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MECHANICAL SCARIFICATION TO INDUCE WHITE SPRUCE REGENERATION IN OLD CUT-OVER SPRUCE STANDS

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INTRODUCTION

In Alberta, it is recognized that, in general, old cut-over spruce stands, even where there appears to be an adequate seed source, are not regenerating sufficiently to form potentially merchantable stands (1). Ways and means must therefore be found to correct this situation and this study was initiated to follow up previous leads (3, 4 and 5) which suggested that the desired results might be obtained by the proper treatment of the seed-bed.

Usually, four conditions are necessary before an adequate catch of spruce seedlings can be expected. They are:

1. A major stand disturbance.
2. An adequate seed supply.
3. A receptive seed-bed.
4. A climatically favourable season or seasons.

Of these four conditions, the first and third can be controlled and the second conformed to. The fourth is an Act of God and may result in the failure of the best laid plans.

In the particular phase of the regeneration problem embraced by this investigation, the stand disturbance had already been completed many years ago and was therefore a factor we could not control, other than to further reduce the volume of the residual stand, had such been desired.

Even under receptive seed-bed conditions a heavy seed crop may be of the utmost importance, since it is recognized that the loss of seed to rodents, insects and diseases may be enormous. Squirrels alone can remove almost the entire crop in a year of light seed production, leaving little or nothing for the forest floor.

Previous studies undertaken in this District and in many other areas across Canada strongly suggest that the bare mineral soil can be a most receptive seed-bed, and such a condition can be readily created artificially. Studies previously undertaken by the author (3, 4 and 5) incorporating a variety of methods of scarifying the forest floor to expose the mineral soil, suggest that the more completely the latter is bared and compacted the better the survival of spruce seedlings. Such baring and compacting appeared to be most efficiently obtained through the use of a dozer blade.

The following investigation was therefore initiated in 1950 under a residual stand of white spruce in order to study the regenerating effect of using the dozer blade to expose the mineral soil during a seed year.

EXPERIMENTAL AREA

In selecting an area for this study the following requirements were kept in mind:

(*a*) logging on the area completed at least five years previously, and the regeneration since disturbance inadequate,

(*b*) a light residual stand, but sufficient to provide an adequate seed source,

(*c*) a good site,

(*d*) sufficiently sparse slash and windthrow to permit dozer operation without undue hindrance,

(*e*) an area of at least 10 acres.

The area finally selected was in the valley of the Red Deer River in the Foothills Section of the Boreal Forest Region in Alberta.

The residual spruce on the area was 116 years of age in 1950, and the stand had been logged over in 1909 and again in 1941. The site is flat and is situated on the old flood plain of the Red Deer River. The soil is a rich alluvium and of a sandy loam texture, high in calcium and in places showing pronounced signs of podsolization. The forest floor supported a rank growth of grass, often reaching knee height in the moister locations.

The residual stand was composed primarily of western white spruce (*Picea glauca* (Moench) Voss var. *albertiana* (S. Brown) Sarg.), but in the moister locations, poplar (*Populus tremuloides* Michx and *Populus balsamifera* L.) also entered the association.

