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An Evaluation of Scarification and Direct Seeding in Alberta

by H. J. Johnson

NORTHERN FOREST RESEARCH CENTRE
EDMONTON, ALBERTA
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A. INTRODUCTION

In 1970 the Canadian Forestry Service, with the support of the Alberta Department of Lands and Forests, initiated an evaluation of the provincial reforestation program. Reforestation by the Alberta Forest Service had been done on an operational scale for ten years and it was important to know the effectiveness of the program both from forest management and research points of view. Forest managers needed to know the success of the new program in terms of stocking and survival. Researchers required the same basic information to determine the direction and scope of regional reforestation research.

The evaluation was done in two phases. Phase one consisted of surveys of planted bare-root and container stock. This work was part of a larger evaluation which included reforestation programs in Saskatchewan and Manitoba (Froning 1972). Phase two consisted of an asssessment of approximately 100,000 acres of scarification and seeding in Alberta. Direct seeding programs in Manitoba and Saskatchewan have been relatively small and so were not included in this evaluation.

This report concerns phase two; the evaluation of the Alberta Department of Lands and Forests scarification and hand seeding program. Primarily the survey was designed to answer one basic question. Has the

program been successful as a method of reforesting cut-over and burned forest lands and in converting large tracts of poplar to mixedwood stands? The evaluation was not designed to determine or rate factors responsible for failure. Most frequently isolation of the precise reason for failure was impossible. However, it became evident that a few controllable factors probably accounted for many of the failures and these are discussed later in the report.

The Department of Lands and Forests is to be commended on their forthright approach to the evaluation. All information was made freely available and every support was extended to the Canadian Forestry Service including the provision of student assistance.

B. METHODS

Sampling methods were discussed thoroughly with officers of the Alberta Department of Lands and Forests prior to field surveys which commenced in the spring of 1972. Sequential sampling was selected as an efficient method which would provide stocking estimates within defined limits of error.

Table 1 shows the acreage of scarification and hand, spot seeding inspected in each Forest during the summer of 1972 (approximately five per cent scarified without subsequent seeding). This is about one-half of the estimated total acreage of scarification and seeding done by the Alberta Forest Service to 1971 (Hellum 1973). The reasons for the less than total coverage are as follows:

1. Treated areas less than three years of age were not examined as little significance could be attached to stocking figures from recent treatments.

2. Logistically it was impossible to supply stocking estimates for blocks smaller than 200 acres in size. Also, it was agreed that a unit of this size was reasonable in terms of the minimum size the Alberta Forest Service would consider for re-treatment of failed areas at the present level of forest management in the province.
3. Projects in the Footner Lake and Peace River Forest Districts were not sampled as scheduled. Sampling will be done in 1973 and a supplementary report will be prepared on the status of scarification and seeding projects in these Forests.

Table 1 Scarification Sampled in 1972

Forest	Evaluated Acreage
Athabasca	2,911
Bow River	1,648
Edson	2,563
Grande Prairie	8,778
Lac La Biche	5,830
Rocky-Clearwater	8,921
Slave Lake	8,034
Whitecourt	4,271
Crowsnest	2,012
	44,968 acres

An even distribution of 50 to 100 milliacre quadrats over a two-hundred acre unit, in accordance with the principles of sequential sampling, provided an estimate of stocking within ± 10% at the 95% level of probability. (See Appendix for description of method.)

Large scarification projects were divided into approximate 200-acre blocks using features such as creeks, roads and seismic lines as boundaries. A separate estimate of stocking was made for each block in the project. For very large projects (in excess of 1,000 acres) 200-acre blocks were delineated and half of these selected at random for sequential sampling. In some cases a number of blocks smaller than 200 acres, but in close proximity, were grouped and an aggregate estimate made. All projects were mapped showing the block divisions and a separate estimate was made of stocking on each.

The objective of the survey was to determine stocking on the entire block and not just the treated or disturbed portion. Therefore, after reconnoitering a project and dividing it into 200-acre blocks, the field crew ensured that the sampling lines crossed the direction of treatment.

