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Province of British Columbia

Ministry of Forests

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ABSTRACT

The first five years' progress of six cut-over lodgepole pine areas that were drag scarified in 1972 and 1973 is reported. Each area was examined for seedbed, seed source and the resultant fourth year regeneration. The degree of disturbance, cone supply and the age of slash were found to be the most important silvicultural factors influencing the success of scarification. Given an adequate cone supply and fresh logging slash, 60% distribution of mineral soil plus disturbed seedbed was found to produce a satisfactory stocking level of 50% on a milacre basis. If scarification is delayed until after the summer heat, an additional 20 to 25% disturbance would be required to produce similar stocking levels. Factors influencing the cost of scarification are also discussed.

DRAG SCARIFICATION TRIALS IN LODGEPOLE PINE LOGGING SLASH IN THE NELSON FOREST DISTRICT OF BRITISH COLUMBIA

When the Nelson Forest District acquired its first chain drag scarifier in late 1971, the current treatment for cut-over areas of lodgepole pine was to either leave them and hope for natural regeneration, or to broadcast burn if the slash appeared to present a hazard. About the same time, doubts were being expressed about the effectiveness of the current practice in producing satisfactorily naturally restocked areas. It was hoped that the drag scarifier would be a valid silvicultural alternative to the usual treatment.

This research note is an account of the progress of the first six locations to be drag scarified in the Nelson Forest District during 1972 and early 1973.

AIMS

The primary aim of this project was to test the effectiveness of the chain drag scarifier in inducing natural regeneration of lodgepole pine.

A secondary aim was to examine the relationships between the nature of the clearcut and the effectiveness of the scarifier.

LOCATIONS

Each location scarified (Table I) was selected by District Silvicultural staff and by Ranger staff. Before treatment, a portion of the area (usually about two hectares) was selected and marked as a control. The selection of the control was often tempered by considerations of efficient machine operation. In all cases, the control is considered to be satisfactorily representative of the treated areas.

SURVEYS

1. Seedbed

The seedbed surveys (Table 2) were carried out using the procedures described by Decie and Fraser (1960) although the criteria for the seedbed classifications were different.

Percentage distribution of seedbed was determined using about 200 milacre plots (100 in controls) distributed at predetermined intervals through the treated area. In each plot, seedbed was tallied in the order: Mineral, Disturbed, Rotten Wood, Undisturbed and No Seedbed, with at least one square foot of a seedbed being required before a plot could be tallied to that seedbed. Thus a plot would be tallied as "disturbed" if it contained less than one square foot of mineral soil, but more than one square foot of disturbed. It would be immaterial how much of the other seedbeds were present.

Table 1

Locations Scarified

LOCATION	PRIME MOVER	AREA (ha)	COST* ($/ha)
Wuho Creek	D8	13.8	52.8
Elk Creek	D8	24.4	70.3
Goathide Creek	D8**	21.0	100.2
Kettle River - A	JD440	18.8	22.8
- B	TJ404	19.2	34.4
- C	D7	19.2	58.8
- D	D6	4.8	71.3
Beaverfoot River	TD24	28.0	52.0***
White River	D8	14.0	75.0***

* Scarification Cost only, excludes fireguards, repairs, transportation, etc., these costs range from 69% (Elk Creek) to 93% (Goathide Creek) of the total cost per hectare.

** Many small areas combined.

*** Estimated costs, they are probably "all found".

NB Mention of Trade names is for identification purposes only; it should not be construed as an endorsement.

The basic scarifier consists of four chains attached behind two triangular boats (two chains per boat). Each boat (with chains) can be used independently as at Kettle River, or combined behind a third larger boat to make a four chain drag as was used at the remaining areas.

