CANADA

DEPARTMENT OF FORESTRY

REGENERATION FOLLOWING STRIP CLEAR CUTTING, SCARIFICATION AND SLASH DISPOSAL IN A LODGEPOLE PINE STAND

by

R. F. Ackerman

•

Forest Research Branch
Technical Note No. 123
1962

Published under the authority of
The Honourable Hugh John Flemming, P.C., M.P
Minister of Forestry
Ottawa, 1962

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1962

Cat. No. Fo-47-123

CONTENTS

60879-4—1½

Regeneration Following Strip Clear Cutting, Scarification and Slash Disposal in a Lodgepole Pine Stand

by

R. F. Ackerman[1]

SUMMARY

A study was initiated in 1954 to determine whether scarification and slash removal after clear cutting in 5-chain strips are effective regeneration methods for mature even-aged lodgepole pine stands in the Foothills Section of Alberta.

The following three treatments were randomly assigned to 12, one-acre plots:

1. Control; seedbed undisturbed; slash lopped and scattered.
2. Seedbed undisturbed; slash removed.
3. Seedbed scarified; slash windrowed.

Seedfall from the adjacent stands was measured by seed traps set out on each plot. The regeneration was sampled on each plot by two transects of 25 contiguous milliacre quadrats.

The results six years after treatment were as follows:

1. Scarification after clear cutting resulted in satisfactory stocking to lodgepole pine and white spruce.
2. Without seedbed treatment neither lopping and scattering nor removal of the slash was of any value except possibly to reduce the fire, insect and disease hazards.
3. Ninety per cent of the pine regeneration came in during the first two years after treatment.
4. Seedfall from the adjacent stands averaged only 1,200 sound seed per acre per year. Slash-borne and free cones apparently provided most of the pine seed available to the clear cut strips.
5. Further investigation of methods and timing of post-logging scarification is necessary to define means of taking full advantage of the slash-borne seed supply.

INTRODUCTION

Lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) is an intolerant species that reproduces abundantly after fire. Reproduction after logging, however, has not generally been adequate in Alberta (Blyth 1957, Candy 1951) and corrective measures are being sought. In 1953 the Forest Research Branch initiated a study in the Edson district to test scarification and slash removal as regeneration methods after clear cutting in strips.

Known examples of satisfactory regeneration of lodgepole pine without seedbed treatment have in common a comparatively dry site with a minimum of unincorporated organic material and a paucity of competing vegetation (Anon. 1952, Crossley 1952a). On the better Subalpine sites and in the Boreal Forest

[1] Research Officer, Forest Research Branch, Dept. of Forestry, Calgary, Alberta.

Region of Alberta, where the organic layer is deeper and the vegetation more luxuriant, the evidence indicates that seedbed treatment is required for regeneration. Crossley (1956c) obtained excellent regeneration of lodgepole pine in the Boreal Region by scarification before logging and concluded that seedbed treatment was a prerequisite to regeneration success.

Scarification before logging should be particularly effective for lodgepole pine since the supply of slash-borne seed can be utilized to best advantage. The cost of such treatment in normally dense lodgepole pine stands is high, perhaps prohibitive, with the type of equipment available. If adequate regeneration can be obtained by scarification after logging with large efficient equipment, considerable saving might be realized.

Mechanical scarification has been used successfully in Alberta to obtain spruce regeneration (Crossley 1949, 1952b, 1955b: Quaite 1956). Also, studies by Eyre and Le Barron (1944) in the Lakes States and by Noakes (1946) in Ontario indicate that jack pine may be regenerated by this treatment.