For each block, vegetative competition, depth of organic material, soil texture, slash accumulation, aspect and slope were rated; usually on a three or four point subjective scale. (See Appendix for block description sheet.) The amount of mineral soil on each quadrat, expressed as a percentage of quadrat area, was recorded by ten per cent classes.

Forest Service standards (Anon 1971) were used to determine whether or not a quadrat was considered stocked. One three-year-old or two two-year-old seedlings were required to tally a quadrat as stocked.

Trembling aspen and balsam fir seedlings were listed separately as the presence of these species has a bearing on the definition of acceptable stocking as defined by Alberta Department of Lands and Forests (up to 10% stocking of these species accepted). Advance growth (seedlings established before treatment) was also recorded for each quadrat.

Data were transferred to punch cards and compilation and analysis done by computer. Briefly, stocking data were grouped on the basis of Forest, stand disturbance, Forest Region (Rowe 1959), cover-type, and year of treatment. Two-hundred acre blocks were grouped on the basis of forest type, year of seeding and species and correlation coefficients determined for vegetative competition, slash density, mineral soil exposure, soil texture and aspect. An estimate of scarification coverage was obtained for each block from the measurement of mineral soil exposure made for each sample quadrat. A separate analysis was done to determine the percentage of all quadrats in a Forest stocked with poplar.

C. RESULTS AND DISCUSSION

1. Results by Forest

The average percentage stocking, and number and percentage of blocks successfully stocked to Alberta Forest Service standards (40%+) is shown in Table 2.

Table 2 Percentage Stocking by Forest

Forest	Number of 200-acre Blocks Examined	Average Percent Stocking	Number Satisfactorily Stocked	Percent Success
Athabasca	11	16	0	0
Bow River	7	45	2	28
Crowsnest	8	22	0	0
Edson	13	19	1	8
Grande Prairie	36	24	3	8
Lac La Biche	21	20	1	5
Rocky-Clearwater	33	22	2	6
Whitecourt	13	17	1	8
Slave Lake	33	20	1	3

Table 2 shows that the success of the treatment has been very low. The Bow River Forest was the only Forest where a modest degree of success was obtained. In fact results for this Forest are above the average for seeding in Canada (Waldron 1973).

2. Stocking Related to Year of Treatment, Cover-Type and Forest Region

Stocking data were stratified on the basis of year of treatment, cover-type and Forest Regions (Rowe 1959). Table 3 shows the results obtained.

All blocks treated prior to 1966 were unsatisfactorily stocked in 1972. Those treated in 1966, 1967 and 1968 included a small number of successes; 6 per cent, 9 per cent, and 13 per cent respectively. None of the 13 blocks treated in 1969 and examined in 1972 were satisfactorily stocked.

Lodgepole pine cover-types in the Sub-alpine Forest Region were the most successful in terms of stocking. However, results are only available for two treated blocks.

Success on other cover-types and in other Forest Regions was poor with the exception of the lodgepole pine cover-type in Forest Region B19c which was marginally successful at 40 per cent.

This analysis indicates the highest degree of success in the SA1 and B19c Forest Regions on lodgepole pine cover-types.

Table 3 Number and Percentage of 200-acre Blocks Adequately Stocked by Year of Treatment, Cover-type and Forest Section (Rowe)

