	—	—	8	4	1	—	10	3	1
9	—	12	8	—	—	2	1	—	—	4	3	—	—	4	3	—
10	—	—	5	—	—	2	1	—	—	3	2	—	—	2	3	—
Total	64	567	185	36	46	492	314	41	96	430	103	38	99	469	97	87

Appendix II

VOLUME PER ACRE—SUMMARY

		Total Cubic Foot Volume				Board Foot Volume			
		Control	Heavy Res.	Medium Res.	Light Res.	Control	Heavy Res.	Medium Res.	Light Res.
Before Cutting	wS.	3,090	3,377	2,410	2,069	11,914	13,285	8,965	7,866
	Hwd.	1,990	2,026	2,301	2,363	7,017	7,351	7,738	8,228
	All Spp.	5,080	5,403	4,711	4,432	18,931	20,636	16,703	16,094
Removed by Cutting	wS.	—	1,311	990	1,328	—	5,418	3,972	4,715
	Hwd.	—	119	138	42	—	418	476	16
	All Spp.	—	1,430	1,128	1,370	—	5,836	4,448	4,731
After Cutting	wS.	3,090	2,066	1,420	741	11,914	7,867	4,993	3,151
	Hwd.	1,990	1,907	2,163	2,321	7,017	6,933	7,262	8,212
	All Supp.	5,080	3,973	3,583	3,062	18,931	14,800	12,255	11,363

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