The method of slash disposal in lodgepole pine stands influences both the seed supply from slash-borne serotinous cones and the survival of seedlings. Crossley (1956a) reported that the rate of resin bond rupturing and scale flexing of slash-borne cones increases with proximity to the ground. Consequently, lopping and scattering should increase the rate of seed-release on to the seedbed. Tests of slash disposal methods in Montana showed that concentrated slash inhibited reproduction (Boe 1951, Anon. 1950). There is reason to believe, however, that in Alberta the shelter provided by slash will increase seedling survival, particularly on burned seedbeds and perhaps on scarified seedbeds (Ackerman 1957, Crossley 1956c).

Although post-logging scarification with heavy machinery has economic advantages, the treatment reduces the total effective seed supply by concentrating the cone-bearing slash in fewer places and by burial. Similarly, removal of the slash by piling and burning reduces seed supply. Under these circumstances the amount of seed from the adjacent stands may become a significant factor. Investigating lodgepole pine clear cut areas in Wyoming, Colorado and Montana, Bates et al. (1929), Boe (1951) and Anon. (1950) concluded that adequate regeneration can be obtained on clear cut areas if slash-borne cones are not destroyed by burning. On the other hand, satisfactory regeneration has been observed on undisturbed and burned seedbeds in the apparent absence of seed sources other than the adjacent stands (Crossley 1952a, 1956c). It must be concluded that the adequacy of the adjacent stands as a seed source is in doubt, particularly on large clear cut areas.

METHODS AND MATERIALS

Description of the Area and Stand

The experimental area is located near Edson, Alberta (53° 24′N., 115° 44′ W.) in the Lower Foothills Section of the Boreal Forest Region (Rowe 1959). It is rolling country, more typical of the Mixed-wood Section than of the sharply cut foothills area further west. Species association suggests an ecotone between the Foothills and Mixed-wood Sections. Stands of lodgepole pine with some black and white spruce are present but mixed-woods and pure stands of aspen are also common.

The soil varies from sandy beach deposits to lacustrine and shoved lacustrine materials high in clay content. Soil moisture is also variable, but most of the experimental area is fresh to moist. Depth of unincorporated organic material varies with moisture condition from $1\frac{1}{2}$ to $3\frac{1}{2}$ inches. The site index, based on rate of height growth, is considered average for the region.

Primarily, the stand was even-aged 110-year-old lodgepole pine of fire origin. Scattered black and white spruce, fir, aspen and birch were present, mostly as an understorey. Representative stand statistics obtained in the uncut strips are presented in Table 1.

TABLE 1. REPRESENTATIVE STAND STATISTICS

Item	Species				
	lP	bS	wS	Po	bF
No. stems per acre	166	121	17	46	2
Basal area sq. ft. per acre	72.7	8.2	3.0	1.1	0.1
Average diameter	9.0	3.5	5.7	2.1	3.0
V.c.f. 4″ + per acre	2318	189	44	—	—
V.b.f. 7″+ per acre	9512	593	80	—	—
Average dom. ht.	74	—	—	—	—
Site index (80 yrs.)	63-64 (regional average—62)				

lP lodgepole pine; bS black spruce; wS white spruce; Po poplar; bF balsam fir

The experimental area was partially cut about 1933. A tally of stumps revealed, that on the average, 100-110 stems per acre were removed at that time.

Experimental Treatment and Design

All merchantable trees, seven inches d.b.h. and larger, were harvested in 5-chain strips by conventional horse logging during the winter of 1953-54. Intervening strips were left intact. The living stems remaining on the cut strips were felled in July 1954 and the following three treatments applied:

1. *Control; seedbed undisturbed: slash lopped and scattered*

   This treatment was completed in August, 1954. The seed sources were the adjacent stands, slash-borne and free cones.

