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SURVIVAL OF WHITE SPRUCE SEEDLINGS RESULTING FROM SCARIFICATION IN A PARTIALLY CUT MIXEDWOOD STAND

by
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Project A.12

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INTRODUCTION

Recent surveys in the mixedwood region of northern Alberta indicate that natural white spruce (*Picea glauca* (Moench) Voss) regeneration is a failure on cut-over and burned-over areas (1, 3). A more recent study on burned-over areas of Alberta showed that the quantity of spruce regeneration may be satisfactory only to a distance of six chains from the seed source (2).

The problem of reproducing the logged-over or burned spruce stands of Alberta was recognized some 30 years ago (5). Early investigators realized that if the moss and duff layer was removed by fire or other means, and providing there was an adequate seed source, good spruce reproduction would result (5, 6). Recently, Blyth (2) found that white spruce seedlings exhibited excellent height growth and healthy foliage on burned-over areas while on cut-over areas seedlings showed little height growth and were anaemic in appearance. It is accepted that moisture is one of the limiting factors influencing spruce reproduction. While spruce germinates rather easily, it has difficulty in surviving because of its short primary root which cannot penetrate through the raw humus layer of the forest floor to the moisture-holding mineral soil. The obvious solution to the problem of obtaining successful white spruce reproduction appeared to be removal of the humus to expose the mineral soil.

A partial cutting experiment was initiated in a 95-year-old white spruce-aspen stand near Smith, Alberta, in 1951. The soil was very representative of the Grey-wooded Soils of the region in that it was derived from a heavy, clay loam till. Litter was negligible. The upper four inches of fluffy, fibrous organic matter was only partially decomposed, while the remaining two inches was compacted and decomposed. On very wet sites the depth of organic matter often exceeded two feet. On dense portions of the stand where spruce made up the bulk of the volume, the ground cover consisted almost entirely of feather mosses and scattered herbs. Where poplar made up a considerable part of the volume, the shrubs such as high bush cranberry, red osier dogwood, and rose were prevalent. The herb layer was composed mainly of aster, aralia and tall grasses. As most of the stand area was made up of a spruce-aspen admixture with accompanying heavy herb and shrub competition, it is obvious that conditions were very unfavourable for germination and survival of white spruce seedlings.

The stand was divided into three equal-sized blocks with each block further divided into eight cutting areas. Each cutting area in a block was subjected to a different cutting method. Cutting methods varied from clear cut to no disturbance with emphasis on leaving various densities of spruce in the residual stand. Eight scarified and eight unscarified quarter-milacre regeneration plots were established within each cutting area. This resulted in a total of 384 regeneration plots, half of them unscarified.

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Scarification was accomplished by rolling back the sod with a shovel or grub hoe, thus exposing the mineral soil. Only the top foot of organic matter was removed from the very wet sites. Each scarified area was about five feet square. A circular, quarter-milacre plot was established in the centre of each scarified area and a quarter-milacre control plot was located within 20 feet of each scarified plot.

As 1951 was an excellent seed year for white spruce, the scarification was carried out in early August of that year. Logging was completed before scarification. The seedlings on each regeneration plot were tallied in September of 1952 and 1954. As practically all the seedlings tallied in 1954 were survivors of the 1952 germinates, only these were used in the analysis.

RESULTS

An analysis of variance was attempted on the 1952 spruce germinates surviving in September, 1954. Tables 1 and 2 in the Appendix indicate that the analysis of variance was based on a split plot design. The eight scarified and the eight control regeneration quadrats within each cutting area were combined to form one scarified and one control plot respectively.