Table 2 Percentage Distribution of Seedbed

LOCATION	SCARIFIED					CONTROL				
	Min.	Dis.	R.W.	UnD.	Nil	Min.	Dis.	R.W.	UnD.	Nil
Wuho Creek - light, old slash	71.7	13.3	0	15.0	0	25.9	21.6	1.9	50.6	0
- heavy, old slash	60.6	26.8	0	12.6	0	9.9	23.4	0.7	66.0	0
- heavy, fresh slash	64.5	20.6	0	14.6	0					
Elk Creek	44.9	29.5	5.1	15.9	4.3	0	0	0	99.1	0.9
Goathide Creek	67.0	13.5	0	18.4	0.8	22.1	8.0	0	69.7	0
Kettle River - A	38.8	21.2	11.1	26.8	1.8	14.2	17.4	12.6	55.5	0
- B	58.8	28.8	3.3	5.2	3.3					
- C	53.8	16.6	2.5	25.6	0					
- D	49.6	22.8	5.3	22.1	0					
Beaverfoot River	47.8	22.6	0	26.8	2.6	6.5	6.5	0.6	78.2	7.8
White River	41.7	29.8	4.6	12.9	11.6	10.8	13.5	13.5	48.6	13.5

The different seedbeds are as follows:

a. Mineral--areas from which the duff layers have been removed either by scarification or during the course of logging.

b. Disturbed--areas where the duff layers have been broken up. Mineral soil may be visible, but in minor qualities; often includes a mixing with mineral soil to a greater or lesser extent.

c. Rotten Wood--well decayed and flattened - usually sparse in pine stands.

d. Undisturbed--the duff layer is essentially unaltered. Equipment tracks may be visible, but the surface is unbroken. No mineral soil is visible.

e. No Seedbed--Rocks, open water, logs, stumps and slash piles too deep for seedlings to emerge through.

The only permanent markers used in all surveys were the start of each survey line. No plot centres were marked.

2. Cone Supply

In every fourth milacre plot, a one-square-foot plot was marked at the start of the plot along the line of travel. The number of cones in this plot were counted. Only old fully open cones were ignored.

3. Seed Quality

The two cones closest to each milacre plot centre were collected at Wuho Creek. These cones were stratified by degree of weathering, extracted and the resulting seeds germinated (Table 4).

4. Regeneration

Up to three regeneration surveys were made using milacre plots at the same spacing as the seedbed survey (Table 5). With one exception, regeneration surveys did not start until the third year after scarification. An arbitrary three, one-year seedlings or one, two-year seedling were regarded as satisfactory stocking for one plot. Many "stocked" plots were in fact "overstocked".

FACTORS INFLUENCING THE EFFECTIVENESS OF SCARIFICATION

Most factors are inter-related to a considerable extent. For the sake of simplicity however, they will be discussed separately.

Table 3

Cone Distribution

LOCATION	NUMBER OF CONES PER m^2 Scarified	Control
Wuho Creek		
Light, old slash	17	53
Heavy, old slash	36	24
Heavy, green slash	13	
Elk Creek	12	21
Goathide Creek	11	18
Kettle River - A	22	32
- B	19	
- C	25	
- D	9	
Beaverfoot River	22	44
White River	21	14

Table 4

Cone and Seed Quality (Wuho Creek)

Degree of Weathering	No. of Seeds	Germination Percent	No. of Viable Seeds	No. of Cones	Viable Seeds Per Cone
0-25%	2,522	66.0	1,664.5	218	7.6
25-50%	1,190	66.8	794.9	104	7.6
50-100%	6,568	56.4	3,704.4	1090	3.4
TOTAL	10,280		6,163.8	1412	4.4

Table 5

Regeneration Surveys

Area	Date Logged (approx.)	Date Scarified	Regeneration Survey (fall) Percent stocked (by milacre) 1975	1976	1977
Wuho Creek		6-72			
Light, old slash	7-71		46	46	
Light, fresh slash[c]	10-71		41*	nil**	
Heavy, old slash	7-71		45	57	
Heavy, fresh slash	10-71		64	74	
Heavy, old slash[c]	9-70		30	36	
Elk Creek	1-71	7-72	14	16	
Control				6	
Goathide Creek	2-72	8-72	60		
Control			12		
Kettle River	4-72	9-72			
A			22	13	30
B			29	36	63
C			23	21	40
D			14	6	26
Control			13	14	30
Beaverfoot River	11-72	6-73		26	51
Control				15	11
White River	10-72	7-73	63	55	
Control			10	10	

* 41% is lodgepole pine, with all species is 70%
** destroyed by slashburn escape.
c control

1. Cone and Seed Supply

Scarification reduced the number of cones present from a weighted average of 31.1 cones per m^2 on all control areas to 17.2 cones per m^2 on the treated areas. Distribution was irregular, with up to 37 cones being recorded on one square-foot plot. The overall distribution of cones was not drastically altered by scarification, with an average of 71 percent of the control plots containing one or more cones and 66 percent of the scarified plots containing one or more cones.