2. *Seedbed undisturbed; slash removed*

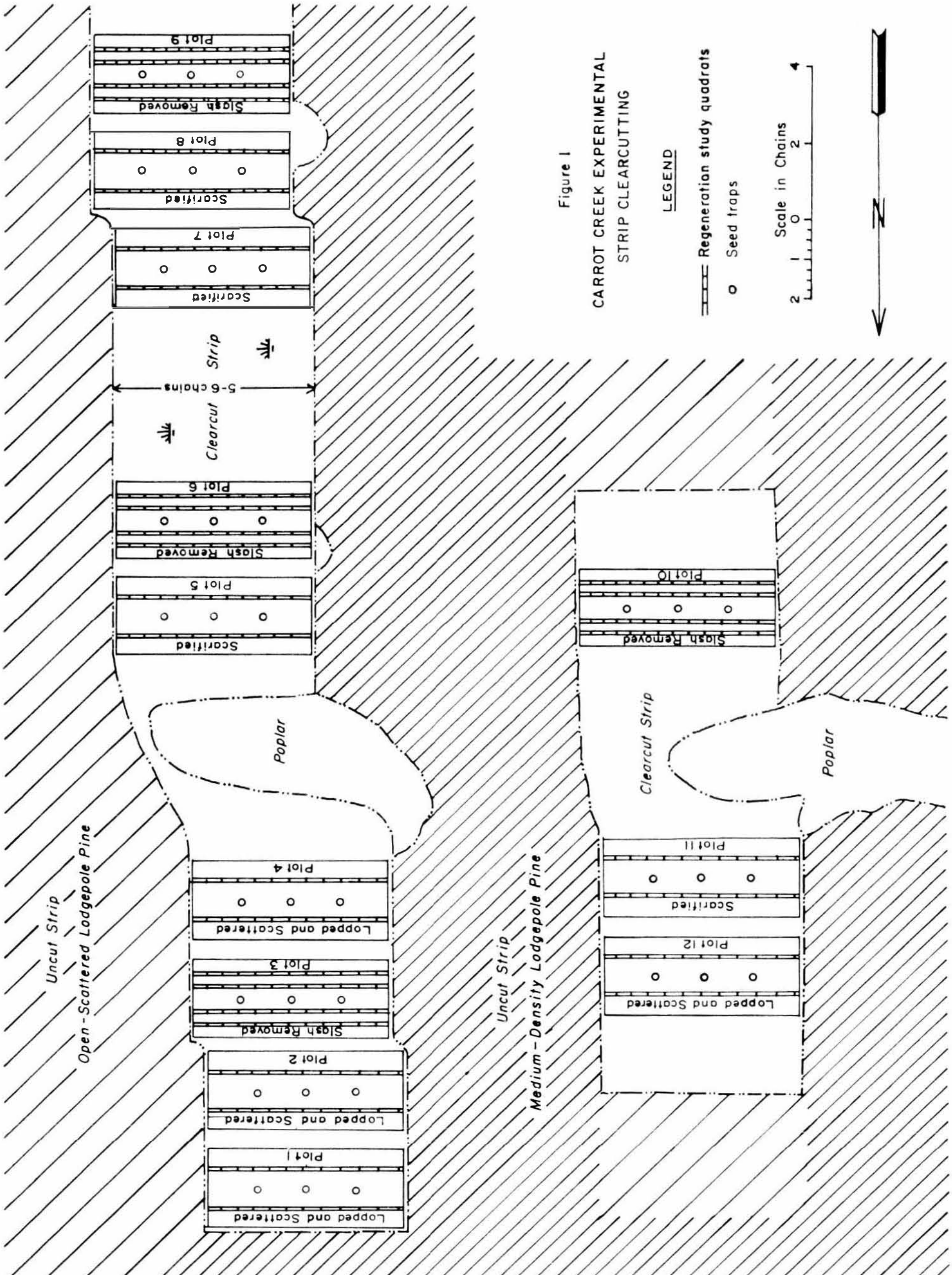
   After final cutting, all slash was removed by hand. Treatment was completed in August. The seed sources were the adjacent stand and free cones.

3. *Seedbed scarified; slash windrowed*

   Scarification and windrowing of slash was done in November 1954 with a D7 tractor equipped with a standard 12-foot scraper blade. Seed source for this treatment was limited to the adjacent stands and the free cones that were not pushed into the slash windrows.