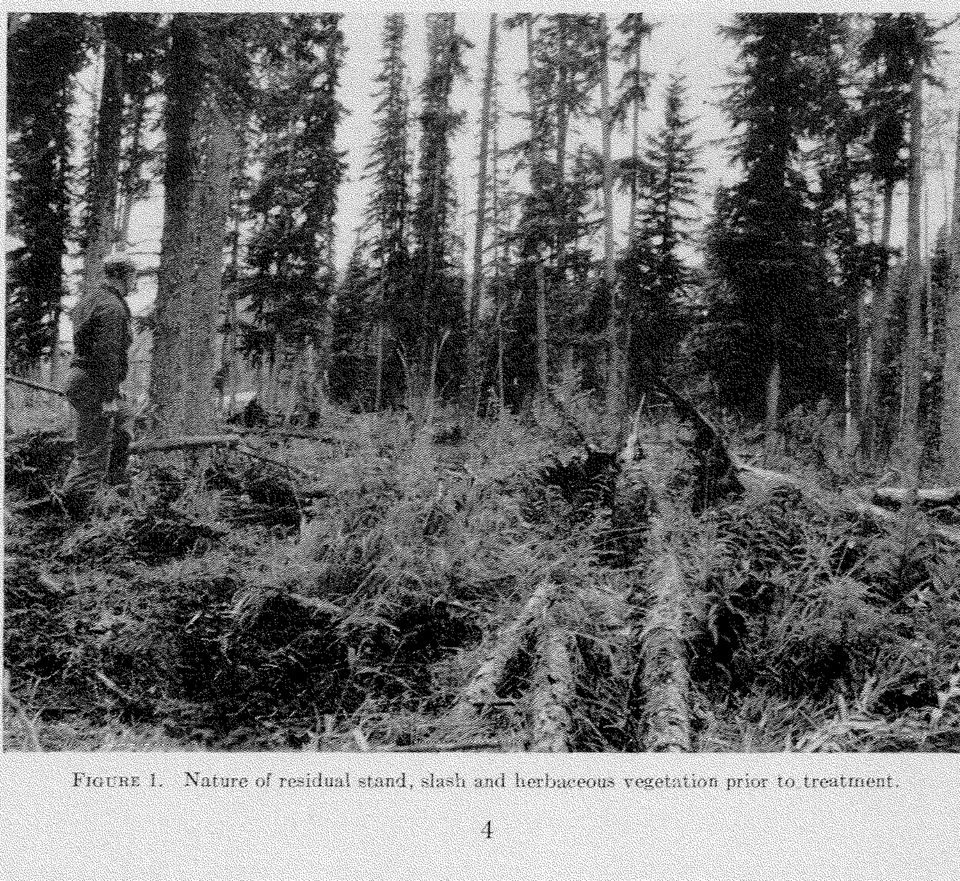

FIGURE 1. Nature of residual stand, slash and herbaceous vegetation prior to treatment.

The average residual stand in 1950, based on a 100 per cent cruise of the area, is presented in Table 1. The residual basal area of 41 square feet per acre suggests that roughly three quarters of the original stand must have been removed in the two cuts.

In order to obtain information on the advance growth prior to scarification, a five per cent sample of the area was taken and the information obtained is here presented.

Table 1. Average Residual Stand and Advance Growth Per Acre, 1950, before Scarification.

Species	Main Stand			Advance Growth	
	No.	Basal Area	Av. Diam.	No.	% Stocking
		sq. ft.	inches		(milacre)
White spruce	91·5	23·9	6·9	448	15
Trembling aspen	40·2	4·5	4·5	177	12
Balsam poplar	45·6	12·2	7·0	204	8
Lodgepole pine	0·3	0·1	7·7		
Mountain alder	14·3	0·3	1·8		
Willow	0·2	0·0	1·0		
Total	192·1	41·0	6·2	829	31

Some of the advance growth regenerated more than 25 years ago following the first disturbance, but grew slowly and remained in a more or less suppressed condition until released by the second logging operation. Some advance growth has appeared following this last disturbance, but taken altogether the numbers are inadequate to produce an acceptable merchantable stand.

STUDY PROCEDURE

Initial procedure

The 13 acres chosen for this study were broken up into one-acre units. Six units or blocks were treated and the other seven were reserved as controls.

Scarification was undertaken during the summer of 1950 with an 18 h.p. Beetle tractor equipped with a dozer blade 50·5 inches in width. It is not intended to suggest that this is ideal equipment for forest floor scarification. It was used because it was available as a piece of research equipment, and because the effect of scarification is very similar no matter what the size or power of the equipment used. No attempt was being made to establish costs of such treatment.

A completely scarified area was not the objective in this investigation, even if that had been possible; rather, the aim was to remove the duff and bare the mineral soil in small patches of one-third to one-half milacre in size, with treated units well distributed and totalling at least 50 per cent of the area. It was felt that such a system would aim at good stocking without too much effort being put into scarification.

FIGURE 2. Beetle tractor on scarification run removing the humus and exposing mineral soil.

FIGURE 3. The scarified unit resulting from the action of the dozer blade. Note the area bared to mineral soil and the rolled sod deposited at the margin.