Only on area D at Kettle River, is it felt that the cone supply may have been limiting. There, the cone count (9 per m^2) was the minimum suggested by Clark (1971) as being necessary for successful restocking. The cone distribution percent was less than 50% (48.5%). Theoretical calculations suggest that this should still have been adequate for restocking. This does not appear to be the case. The second lowest cone count (11 per m^2, 55% cone distribution) at Goathide Creek, was obviously not limiting to regeneration.

Cones were collected only at Wuho Creek, and the seeds were extracted and tested. The number of viable seeds per cone (Table 4) is low compared with the average of 24 seeds per cone with 80% viability reported by Clark (1974). Of interest is the relatively uniform germination capacity of the seeds from different aged cones (as assessed by the degree of weathering). The lower yield from the older cones is possibly a result of misjudging their serotiny. It is possible that some of them had previously opened, especially as some cones will open at lower temperatures than originally reported (Perry and Lotan 1977).

All the areas scarified were believed to have a high degree of cone serotiny. This factor was not formally monitored, but all the locations were in areas where a generally closed cone habit predominates.

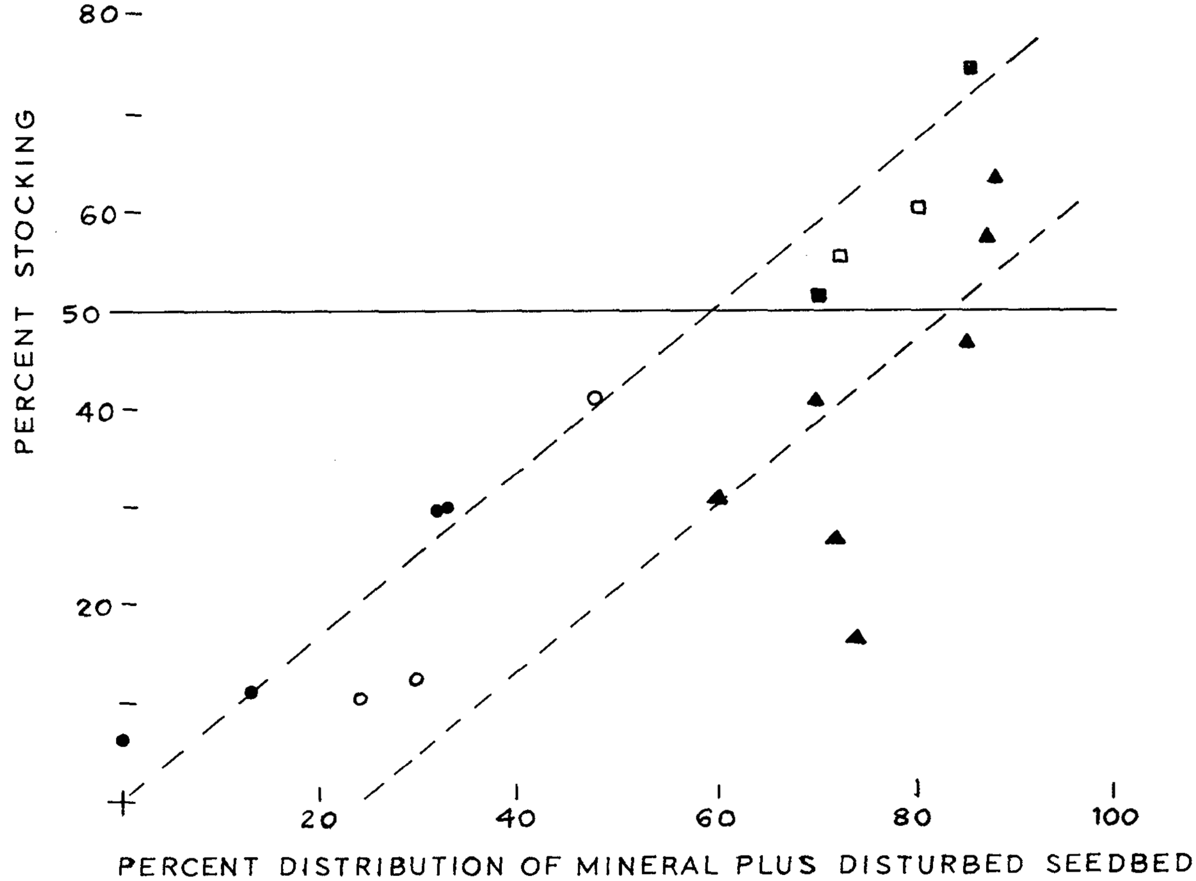
If the lowest cone count from Table 3 and the average seed count from Table 4 are used a figure of 396,000 viable seeds per hectare is obtained. It is felt that this should be adequate to produce 1,200 seedlings per hectare. This would be a ratio of 330 viable seeds to 1 established seedling.