The above treatments were randomly assigned to twelve, 1 acre plots (5 by 2 chains) to provide four replications of each. To assess the regeneration, two transects each containing 25 contiguous, rectangular, milliacre quadrats were established across each plot (a 5 per cent sample). The layout of the experiment is shown in Figure 1.

To determine seedfall from the adjacent stands, three $\frac{1}{20}$ milliacre seed traps were set out at regular intervals across each of the 12 plots. Provision was made for assessing the significance of this seed source by hand picking the free cones from two additional transects of milliacre quadrats established on each plot of treatment 2 (slash removed). This attempt to limit the seed supply to that received from the adjacent stands was not completely successful because the free cones were not removed until August, by which time some cone opening had occurred.



The regeneration was tallied in August of 1955, 1956 and 1960 and the seed traps were emptied each year from 1955 to 1960. All seedlings were marked with wire pins to aid in determining survival.

The degree of scarification was assessed on all milliacre quadrats by estimating the extent of the following three seedbed types:

1. Mineral soil
2. Disturbed; mineral soil not exposed
3. Undisturbed.

Estimates of the proportion of these seedbeds on the four scarified plots are given in Table 2. Average conditions on the undisturbed plots are included for comparison.

TABLE 2. SEEDBED CONDITIONS FOLLOWING TREATMENT

Seedbed Treatment	Plot Number	Seedbed: Percentage of Total Surface			Percentage of Quadrats with some Mineral Soil
		Mineral Soil	Disturbed	Undisturbed	
Scarified	5	41	47	12	93
	7	20	34	46	58
	8	40	43	17	78
	11	70	29	1	92
	Mean	43	38	19	80
Not Scarified	Mean	1	3	96	2

RESULTS

The results six years after treatment are presented in Table 3. Statistical analyses of percentage stocking to pine and spruce seedlings and the number of pine and spruce seedlings per acre are presented in the Appendix.

Scarification resulted in a significantly greater number of pine seedlings and a significantly higher level of stocking to pine than all other treatments (Plate 1). It is the only treatment to meet the minimum stocking standards set by the Alberta Department of Lands and Forests (40 per cent stocking, by milliacre quadrats to softwoods or 30 per cent to softwoods plus 10 per cent to hardwoods). Scarification also resulted in a significant increase in the stocking and density of spruce seedlings.

There were no significant differences in stocking or in numbers of seedlings attributable to either slash or free cone removal. Apparently the effects of slash and cone removal on seed supply and environment were masked by the over-riding influence of an unfavourable seedbed.

Aspen root suckers are abundant on many plots and there is little doubt that, in the absence of pine regeneration, aspen will predominate in the new stand (Plate 2). The presence and abundance of the aspen suckers reflects the chance occurrence of this species in the stand before logging and is apparently not related to either seedbed treatment or slash removal.

TABLE 3. 1960 REPRODUCTION SUMMARY

Treatment	Regeneration					Advance Growth			Regeneration + Advance Growth				
	lP	wS	Po	lP+wS	All	lP	wS	lP+wS	lP	wS	lP+wS	Po	All
	Percentage Stocking												
Scarified	45	32	39	60	77	4	1	4	46	33	62	39	79
Lopped and Scattered	12	5	58	14	62	2	4	4	12	8	18	58	64
Slash Removed	9	4	28	12	37	4	2	6	12	6	15	28	39
Slash and Cones Removed	4	2	35	5	38	2	1	2	6	2	7	35	40
	Number of Seedlings per Acre												
Scarified	1,595	740	1,505	2,335	3,840	40	10	50	1,635	750	2,385	1,505	3,890
Lopped and Scattered	220	90	2,440	310	2,750	15	45	60	235	135	370	2,440	2,810
Slashed Removed	180	45	1,085	225	1,310	35	55	90	215	100	315	1,085	1,400
Slash and Cones Removed	90	20	1,180	110	1,290	20	10	30	110	30	140	1,180	1,320

PLATE 1. Lodgepole pine regeneration on scarified plot 5.