The tractor operator attempted to work back and forth in parallel lines across the unit being treated. However, because of the presence of residual stand, stumps and slash, it was necessary to deviate considerably from this plan. It was impossible to avoid passing back and forth over the areas already treated; consequently the debris was often redisturbed and redeposited on the units previously scarified. As a result the soil surface of each treated acre could be classified as follows:

(*a*) scarified—where the surface layer had been removed and the mineral soil of the upper part of the soil solum was revealed.

(*b*) disturbed—where loose mineral soil was revealed, in the form of rolled or over-turned sods, or as scattered and unconsolidated mineral material either by itself or mixed with loose humus debris.

(*c*) undisturbed—the untouched forest floor.

Table 2 presents the average results on 300 milacre quadrats (5 per cent tally) at the conclusion of mechanical scarification.

Table 2. Average Scarification Results.

Scarified	*Disturbed*	*Undisturbed*
10%	58%	32%

It will be noted from Table 2 that mineral soil in one form or the other was bared on 68 per cent of the treated area. There is considerable knack in the efficient operation of the Beetle tractor under the conditions which prevailed, and it was not until several of the units had been treated that the operator became proficient. At this time, an average of six hours per acre was required to obtain the desired scarification results*.

After scarification had been completed, 50 circular milacre quadrats were established on each of the 13 acres comprising the experiment. These systematized quadrats were located on strips running at one-chain intervals across each block, thus providing a tally of five per cent, and were designed for the express purpose of tallying future stocking. In addition, the quadrats were utilized during a post-scarification cruise to tally the advance growth that survived the treatment.

Table 3. Advance Growth after Scarification, by Stocked Milacre Quadrats.

weS	*tA*	*bPo*	*Total*
9%	4%	3%	14%

A comparison of the data presented in Tables 1 and 3 provides information on the destruction of advance growth that resulted from the scarification treatment; that is, the spruce stocking had been reduced from 15 to 9 per cent and overall stocking from 31 to 14 per cent.

In order to provide a picture of the actual effect of scarification on the germination and survival capacity of the seed-bed, one-half milacre split-plots

* Clark, Lehrle and Smith (2), studying the cost of scarifying in the Engelmann spruce-alpine fir forests of the interior of British Columbia, reported that it had been done with more suitable equipment for $22.00 per acre (1·6 tractor hours plus 4·5 man hours) and that this figure could quite possibly be reduced by pre-planning, and through the use of modified equipment.

were laid out on the treated units, 4 per block, or 24 in all. Each position was selected arbitrarily in locations where one-half the quadrat was situated on well-scarified soil and the other half on the non-scarified forest floor. Any advance growth was removed from these split-plots in order that the germination capacity would not be reduced by this factor.

Subsequent procedure

Germination, survival, and per cent stocking tallies were undertaken in the autumns of 1951, 1952 and 1954. At the same time, observations were made on the invasion of the scarified areas by vegetation that would compete with the coniferous seedlings attempting to become established.

Fireweed and grass were the principal invaders and Figure 4 illustrates the rank growth one year after scarification.

FIGURE 4. Flora that had invaded the scarified forest floor one year after treatment.

RESULTS

The germination and survival results of white spruce on the split-plots are presented by years of germination in Table 4. While germinates were present in the fourth season (1954), they were only in a cotyledinous state and therefore could not be considered established and are not reported.

Table 4. Per Acre Survival in 1954 of White Spruce Germinates of Successive Years from 1951 to 1953 Based on One-quarter Milacre Split-plots.

Date of germination and years since treatments	Treatment	Germination	% Mortality	Survival	% Stocking
1951 (1)	Scarified	18,600	67·7	6,000	50
	Unscarified	222	100·0	0	0
1952 (2)	Scarified	1,555	29	1,111	27·8
	Unscarified	0	—	—	0
1953 (3)	Scarified	2,000	0	2,000	38·9
	Unscarified	0	—	—	0
1951, 1952, 1953	Scarified	22,155	61	9,111	77·7
	Unscarified	222	100	0	0

A stocking tally on the 650 circular milacre quadrats previously systematically distributed over the complete study area provided the data presented in Table 5.