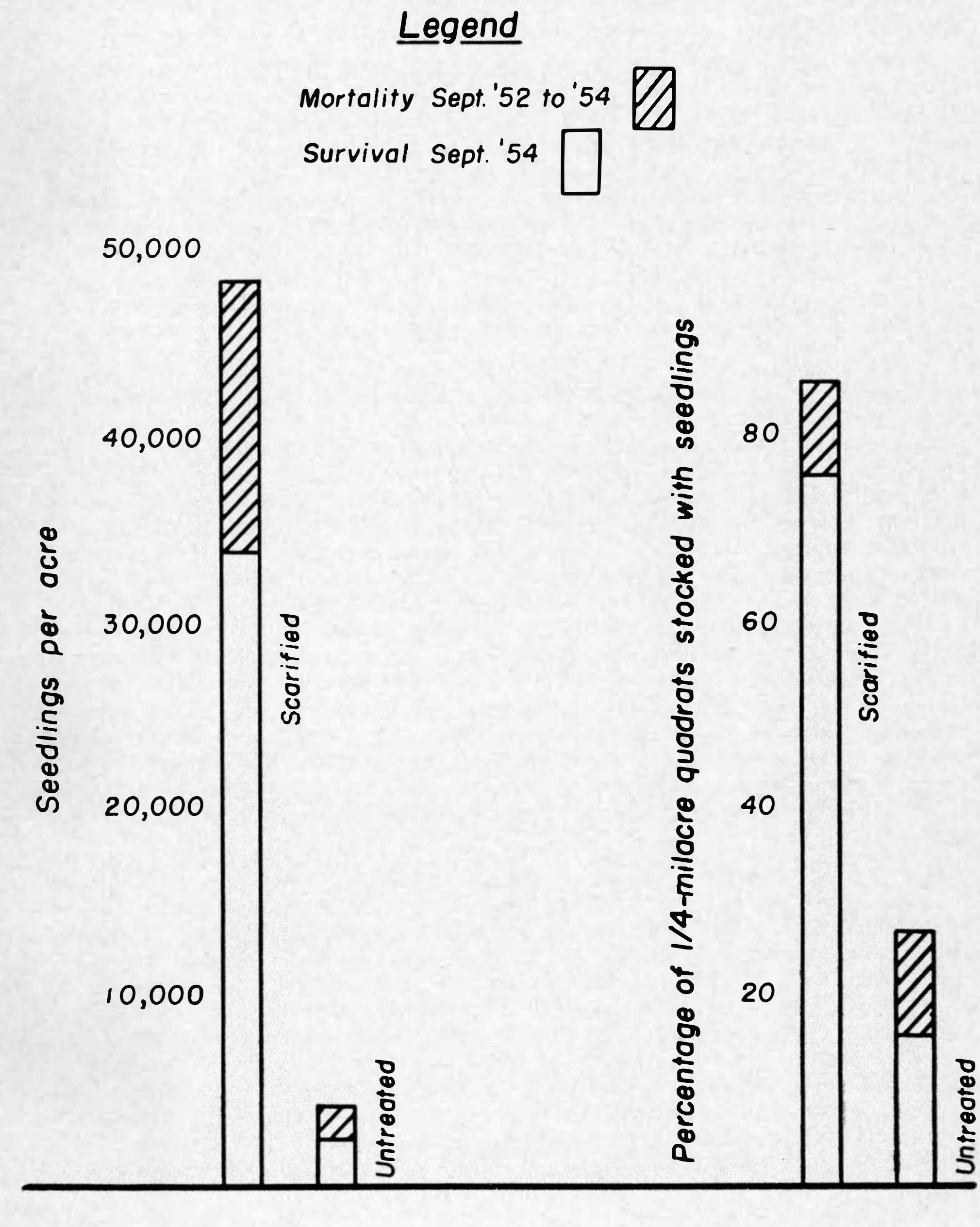
The analysis showed that in terms of number of seedlings or seedling distribution, there was a very significant difference between the scarified and unscarified treatments but no significant difference between blocks or between cutting methods. Figure 1 compares the survival over the two-year period of the white spruce seedlings on scarified and untreated plots. This graph shows that from September 1952 to September 1954, the scarified plots with 48,000 stems per acre and with 86 per cent of the quarter-milacre quadrats stocked with seedlings in 1952 showed a loss of 30 per cent in numbers of seedlings and dropped to 76 per cent on the basis of stocked quadrats. The unscarified plots with only 4,200 seedlings per acre and a stocking figure of 27 per cent in 1952 gave comparative figures of 38 and 16 per cent. Crossley (4) noted that in the subalpine region of Alberta spruce seedling mortality levelled off after three years. Spruce seedling mortality on the scarified plots has not only levelled off but the seedlings are much more vigorous than seedlings of the same age in the subalpine region. Plate 1 shows that seedlings on scarified areas beneath a partially cut stand averaged about six inches in height. This would seem to indicate that these seedlings are well established and that stocking on the scarified plots is more than adequate. On the other hand stocking is a failure on the untreated plots.