PLATE 2. Sucker growth of aspen following clear cutting.

The height of the tallest seedling of each species present on each quadrat was recorded in 1960. These results are summarized by species and seedbed treatment in Table 4.

TABLE 4. AVERAGE HEIGHT OF THE TALLEST SEEDLING OF EACH SPECIES ON EACH QUADRAT SIX YEARS AFTER TREATMENT

Seedbed Treatment	Species		
	lP	wS	Po
	Inches		
Scarified	14.4	4.1	18.3
Not Scarified	6.6	4.1	31.7

A marked increase in the initial height growth of lodgepole pine and a marked decrease in the height growth of aspen suckers occurred on the scarified plots. The growth of spruce was not affected. The difference in height growth of pine and spruce seedlings of the same age, side by side on apparently identical seedbeds, is illustrated in Plate 3.

The percentage survival of lodgepole pine and white spruce seedlings during the first five year period is given in Table 5 for scarified and undisturbed areas. The differences between treatments are not statistically significant.

PLATE 3. Six-year-old lodgepole pine and white spruce seedlings on a scarified seedbed.

TABLE 5. PERCENTAGE SURVIVAL OF 1955 AND 1956 SEEDLINGS IN 1960.

Seedbed Treatment	1955 Seedlings in 1960		1956 Seedlings in 1960	
	lP	wS	lP	wS
	Per cent survival			
Scarified	49	47	74	77
Not Scarified	42	67	61	75

The nature of the seedbed occupied by each new seedling was determined in 1955 and 1956. These results are given in Table 6.

TABLE 6. PERCENTAGE OF PINE AND SPRUCE SEEDLINGS OCCUPYING VARIOUS SEEDBEDS

Seedbed Treatment	Seedbed					
	Mineral Soil		Disturbed		Undisturbed	
	lP	wS	lP	wS	lP	wS
Scarified	63	88	36	12	1	—
Not Scarified	4	32	37	21	59	47

On the scarified plots, nearly all pine and spruce seedlings occurred either on a mineral soil or on disturbed seedbed. The preference of seedlings for a treated seedbed was also evident on the control plots. Here, 41 per cent of the pine seedlings and 53 per cent of the spruce seedlings occurred on mineral soil and disturbed seedbeds (roads and skid trails) which occupy only 4 per cent of the area.

During the period 1954 to 1960, the annual pine seedfall into the clear cut strips from the adjacent stands averaged only 1,200 sound seed per acre (Table 7). This is similar to an estimate of 1,500 sound seed per acre obtained by Crossley (1955a) at the Kananaskis Forest Experiment Station.

TABLE 7. LODGEPOLE PINE AND WHITE SPRUCE SEEDFALL—1954 to 1960

Year	Species	
	lP	wS
	Number of Sound Seed Per Acre	
1954–55	1,000	10,000
1955–56	—	—
1956–57	1,200	1,200
1957–58	3,800	2,000
1958–60	1,500	9,100
Mean Annual	1,200	3,700

The occurrence of pine seedlings by years following treatment is given in Table 8.

TABLE 8. LODGEPOLE PINE GERMINATION BY YEAR AND SEEDBED TREATMENT

Seedbed Treatment	Year of Germination			
	1st Year 1955	2nd Year 1956	3rd Year 1957	4th-6th Year 1958–60
	Percentage of Total Germination			
Scarified	37	52	9	2
Not Scarified	59	34	6	1

Approximately 90 per cent of the pine seedlings came in during the first two years after treatment. Germination was much reduced in the third year and it was negligible by the fourth year.