Table 5. Summary of White Spruce Stocking on the Study Area at the Conclusion of the Fourth Season, by Milacres.

	% Stocking
Treated blocks	61·4
Untreated blocks	45·5

After four seasons of growth, the surviving seedlings generally appear similar to the six right-hand seedlings in Figure 5. The three seedlings on the left were taken from the odd scarified patch where re-invasion of competing vegetation was not rapid, and they serve to illustrate the effect of the competition of the forest flora.

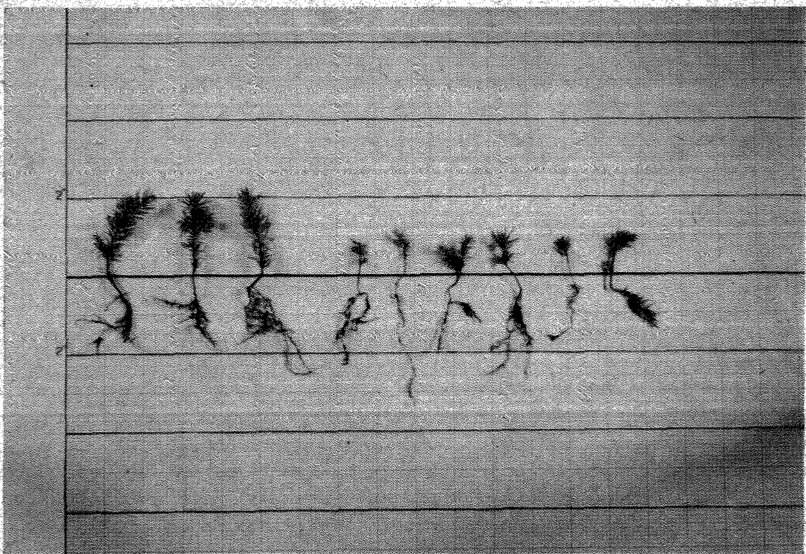

FIGURE 5. Growth of 4-year-old seedlings on scarified soil.

DISCUSSION

The discrepancies in the information presented in Tables 4 and 5 are due to the fact that source data are not strictly comparable. For example, one-half of the split-plots were completely scarified and therefore provided a maximum area of receptive seed-bed. On the other hand, individual milacre quadrats provided a variety of seed-bed conditions from completely scarified to completely unscarified.

The split-plot tally indicates a pronounced difference in seed-bed receptivity and seedling survival between the treated and the untreated forest floor. In addition, the detailed study which they received provides a figure on the number of seedlings per acre resulting from treatment. More than 9,000 surviving seedlings per acre on the treated unit at the conclusion of the fourth year, when compared to no survivors on the untreated counterpart, would appear to justify comparative conclusions. However, similar figures did not result from the much more intensive sampling by milacre quadrats and it would therefore be unwise to accept such extreme differences.

Since the sample of milacre quadrats was so much larger than that of the split-plots, the former provides a much more reliable figure on the comparative stocking between treated and untreated blocks. Since these units were only 68 per cent treated, the subsequent stocking figure of 61·4 per cent can be regarded as satisfactory, particularly when it is recalled that each acre still supports a considerable residual stand of mature timber.

The stocking tally on the unscarified blocks at the conclusion of the fourth year has resulted in an unexpectedly high figure. The per cent stocking during this period has increased from 15 to 45·5 per cent, or an unassisted improvement of 30·5 per cent. During the same time, an increase of from 9 to 61·4 per cent has occurred on the scarified blocks, or an improvement of 52·4 per cent. Such a rate of improvement was, however, obtained at the expense of some of the original advance growth destroyed on the area at the time of scarification and strictly speaking the difference between the final stocking figures of 61·4 per cent and 45·5 per cent more accurately represents the degree of improvement. Perhaps one would not be justified in going to the expense of scarifying to obtain such a small increase in stocking, but the decision to scarify must necessarily be based on the inadequacy of the advance growth at that time.

While no attempt was made to tally the entry of poplar seedlings or suckers on the milacre quadrats, none appeared on the split-plots. Because of the paucity of the latter sample, the evidence is not conclusive, and similar future studies in mixedwood stands should make provision for the detailed collection of such data.