Cover-type	1960		1961		1962		1963		1964		1965		1966		1967		1968		1969	
	Number	% Success	Number	% Success	Number	% Success	Number	% Success	Number	% Success	Number	% Success	Number	% Success	Number	% Success	Number	% Success	Number	% Success
Forest Region SA1 (% Blocks 40% + Stocking																				
White Spruce									1	0									1	0
Lodgepole Pine															2	100				
Poplar					2	0														
Mixed									1	0	1	0					2	0		
Forest Region B18a																				
White Spruce																				
Lodgepole Pine															13	8	5	0		
Poplar															7	0	8	0	2	0
Mixed									2	0	3	0	3	0	3	0	8	25	7	0
White Spruce																				
Lodgepole Pine															2	0	2	0		
Poplar					7	0	2	0	2	0			6	0	22	9				
Mixed	1	0	3	0	1	0	9	0			6	0	7	14	15	7			3	0
Forest Region B19c																				
White Spruce																				
Lodgepole Pine											4	0			1	0	5	40		
Poplar											4	0								
Mixed									2	0										
	1	0	3	0	10	0	11	0	8	0	18	0	16	1	65	6	30	4	13	0
		0%		0%		0%		0%		0%		0%		6%		9%		13%		0%

3. Stocking Related to Stand Disturbance

Table 4 shows success related to type of stand disturbance. Appraised blocks were disturbed in one of the following ways prior to scarification and seeding.

1) Logged
2) Burned
3) Aspen conversion (strips were bulldozed in aspen stands at regular intervals)

Table 4 indicates that the greatest success can be expected on logged areas, particularly in the Bow and Rocky-Clearwater Forests. On both Forests 29 per cent success was achieved. Treatments of Aspen Conversion and burned areas were an unqualified failure. One project of 48 sampled was satisfactorily stocked on Aspen Conversion blocks examined. On burned areas two of 58 were successful.

Table 4 Success by Forest and Type of Disturbance

Stand Disturbance	Forest	No. Blocks Examined	Number Satisfactorily Stocked (40%+)	Percent Satisfactorily Stocked (40%+)
Logged	Athabasca	2	0	0
	Bow River	7	2	29
	Crowsnest	6	0	0
	Edson	1	0	0
	Grande Prairie	9	1	11
	Lac La Biche	8	1	13
	Rocky-Clearwater	7	2	29
	Slave Lake	23	2	4
	Whitecourt	13	1	8
Aspen Conversion	Athabasca	2	0	0
	Crowsnest	2	0	0
	Edson	12	1	8
	Rocky-Clearwater	24	0	0
	Slave Lake	3	0	0
Burned	Athabasca	7	0	0
	Grande Prairie	27	2	7
	Lac La Biche	13	0	0
	Rocky-Clearwater	2	0	0
	Slave Lake	7	0	0
	Whitecourt	2	0	0

4. Success Related to Scarification Coverage

Table 5 presents the average percent stocking per 200-acre block by Forest and the average percent disturbance by scarification.

Table 5 Relationship Between Stocking and Amount of Mineral Soil Exposed by Scarification

Forest	No. 200-Acre Blocks Examined	Species Seeded	Average % Stocking	Average % Exposure of Mineral Soil
Athabasca	11	White Spruce	16	12
Bow River	7	Lodgepole Pine & White Spruce	45	23
Crowsnest	8	Lodgepole Pine & White Spruce	22	24
Edson	13	Mainly White Spruce	19	9
Grande Priaire	36	White Spruce & Lodgepole Pine	24	13
Lac La Biche	20	White Spruce	20	8
Rocky-Clearwater	33	Mainly White Spruce	22	14
Slave Lake	33	Mainly White Spruce	17	23
Whitecourt	13	White Spruce	20	11

There was no correlation between percentage stocking and average scarification coverage as indicated in Table 5. It will be noted that average coverage is low for most Forests.

Distribution of scarification on the blocks (the percentage of quadrats with more than one per cent mineral soil exposure) was related to total coverage of scarification and the trend is shown in Fig. 1. It will be noted that fairly low total coverage resulted in adequate distribution (40%+).