The pattern of germination observed in this experiment agrees quite well with the schedule of slash-borne cone opening described by Crossley (1956a). Considering this, and the meagre seedfall indicated by the seed traps, it is probable that the major source of seed in this experiment was the slash-borne and free cones.

The recovery of the seedbed on the scarified areas has been remarkably slow, so that some increase in stocking can be expected on these areas, particularly of spruce, as a result of seedfall from the adjacent stands.

DISCUSSION

This experiment confirms the hypothesis that seedbed treatment is necessary to obtain adequate regeneration of lodgepole pine after cutting. Further, inasmuch as the regeneration obtained meets the minimum standards set by the Alberta Department of Lands and Forests, scarification with heavy equipment after logging can be considered a promising technique. However, the stocking level attained is not high and does not compare favourably with the regeneration results obtained by Crossley with prescarification. This difference is apparent in spite of the fact that post-scarification resulted in exposure of twice as much mineral soil.

The poorer regeneration obtained by post-scarification is believed to be the direct result of less efficient utilization of the slash-borne seed supply. A full summer elapsed before scarification, which allowed ample time for the serotinous cones to open and release their seed on an unreceptive seedbed. Also, the scarification and windrowing removed most of the cone-bearing slash and many free cones from the treated seedbed. Provided treatment is given soon after logging and an effort is made to scatter rather than windrow the cone-bearing slash, it is believed that post-scarification will result in good regeneration.

Post-scarification is now being tested in this region employing D9 tractors and custom blades. The objective is to provide a minimum of well-distributed mineral soil and effective distribution of the cone-bearing slash over the scarified seedbed. Additional information is required concerning seed release from slash-borne cones so that the significance of delay between logging and seedbed treatment can be assessed.

The requirement of seedbed preparation immediately suggests the method of prescribed burning, particularly as lodgepole pine is known to reproduce abundantly after wild fire. With burning, however, there is a risk of destroying the slash-borne seed (Bates et al. 1929, Boe 1951). Also, there is some evidence that a burned seedbed without shelter is less favourable for survival of seedlings than a scarified seedbed (Ackerman 1957, Crossley 1956c). Implementation of prescribed burning as a regeneration method in Alberta must be preceded by further investigations.

Neither lopping and scattering nor removal of the slash were effective as regeneration methods in this experiment. Any effect of these treatments either on seed supply or on environment was obscured by the influence of an unfavourable seedbed. If seedbed treatment is not employed, then slash disposal is mainly a question of reducing the fire hazard; the method of disposal is a matter of cost.

This experiment did not determine, by regeneration response, the relative contributions of the slash-borne cones and the adjacent stands to the total seed supply. Nevertheless the very light seedfall measured by the seedtraps and the pattern of germination after treatment strongly suggest that the major fsource of seed was the slash-borne cones. If this observation is substantiated by uture trials, the size and shape of clear cut areas can be dictated by considerations other than seed supply from the adjacent stands.

REFERENCES

ANON. 1950. Preliminary data on natural reseeding in lodgepole pine clear cutting on the Lewis and Clarke National Forests. Northern Rocky Mountain Forest and Range Experiment Station, Missoula, Montana. Res. Hi-lites, Vol. 2, No. 3.

ACKERMAN, R. F. 1957. The effect of various seedbed treatments on the germination and survival of white spruce and lodgepole pine seedlings. Canada, Dept. Northern Affairs and National Resources, Forestry Branch. For. Res. Div., Tech. Note No. 63.

BATES, R. C., C. A. HUBER and T. KREUGER, 1929. Experiments in the silvicultural control of natural reproduction of lodgepole pine in the Central Rocky Mountains. Jour. Agric. Res., Vol. 38, No. 4.

BLYTH, A. W. 1957. The effect of partial cutting in even-aged lodgepole pine stands. Canada, Dept. Northern Affairs and National Resources, Forestry Branch. For. Res. Div., Technical Note No. 61.