It is interesting to note that all the scarified quadrats that did not contain spruce seedlings in 1952 and 1954 were flooded with water. That these flooded quadrats invariably occupied the wetter sites does not necessarily imply that some form of scarification would not be successful on wet sites. However, the method of scarification employed in this experiment did leave deep troughs on the wetter sites. These troughs acted as "catch basins" for the spring run-off with the resultant death by drowning of any seedlings that may have germinated.

DISCUSSION

This experiment gave much more successful results than did a somewhat similar experiment carried out in the mixedwood region of Manitoba (7). Phelps in 1947 used an Athens' disc plough to expose the mineral soil beneath an undisturbed 100-year-old white spruce-aspen stand. His results indicated very heavy mortality on both scarified and unscarified plots. This may be

Fig. I Comparative survival over a two-year period of white spruce on scarified and untreated plots



partially accounted for by the fact that the Athens' disc plough leaves a loosely packed mineral surface with a poor waterholding capacity as opposed to the relatively compact mineral surface left by the sod removal method as used in this experiment. However, the excellent survival in this region of Alberta may probably be attributed most to the wet summers of 1952, 1953, and 1954.

Investigators continue to disagree as to what criteria should be used to describe an adequately stocked stand. Standards have varied from 250 to 1,000 established, well-distributed seedlings per acre for full stocking. Sixty per cent stocking is usually considered as adequate. It may be noted that stocking does not necessarily apply to only one species but may consider several species together.

With this in mind it should be pointed out that the mixedwood stands of northern Alberta are rather open with aspen making up the greater proportions of the number of stems, especially when the stand is very young. Regardless of the nature of the disturbance, aspen invariably invades the stand upon disturbance. Again, perpetuation of the mixedwood condition is probably necessary for the maintenance of site quality, and aspen itself is rapidly becoming a species of commercial importance. Considering these factors and that present cutting practices in Alberta's mixedwood stands remove only some 30 to 40 stems per acre, it is believed that 200 to 300 established, well-distributed spruce seedlings per acre would provide at least as great a volume of spruce as can be obtained from present mixed stands.

The general opinion is that providing there is an adequate seed supply, good spruce germination will result from scarification. Some writers interpret the term "adequate seed supply" to mean a heavy seed crop. Crossley (4) initiated a scarification experiment in a clear-cut white spruce stand in the subalpine region of Alberta in 1948. He writes that "only a heavy seed crop will satisfy the enormous demands made by the forest fauna while still leaving sufficient for regeneration purposes". Despite apparent seed-crop failures in northern Alberta since 1951, some 1,300 well-distributed 1- and 2-year-old seedlings per acre were found in September, 1954, on the scarified plots. Again, within eight miles, a similar but much larger scarification project was initiated in 1952. A 10-per-cent check of this area in the autumn of 1955 indicated that 30 per cent of the scarified quarter-milacre quadrats were stocked with one or more vigorous spruce seedlings. It appears that either the forest fauna population was very low on the two experimental areas or that for some unknown reason they did not disturb the seed. In any event, if there are sufficient standing stems, and provided that forest fauna do not disturb the seed, and because scarified areas remain receptive for several years, one may expect scarification to eventually result in adequate spruce reproduction in Alberta's mixedwood stands.

It is not enough to have a sufficient number of seedlings on an area for adequate stocking; the seedlings must also be vigorous enough to become well established. Plates 1 and 2 illustrate some of the growth differences encountered on the experimental area. Plate 1 shows that seedlings are much more vigorous on scarified plots beneath a partially cut stand than those beneath a dense, undisturbed stand. All seedlings were growing on a heavy clay loam. Original total volume was 6,000 cubic feet per acre while the volume removed was approximately 2,000 cubic feet per acre. Seedlings on untreated plots beneath a partially cut stand showed poorer growth than those on scarified plots beneath the dense, undisturbed stand. Plate 2 indicates that immediately following germination, spruce seedlings develop much more rapidly on the light-textured soils. Seedlings on the right were growing on a sandy loam, those to the left on a heavy clay loam.