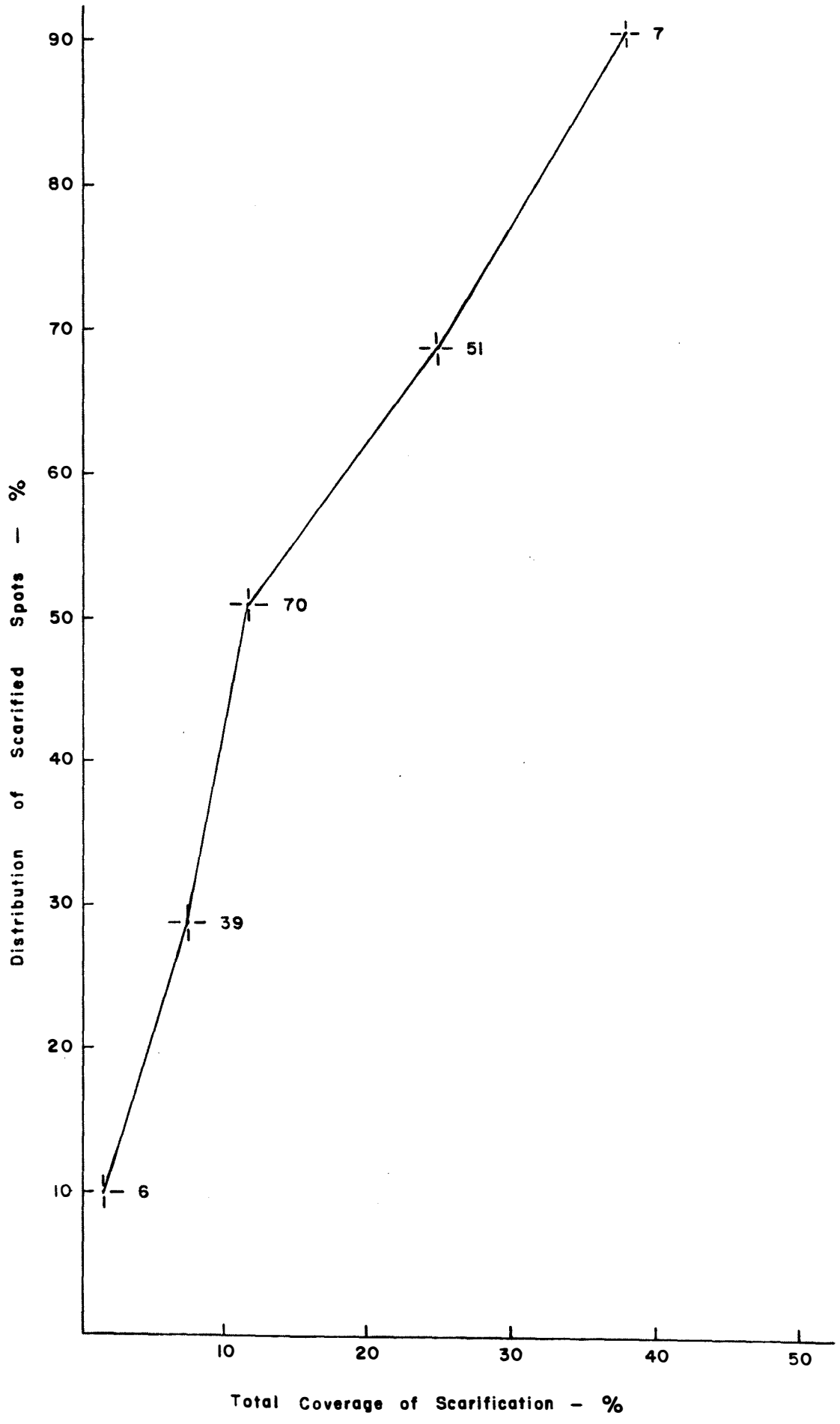

Figure 1. Relationship between total coverage of scarification and distribution of scarified spots.

Over 40 per cent distribution of mineral soil spots (one half a square foot or more) required a minimum total area coverage of 10 per cent. It is interesting to note that of the 173 blocks examined 45 (26%) had mineral soil distributions of 40 per cent and below. Therefore, assuming the necessity for a mineral soil seedbed, on 26 per cent of the blocks it was virtually impossible to achieve satisfactory stocking to Alberta Forest Service Standards.