BOE, K. N. 1951. Natural regeneration of lodgepole pine on seedbeds created by clear cutting and slash disposal. Northern Rocky Mountain Forest and Range Experiment Station. Res. Note 99.

CANDY, R. H. 1951. Reproduction on cut-over and burned-over land in Canada. Canada, Dept. Resources and Development, Forestry Branch. For. Res. Div., Silv. Res. Note No. 92.

CROSSLEY, D. I. 1949. Reproduction of white spruce in a mixed-wood stand following mechanical disturbance of the forest floor. Canada, Dept. Resources and Development, Dom. For. Service. Silv. Res. Note No. 90.

———1952a. Some observations on lodgepole pine regeneration after clear cutting in strips. Canada, Dept. Resources and Development, Forestry Branch. Res. Div., Silv. Leaflet 65.

———1952b. White spruce reproduction resulting from various methods of forest soil scarification. Canada, Dept. Resources and Development, Forestry Branch. For. Div., Silv. Res. Note No. 102.

———1955a. The production and dispersal of lodgepole pine seed. Canada, Dept. Northern Affairs and National Resources, Forestry Branch. For. Res. Div., Tech. Note No. 25.

———1955b. Mechanical scarification to induce white spruce regeneration in old cut-over spruce stands. Canada, Dept. Northern Affairs and National Resources, Forestry Branch. For. Res. Div., Tech Note No. 24.

———1956a. Effect of crown cover and slash density on the release of seed from slash-borne lodgepole pine cones. Canada, Dept. Northern Affairs and National Resources, Forestry Branch. For. Res. Div., Tech. Note No. 41.

———1956b. Fruiting habits of lodgepole pine. Canada, Dept. Northern Affairs and National Resources, Forestry Branch. For. Res. Div., Tech. Note No. 35

———1956c. Mechanical scarification and strip clear cutting to induce lodgepole pine regeneration. Canada, Dept. Northern Affairs and National Resources, Forestry Branch. For. Res. Div. Tech. Note No. 34.

EYRE, F. H. and R. K. LEBARRON. 1944. Management of jack pine stands in the Lake States. U.S.D.A. Tech. Bul. No. 863.

NOAKES, J. W. 1946. Effect of different methods of slash disposal on jack pine reproduction. Canada, Dept. Resources and Development. Dom. For. Service, Silv. Res. Note No. 78.

QUAITE, J. 1956. Survival of white spruce seedlings resulting from scarification in a partially cut mixed-wood stand. Canada, Dept. Northern Affairs and National Resources, Forestry Branch. For. Res. Div., Technical Note No. 44.

ROWE, J. S. 1959. Forest regions of Canada, Can. Dept. of Northern Affairs and National Resources, For. Branch Bul. 123.

APPENDIX

Analysis of Variance: Per Cent Stocking to Spruce and Pine in 1960.

Source	*D.F.*	*S.S.*	*M.S.*	*F.*
Total	15	4704.0		
Treatments	3	3631.8	1210.6	13.55**
Error	12	1072.2	89.4	

T-Tests

Scarified vs. lopped and scattered	31.4**
Scarified vs. slash removed	32.2**
Scarified vs. slash and cones removed	38.8**
Lopped and scattered vs. slash removed	0.7
Lopped and scattered vs. slash and cones removed	7.5
Slash removed vs. slash and free cones removed	6.6

Analysis of Variance: Number per Acre of Spruce and Pine in 1960.

Source	*D.F.*	*S.S.*	*M.S.*	*F.*
Total	15	216,106		
Treatments	3	135,893	45,298	6.78**
Error	12	80,213	6,684	

T-Tests

Scarified vs. lopped and scattered	2,025**
Scarified vs. slash removed	2,110**
Scarified vs. slash and cones removed	2,230**
Lopped and scattered vs. slash removed	85
Lopped and scattered vs. slash and cones removed	205
Slash removed vs. slash and free cones removed	120

** Significant at 1% level.