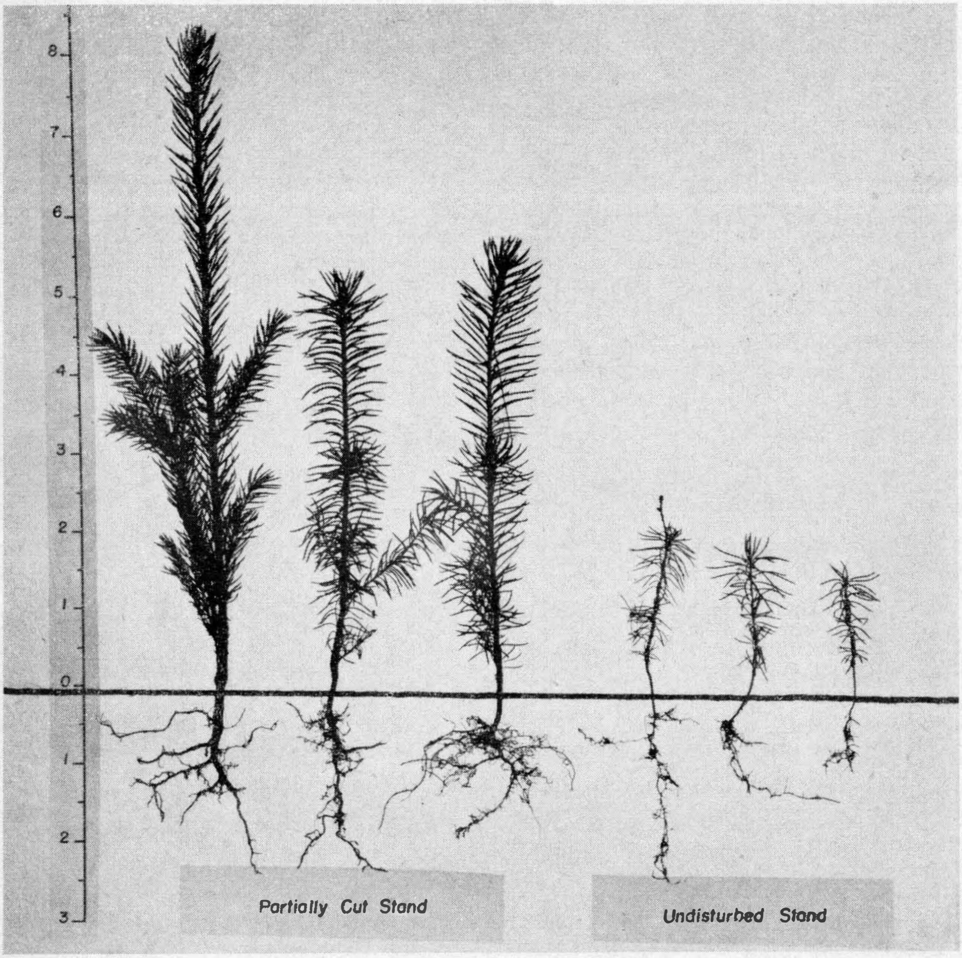


PLATE 1.—Three-year-old white spruce seedlings from scarified plots beneath a mixedwood stand.