2. Age of Slash and Season of Scarification

A temperature of 45 to 55°C was originally reported as being required to break the resin bond of serotinous cones before the seed can be released (Clements 1910). This temperature can be achieved near ground level with air temperatures of at least 27°C (Crossley 1956). Thus slash that has not been through the heat of summer before it is scarified has a larger quantity of seed available for regeneration. The older slash has already released some seed that is probably buried by the scarification. Two areas at Wuho Creek and four areas at Kettle River had been through the heat of summer and thus had probably lost a portion of their available seeds. This is reflected in considerably lower stocking levels when compared with other areas of comparable disturbance. Of these areas, the area at Wuho Creek that exceeded 50% stocking had double the cone count of its less successful neighbour. This area also had heavier slash. It is quite possible

FIGURE 1

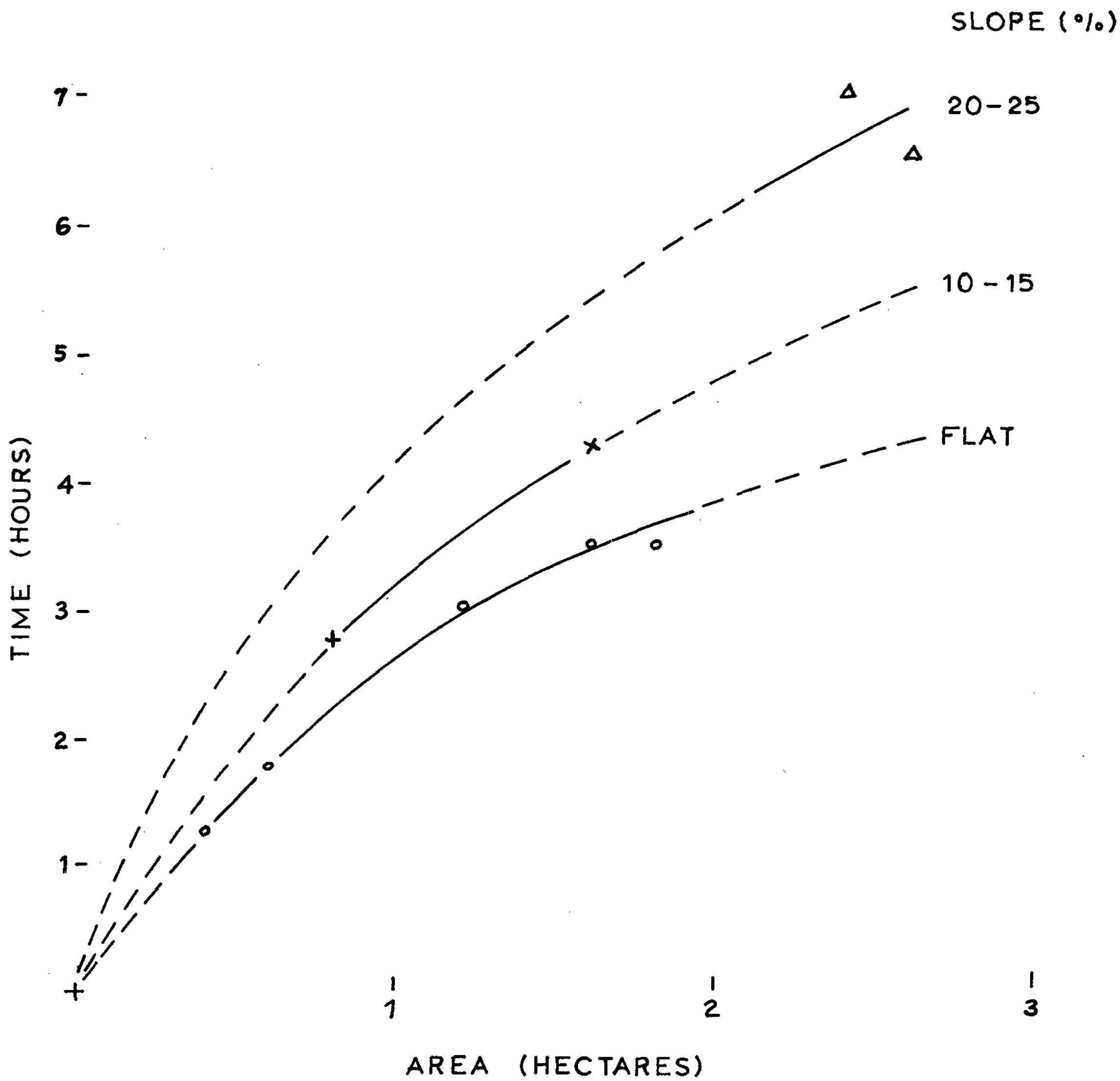
EFFECT OF DISTURBANCE ON STOCKING



Stocking	3rd year	4th year
Control Areas	○	●
Fresh Slash	□	■
Old Slash	△	▲

FIGURE 2

VARIATION OF TIME WITH AREA AND SLOPE



GOATHIDE CREEK
1972

that scarification lowered the level of the slash such that more cones were exposed to the temperature required to open the cones. More seeds would thus become available. At Kettle River, only one of the four areas exceeded 50% stocking; this one area had a greater degree of disturbance than its neighbours: both the cone count and the slash loading at Kettle River were very uniform, with the exception of area D. At Elk Creek, over a year had elapsed between logging and scarification; this is reflected in the low stocking level at that location. The absence of suitable seedbed hindered regeneration of the control in spite of a more than adequate cone supply.

3. Degree of Disturbance

Lodgepole Pine regeneration was growing primarily on areas of mineral soil or on areas where mineral soil and duff had been mixed ("Disturbed"). Figure 1 shows the strong dependence of stocking on the degree of disturbance as measured by the percentage distribution of mineral soil plus disturbed seedbed, once the basic difference between "fresh" and "old" slash is recognized.

For the purposes of Figure 1, all control areas were regarded as "fresh" since no disturbance occurred after logging.

Figure 1 shows that failure to scarify promptly after logging can result in a reduction of the potential stocking level after four years of about 20%, for a given degree of disturbance. In fresh slash, with an adequate cone supply, about 60% distribution of mineral soil plus disturbed seedbed is required to achieve 50% stocking (on a milacre basis) or 1,200 stems per hectare after four years. This is the current minimum acceptable administrative stocking standard for lodgepole pine in British Columbia (B.C.F.S. n.d.). To achieve a similar stocking level of lodgepole pine in slash that has been through a summer before scarification, the disturbance percentage must be raised to about 80 to 85%.

4. Season of Logging

The likely results of logging in the snow free season are lower stumps and a greater degree of disturbance, the former permitting easier machine movement, the latter possibly making scarification unnecessary, if topography is such that a skid trail system is unnecessary.