The detailed study on the split-plots has provided some information on the duration of seed-bed receptivity after treatment.

Table 6. Seed-bed Receptivity After Scarification in 1950.

Year of germination	Germination per acre		% stocking in 1954	
	Scarified	Unscarified	Scarified	Unscarified
1951	18,600	222	50	0
1952	1,555	0	28	—
1953	2,000	0	39	—

Owing to the fact that there was a nil supply of seed during the second and third year following scarification, the subsequent appearance of spruce germinates must be attributed to delayed germination from the initial seed crop. From the data supplied in Table 6 it is obvious that the improved seed-bed conditions resulting from scarification persisted for at least another two years. We can therefore conclude that the initial surge of germinates will normally be supplemented during the next two years at least without any increase in seed supply from subsequent cone crops. A further supply would undoubtedly have been beneficial.

It was unfortunate that further seed crops did not materialize in order that it might have been possible to gather data on the rate of decline of seed-bed receptivity.

While many seedlings have regenerated on this study area since the investigation was established, their subsequent growth has been disappointing. Since the site is good, the most natural explanation is to credit such poor results to the effect of vegetative competition. Surprisingly rapid invasion of the scarified areas did occur, and apparently the seedlings originating on such seed-beds were not able to become established with sufficient rapidity to minimize the competitive effects of other vegetation.

Seedling vigour is an important criterion of success and, regardless of adequate stocking, it is important to know if and when the reproduction obtained will dominate the competing vegetation. Previous studies (3, 4 and 5) have not indicated such rapid re-invasion and the seedlings had a chance to become established before competition became severe.

Two causes are suggested to explain this rapid re-invasion. First, because of the high lime nature of the soil in this general area, grass rapidly invades whenever abundant light is permitted access to the forest floor. Second, on a rich alluvial site such as the one on which the investigation was undertaken, the disturbance of the forest floor activates the nitrogen cycle and results in a luxuriant, but temporary, growth of nitrogeneous plants such as fireweed. These, together with the rapidly invading grass, provide immediate and vigorous competition to the coniferous germinates that are attempting to establish themselves.

It is possible that less severe re-invasion might have resulted if a more intensive job of scarification had been undertaken. The use of a toothed brush-piling blade for example, powered by heavier mechanical equipment, would have permitted considerably more disturbance of the forest floor. This would perhaps have delayed or reduced re-invasion for a period sufficient to permit the establishment of a greater percentage of the coniferous germinates, and, what the results of this particular study suggest is more important, would have resulted in better growth. They would therefore be more vigorous and able to compete on more even terms with other vegetation when it did re-invade. It is obvious that considerable thought will have to be given to this question of seedling vigour when considering subsequent studies on spruce regeneration in this area.

SUMMARY

In spite of residual stands of varying intensity, most white spruce cut-overs in the Province of Alberta are not regenerating adequately, and various studies have been inaugurated to find practical methods of correcting this situation. During the summer of 1950, light mechanical equipment was used to scarify the forest floor under an inadequately regenerating residual stand of spruce and poplar. A light white spruce seed supply was available in the

crowns of the residual stand at the time of scarification, but no crops were reported the following two years. Annual tallies were undertaken on the resulting germination, and the results to the autumn of 1954 are summarized below:

1. Scarification with the Beetle tractor required six tractor and man hours per acre. This figure has been substantially reduced by subsequent investigators using mechanical equipment heavier and more powerful, but also more expensive to operate.

2. Baring the mineral soil to coniferous seed fall has resulted in an increase in spruce stocking four years later.

3. In spite of a mixedwood residual stand, there has been little appearance of poplar regeneration following scarification.

4. The growth of spruce germinates during four seasons has been poor. This is undoubtedly due to the prolific and almost immediate invasion of dominating ground vegetation.

5. There is the suggestion that good sites may require different scarification techniques than medium or poor sites. Somehow or other the re-invasion of competing vegetation must be retarded until the coniferous seedlings have had at least a year to become established.

6. For at least three years the scarified seed-bed appeared to remain more receptive to spruce germination than the unscarified control.

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