5. Success Related to Season of Seeding

Records concerning season and date of seeding were incomplete and in some cases had to be estimated. On the basis of these rather weak and unreliable data an attempt was made to correlate season of seeding and percentage coverage of scarification with stocking. Blocks were grouped on the following basis.

Winter and Spring - November to May, inclusive

Summer - June and July

Fall - August to October, inclusive

Stocking data from each of the seasons of seeding were grouped in 20 per cent scarification coverage classes in order to determine the effect of this variable. No trends were indicated and in fact within a season of seeding there was as much variation within scarification coverage classes as between. Therefore further analyses were considered unwarranted.

The average stocking for seventy-one winter and spring seedings was 22 per cent. Fall scarification resulted in an average of 26 per cent on forty-three seedings. There was only one observation for summer seeding. Results do not indicate any appreciable difference in stocking due to season of seeding.

6. Stocking Related to Amount of Seed Used per Acre

Records were incomplete regarding amounts of seed applied per acre. However, it is known through discussions with officials that very small amounts were used in the first years of the program. Amounts varied between 1 and 6 oz. per acre; the lower amounts being applied in pinches of 6 - 12 seeds on favorable micro-sites. There is little information on the viability of seed used. It is generally known that the higher quality seed was used for the container planting program and the lower quality seed for direct seeding.

7. Correlation Co-efficients

All stocking data were stratified on the basis of Year of Treatment, Stand Cover-Type, and Stand Disturbance. Correlation co-efficients were determined for the following factors.

a) Vegetative competition

b) Slash density

c) Mineral soil exposure

d) Soil texture

e) Aspect

In only seven correlations of a possible 80 was significance indicated between the variables studied and stocking. This analysis was considered invalid and undoubtedly was due to the generally low success which prevented identification of meaningful relationships.

Table 6 shows the results. Three of the significant correlations are with respect to vegetative competition; two with slash density; and two with soil texture. There were no significant correlations with mineral soil exposure or aspect.

8. Poplar Reproduction

In the Alberta Forest Service reforestation standards poplar is only accepted as a 10 per cent component of the total stocking. On many of the treated areas there is considerable poplar reproduction as a result of treatment which may not be of immediate interest regarding forest management for wood fibre. However, there is considerable interest from wildlife specialists and for this reason average stocking of poplar on quadrats examined on the various forests is shown in Table 7.

These stocking figures have no statistical validity but do indicate the considerable presence of poplar as a result of treatment in some Forests. In fact, there is a distinct possibility that, due to treatment, ultimately some areas may support a larger poplar content than the original stand harvested.

Table 6 Correlation Between Various Factors and Stocking

Cover-Type	Year Seeded	Stand Disturbance	Number of Blocks Observed	Correlation: Vegetative Competition	Slash Density	Mineral Soil Exposure	Soil Texture	Aspect
Lodgepole pine	1965	Logged	4	NS [1]	NS	NS	NS	NS
	1967	Logged	18	[S] [2]	NS	NS	[S]	NS
	1968	Logged	12	NS	[S]	NS	NS	NS
Poplar	1962	Conversion	7	NS	NS	NS	NS	NS
	1965	Conversion	4	NS	NS	NS	NS	NS
	1966	Conversion	6	NS	NS	NS	NS	NS
	1967	Conversion	11	NS	NS	NS	NS	NS
	1967	Burned	18	[S]	NS	NS	NS	NS
Mixed	1963	Burned	6	NS	NS	NS	NS	NS
	1964	Burned	3	NS	NS	NS	NS	NS
	1965	Conversion	6	NS	NS	NS	NS	NS
	1966	Conversion	4	NS	NS	NS	[S]	NS
	1966	Logged	6	NS	NS	NS	NS	NS
	1967	Logged	17	[S]	[S]	NS	NS	NS
	1968	Logged	10	NS	NS	NS	NS	NS
	1969	Burned	9	NS	NS	NS	NS	NS

[1] Not statistically significant.