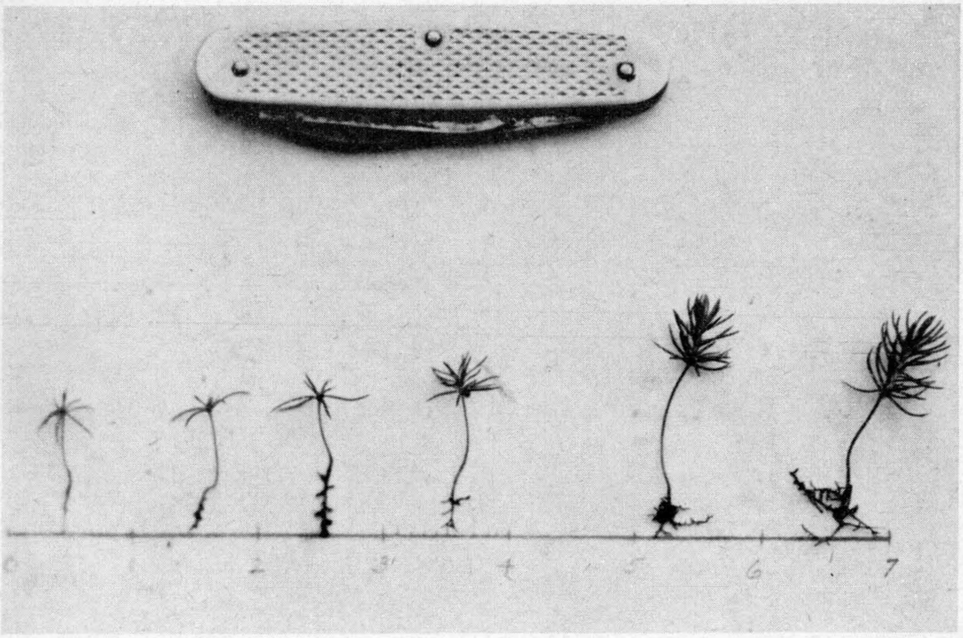


PLATE 2.—Four-year-old white spruce seedlings from scarified plots beneath a partially cut mixedwood stand.

It is suggested that because of the open nature of the majority of the spruce-aspen stands of northern Alberta, they should be scarified before logging. Scarification before logging is not only cheaper than after cutting but the seedlings are protected from the competition of the ground vegetation that moves in following disturbance. The scarification may be carried out several years prior to clear cutting in order to ensure adequate stocking with well-established seedlings. It may be argued that logging will destroy many of the seedlings resulting from scarification prior to logging. This is very doubtful because about 90 per cent of the logging in the mixedwood region is carried out by 'long logging' in the winter. While this method of logging plays havoc with the larger stems, the snow is usually deep enough to protect seedlings that are only a few inches high. If scarification is to be done after logging one must decide whether to log following a heavy seedfall or whether to log when convenient and leave a sufficient number of seed trees to seed in the scarified area.

CONCLUSIONS

Results to date show that in the mixedwood region of Alberta, exposure of the mineral soil creates much more favourable seedbed conditions for both the establishment and subsequent survival of white spruce seedlings. Other conclusions are:

1. Mortality may be considerable during the first year.
2. Seedlings appear to be well established after three years.
3. Open stands and light-textured soils seem to provide the optimum seedling growth on scarified areas.
4. Scarification may not be successful on the very wet sites.
5. Scarified areas remain receptive for several years.
6. Providing there are a sufficient number of standing stems on an area, good seed years do not appear to be necessary in order to obtain satisfactory results.

To summarize, it would appear that it is quite feasible to obtain successful natural regeneration by scarification in the mixedwood region of Alberta. Future experiments should be designed to develop an economical means of securing satisfactory scarification. This would entail operational studies on the questions of when to scarify and what type of mechanical equipment will give the desired results at the least cost.

The mixedwood forest type is extensive and white spruce is the most important saw timber species in Alberta. White spruce reserves are rapidly being depleted and unless some satisfactory method of securing adequate regeneration is found, the white spruce saw timber industry will soon become a thing of the past. It is felt that scarification may be the answer in the mixedwood forest region of Alberta.

APPENDIX

TABLE 1.—ANALYSIS OF VARIANCE FOR NUMBER OF SPRUCE SEEDLINGS SURVIVING IN SEPTEMBER, 1954

Source of Variation	*Degrees of Freedom*	*Sum of Squares*	*Mean Square*	*F*
Main Plots				
Blocks	2	998	499	1.05
Cutting Methods	7	3,410	487	1.03
Error Term	14	6,643	474	
Subplots				
Treatments	1	51,091	51,091	98.06
Treatments × Cutting Methods	7	5,178	740	1.42
Error Term	16	8,340	521	
Total	47	75,660		

TABLE 2.—ANALYSIS OF VARIANCE FOR PERCENTAGE* OF QUADRATS STOCKED WITH SPRUCE SEEDLINGS IN SEPTEMBER, 1954

Source of Variation	*Degrees of Freedom*	*Sum of Squares*	*Mean Square*	*F*
Main Plots				
Blocks	2	826	413	2.27
Cutting Methods	7	313	45	.25
Error Term	14	2,552	182	
Subplots				
Treatments	1	23,235	23,235	131.27
Treatments × Cutting Methods	7	2,588	370	2.09
Error Term	16	2,829	177	
Total	47	32,343		

* Percentages were transferred into angles.

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