The aim of scarification in these projects was to produce 100% coverage by the drag. This is reflected in the relatively small range of the final disturbance, when compared with the quite large range of disturbance in the control area. Thus the major influence of initial degree of disturbance would be to determine whether or not scarification was required.

FACTORS INFLUENCING THE COST OF SCARIFICATION

1. Slash Loading

Heavy slash requires a larger machine to pull the drag scarifier. At the two areas dragged by wheeled skidders at Kettle River, the slash loading was of little impediment to the prime movers. In spite of the fact that the skidders were pulling only two chains, and thus required double the number of trips to produce 100% coverage, the cost of these operations was low compared to areas where the slash required a larger prime mover such as Wuho Creek or Beaverfoot River.

2. Leave Trees

Block C at Kettle River was relatively heavily stocked with leave trees. It was felt[1] that without the leave trees, the full scarifier combination (4 chains) could have been used, halving the number of trips required and thus reducing the cost considerably.

3. Topography

Steep terrain is a major influence on the cost of scarification due to both the requirement for a larger prime mover to combat the steep slopes and to the increased time spent manoeuvering on slopes. Figure 2 summarizes the experience at Goathide Creek where a variety of slopes were experienced. It is felt that 20 to 25% slopes are the maximum that should be tackled, and then only under exceptional circumstances. The operator at Goathide Creek found that the only way he could get effective scarification on the steeper pitches was to scarify downhill. The uphill leg was effectively wasted.

The relatively high cost at White River can be similarily attributed to short steep pitches within the scarification area.

4. Area Size

Figure 2 also shows that in areas smaller than about 4 hectares, the machine spends too much time manoeuvering and too little time actually scarifying. This was a considerable contribution to the cost of scarification at Goathide Creek.

5. Stumps

High stumps from winter logging were a contributor to the high cost at Elk Creek. Similarly at Kettle River, although not too high for the other prime movers used, the stumps were too high for a D6; again producing disproportionately high costs.

DISCUSSION AND CONCLUSIONS

Within the limitations of the above-mentioned influences on both the silvicultural effectiveness and the cost of drag scarification, the two most important factors to consider are the time lapse between logging and scarification and the degree of disturbance achieved by scarification. On the basis of the data assembled in this project, the effects of these two factors

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1. Pistak, W.O. 1972, Pers. comm.

appear to be independent of site! The locations monitored are widely separated geographically, representing four sub-zones in two biogeoclimatic zones (Utzig 1977); and soils range from coarse textured outwash materials to silty loams. About the only unifying features are the generally flat to undulating topography of the majority of the areas, and the fact that lodgepole pine is one of the more appropriate species for all the locations. These overall differences appear to have had little influence on the trends of the results shown in Figure 1.

The stocking levels used are the regeneration plot data from four years after the first regeneration is estimated to have occurred. These are NOT the final stocking levels. Regeneration is continuing as evidenced by new germinants found at each regeneration survey. Smithers (1961) reported that 70 percent of the regeneration occurs in the first five years, with a further 21 percent in the next five years. As a result, many of the areas presently called "satisfactorily stocked" will become over-stocked for optimum growth. In fact, due to the irregular distribution, some are already in that situation. It should be remembered that the 50% stocking level used is a minimum administratively acceptable level. Quite possibly, those areas that are presently marginally or even submarginally acceptable will eventually be close to optimally stocked. Only time will prove that. An arbitrary termination of this project was required in order that the results reported would be still meaningful.

Because of the continuing nature of lodgepole pine regeneration one should be cautious of premature condemnation of apparently unsuccessful scarification projects. Firstly, there is often a delay of several years before regeneration occurs, the precise cause being unknown. Delayed seed release and a form of seed dormancy may both be involved. Secondly, regeneration in lodgepole pine is a process that continues for up to 15 years.

Thus, after five years, we can say that drag scarification is a valid silvicultural technique to achieve administratively acceptable stocking levels in lodgepole pine, provided the seed source is adequate and scarification is prompt. Knowledge of the ultimate stocking of these areas will not be available for another 10 years, by which time juvenile spacing will probably be required in many of the areas. Since most of the areas treated are topographically appropriate, machine spacing should be quite feasible.

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