[2] Statistically significant at 5% level.

Table 7 Poplar Reproduction on Treated Areas

Forest	Total Quadrats Examined	Per cent of Quadrats Examined with Poplar Reproduction
Athabasca	551	53
Bow	457	17
Crowsnest	469	3
Edson	729	16
Grande Prairie	2,114	34
Lac La Biche	1,176	44
Rocky-Clearwater	1,898	27
Slave Lake	1,818	17
Whitecourt	709	8

D. CONCLUSIONS AND RECOMMENDATIONS

The high failure rate of scarification and seeding projects conducted by the Alberta Department of Lands and Forests should not be regarded as a categorical condemnation of this silvicultural practice. The program in Alberta is new and much has been learned on a trial and error basis. It is believed that marked improvements can be achieved by altering technique and operational procedure. In fact, Department of Lands and Forests officers state that recent scarification projects (since 1969) have improved significantly.

Unfortunately, even under optimum conditions of seedbed preparation and availability of sufficient high quality seed, climatic factors can result in the complete failure of a project. This is particularly true in the prairie provinces where prolonged droughts and untimely frosts may be the rule rather than the exception. Unfortunately we do not have sufficient information to estimate the probability of seeding failure due to climate. It may be as high as 50 per cent.

Obviously seeding cannot be a "one-shot" effort without subsequent surveillance. Annual inspections should be made for the first few years and if the catch is inadequate re-seeding should be done while the seedbed is still receptive. This should not increase costs unrealistically in most cases.

Waldron (1973) shows that the success ratio of seeding projects in Canada has been low. This fact must be considered when comparing costs for various reforestation methods. The cost per acre adequately reforested must be the criterion rather than the cost per acre of treatment.

One obvious conclusion that emerges from this survey is that the

amount of seed used per acre (1 - 6 oz.) has been much too low and immediate consideration should be given to application rates of at least one pound per acre. In addition the practice of using the best seed for nursery purposes and relegating lower quality seed for direct seeding projects should be discontinued.

Scarification coverage was low on many projects and on about 25 per cent of the blocks examined was so low that adequate stocking levels could not be reached due to this factor alone. On the basis of blocks examined in this appraisal at least 20 per cent coverage was necessary to obtain a 40 per cent distribution of scarified spots of one-half a square foot or larger in size. To obtain a 70 per cent distribution of these spots at least 25 per cent scarification coverage must be obtained.

Scarification and direct seeding on recently logged areas which had supported coniferous stands offer the greatest chance of success. A possible exception is on wet sites. Scarification and direct seeding of recently burned aspen stands or attempts to convert good, or perhaps any, aspen stands to mixed stands should be discontinued or curtailed due to extreme vegetative competition and attendant rabbit problems which presently are economically insoluble. Lees (1965) remarked on an assessment of scarification and seeding in the Slave Lake Forest "conversion of immature and mature hardwood stands to spruce is a difficult task and probably scarification with hand seeding is not the answer to the problem".

In summary the following recommendations are made:

1. Scarification and direct seeding should be discontinued in aspen stands and restricted on recent burns where vegetative competition may be high and rabbit damage severe.
2. The scarification and seeding program should be modified to ensure a minimum mineral soil distribution of 40% and at least one pound of high quality seed applied per acre where seed-trees are scarce or non-existent.
3. In general the program should be curtailed until an acceptable level of consistent success is obtained through modification of the technique.
4. Individual projects should be carefully monitored and reseeding where necessary should be done while the seedbed is still receptive.
5. Projects should be carefully documented and complete records maintained. It is only in this way that valid analyses may be made and the technique refined.
6. In considering scarification and direct seeding as a reforestation alternative, recognition must be made of the risks involved due to climate and other factors.

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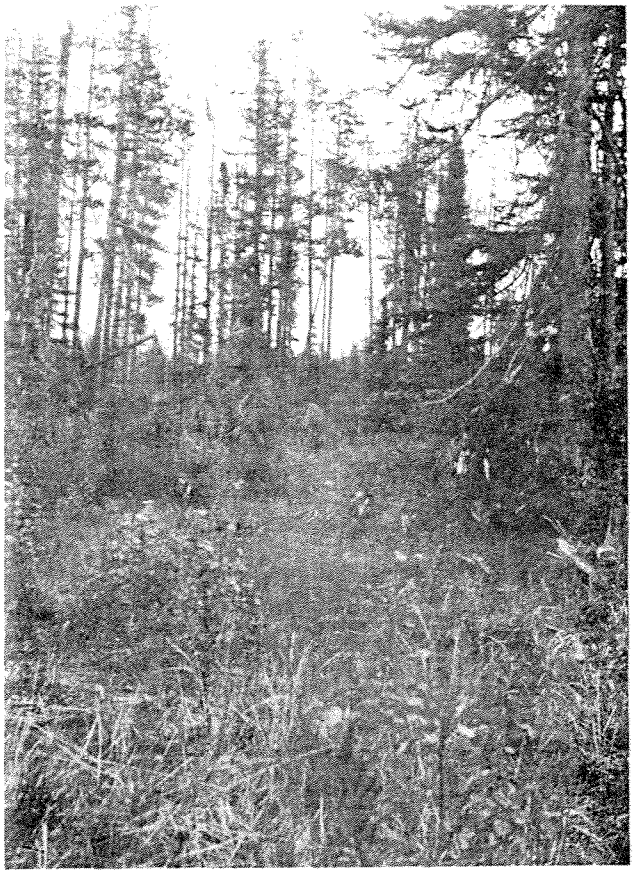


Moist spruce site partially logged, scarified and seeded.

Logged and scarified lodgepole pine site.

Aspen conversion with abundant suckering.

Burned-over aspen stand with dense vegetation.

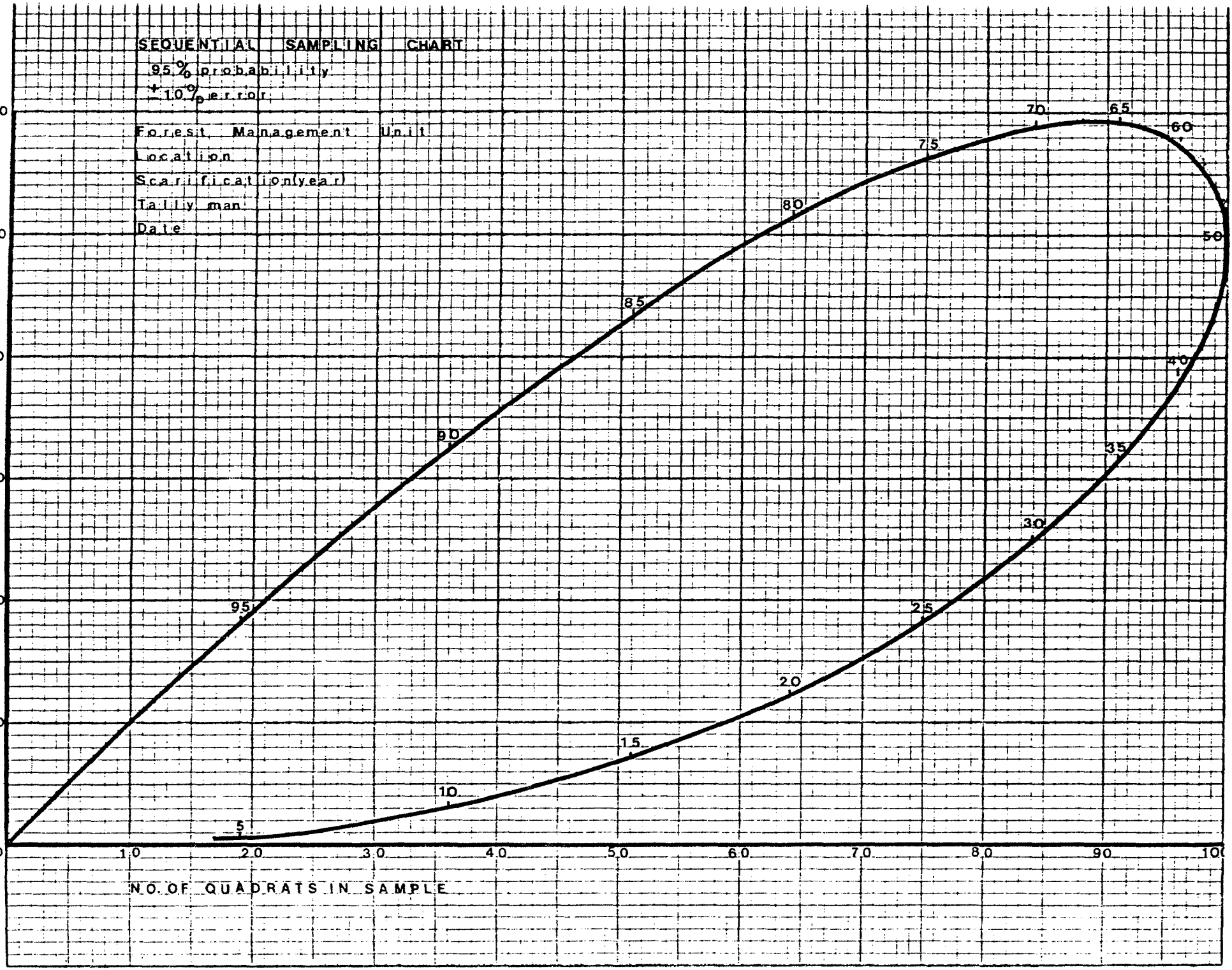
APPENDIX

SEQUENTIAL SAMPLING

For a full description of the method and theory of sequential sampling the reader is referred to Dick (1963). An adaptation of Dick's method was used but the principle applies.

Milliacre quadrats were evenly spaced within the 200-acre block to be sampled. Spacing of quadrats was determined as follows. A pre-estimate of stocking based on ten quadrats, one chain apart, was obtained. Reference to the sequential sampling chart (see attached sample) indicated the number of quadrats required for the estimated stocking level. On this basis spacing of quadrats within the block was calculated.

In all cases a minimum of 50 quadrats were established. These were established along lines running perpendicular to the direction of scarification treatment. The status of each quadrat (stocked or unstocked) was plotted on the sequential sampling chart until the perimeter of the "tear-drop" was crossed. Sampling was concluded at this point or when a minimum of 50 quadrats had been established.


SEQUENTIAL SAMPLING CHART
95% probability
± 10% error
Forest Management Unit
Location
Scarification(year)
Tally man
Date
NO. OF STOCKED QUADRATS
NO. OF QUADRATS IN SAMPLE
0
10
20
30
40
50
60
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10
95
90
85
80
75
70
65
60
50
40
35
30
25
20
15
10
5

BLOCK DESCRIPTION SHEET

ASSESSMENT OF SCARIFICATION AND SEEDED AREAS IN ALBERTA

Project No. _____

Subdivision _____

Forest Management Unit: _____ Est. of Stocking

Location: Sec. _____ Twp. _____ Rge. _____ 1 2 3 4 5 6 7 8 9 10

Forest Region (Rowes): _____ Spacing _____ chains

Vegetative Competition Rated: H M L

Slash Accumulation Rated: H M L

Soil Moisture: Dry _____ Moist _____ Wet _____

Soil Texture: Sand _____ Loam _____ Clay _____

Conversion overwood: Age _____ Basal Area _____

Aspect of Slope: _____

Leaf Smother: H M L Nil

Seedling Damage: Rabbits _____ Insect _____ Disease _____

Depth of Organic Material: _____

Number of Photos taken: _____

Roll No. _____ Photos _____

Notes taken by: _____